KORVUS TECHNOLOGY

Publications Citing use of the HEX or HEX-L Systems

2024

Effects of transition metal ions migration at the cathode|electrolyte interface on the performance of thin-film Lithium-ion batteries with NCM cathodes (2024)

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Abstract:

The advent of all-solid-state thin-film lithium-ion batteries (LIBs) has revolutionized the powering of microsystems due to their miniaturization ease and seamless integration capabilities. Despite the pressing demand for LIBs with higher energy density and enhanced safety, the performance of these devices has been consistently hindered by the complex interfacial dynamics at the cathode|electrolyte boundary. This study delves into the nuanced characterization of transition metal (TM) ions at the cathode|electrolyte interface, utilizing $LiNi_{0.5}Co_{0.2}Mn_{0.3}O_2$ (NCM523) thin films as the cathode material for LIBs. We meticulously explored the profound impact of NCM523|LiPON interfacial properties on the LIBs' overall performance, uncovering that the migration of TM ions and the emergence of TM–O spinel phases, induced by targeted annealing treatments of the cathodes, play pivotal roles in dictating the battery's capacity density and cycling stability. Heat treatments at 600 and 800 °C led to the formation of inhomogeneous spinel-phase nanolayers on the surfaces of NCM523 thin films, which hindered Li^+ transport and affected the LIBs. In stark contrast, the 700 °C treatment yielded a pristine layered structure with clear boundary against LiPON, culminating in a battery with outstanding capacity density and remarkable cycle stability. Our theoretical calculations have unravelled that the temperature-dependent migration of TM ions is intricately linked to the varying strengths of TM–O bonds and the associated Jahn-Teller effects, providing a novel perspective on the design of high-performance LIBs.

Link to Paper: https://www.sciencedirect.com/science/article/abs/pii/S2405829724003258

Mapping the microstructure and the mechanical performance of a combinatorial Co-Cr-Cu-Fe-Ni-Zn high-entropy alloy thin film processed by magnetron sputtering technique. (2024)

Nagy, P., Wątroba, M., Hegedűs, Z., Michler, J., Pethö, L., Schwiedrzik, J., Czigány, Z. and Gubicza, J.,

EMPA Swiss Federal Laboratories for Materials Science and Technology, Laboratory for Mechanics of Materials and Nanostructures, Feuerwerkerstrasse 39, CH-3602, Thun, Switzerland

Abstract:

The Co–Cr–Cu–Fe–Ni–Zn compositional library was studied on a combinatorial high-entropy alloy thin film processed on a silicon substrate by magnetron sputtering technique. The thickness of the coating was between 2 and 3 µm while the lateral dimension was 10 cm. The chemical composition in the layer depended on the location and for each constituent element the concentration varied between 5 and 42 at.%. The phase composition and the microstructure were mapped using synchrotron X-ray diffraction, and the crystallite size as well as the density of lattice defects (dislocations and twin faults) were determined by diffraction line profile analysis. In addition, selected locations were studied by transmission electron microscopy. The influence of the chemical composition on the microstructure and the mechanical behaviour was revealed. The mechanical performance was characterized by nanoindentation mapping which determined the hardness and the elastic modulus versus the element concentrations. It was found that the coating contains single phase face-centered cubic (FCC) and body-centered cubic (BCC) regions as well as an intermediate two-phase area. In the whole combinatorial sample, the microstructure consisted of nanocrystalline columns growing perpendicular to the coating surface and having pores between them. Due to the porosity, the hardness and the elastic modulus were relatively low despite the nanostructure and the very high defect density. The highest hardness (3.4 GPa) and elastic modulus (119 GPa) were measured in the BCC region with the chemical composition of 10%Co–38%Cr–13%Cu–27%Fe–5%Ni–7%Zn (at.%).

Link to Paper: https://www.sciencedirect.com/science/article/pii/S223878542401370X

Angular distribution of species in pulsed electron beam deposition of $Ba_xSr_{1-x}TiO_3$ (2024)

Dobrin, D., Burducea, I., Iancu, D., Burducea, C., Gherendi, F. and Nistor, M.

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Abstract:

The angular thickness and composition profiles of thin films obtained by irradiating a $Ba_xSr_{1-x}TiO_3$ (x = 0.2) target with a pulsed electron beam were investigated by Rutherford backscattering spectrometry for argon and oxygen background gases at a pressure of about 10^{-2} mbar. A "semi-sphere" holder was used, resulting in a fixed target to substrate distance of about 40 mm. The film thickness profiles have forward shaped peaks, with measurable thickness up to 80-90° for major axis

and 25° for minor axis, and presents similar trend for both argon and oxygen background gas. The analysis of the congruent transfer of the elements from the target as a function of the angle showed that the film composition is not uniform over this wide angular range and differs with respect of the ablated target depending on the element used and on background gas.

Link to Paper: https://www.sciencedirect.com/science/article/abs/pii/S0169433224004707

Plasmon-enhanced self-powered GaN/ZnTe core/shell nanopillar array photodetector (2024)

Dong, J., Zhang, D., Ma, Y., You, D., Chen, J., Liu, B., Wang, X., Shi, Z. and Xu, C.,

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Abstract:

Nanostructure photodetectors, as the core component of optoelectronic devices, are mainly focused on the precise preparation of mixed-component nano-heterostructures and the realization of zero power consumption devices. Herein, we successfully fabricated n-GaN/p-ZnTe core/shell nanopillar array and realized self-power ultraviolet/violet photodetection. The radial heterojunction nanodevice reveals high light-dark current ratio of 10^4 at 0 V bias, indicating effective carriers' separation. And more, by integrating plasmonic effect, the responsivity and detectivity of the Au nanoparticles decorated device are increased from 3.85 to 148.83 mA/W and 4.45×10^{11} to 2.33×10^{12} Jones under 325 nm UV light irradiation. While the rise and the fall time are decreased 1.3 times and 6.8 times under 520 nm visible light irradiation at 0 V bias. The high photocurrent gain is derived from that the oscillating high-energy hot electrons in Au nanoparticles spontaneously inject into the ZnTe conduction band to involve the photodetection process. This work presents an effective route to prepare high-performance self-power photodetector and provides a promising blueprint to realize different functional photoelectronic devices based on core/shell nanostructure.

Link to Paper: https://link.springer.com/article/10.1007/s12274-024-6477-9

Toward coupling across inorganic/organic hybrid interfaces: polyaniline-coated gold nanoparticles with 4-aminothiophenol as gold-anchoring moieties (2024)

Yi, G., Hoffmann, M., Seçkin, S., König, T.A., Hermes, I., Rossner, C. and Fery, A.,

Institut für Physikalische Chemie und Physik der Polymere, Leibniz-Institut für Polymerforschung Dresden e.V., 01069, Dresden, Germany

Abstract:

The chemical binding between metal nanoparticles and (semi-)conductive polymer layers is essential to control the (opto-)electronic properties of such hybrid materials. Current approaches that achieve a conjugated binding of organic (semi-)conductive ligands to metal nanoparticles demonstrated promising functional properties, but are based on tedious multi-step organic synthesis to incorporate the required binding moieties at the chain ends of targeted macromolecular species. Herein, we explore the pre-functionalization of gold nanoparticles with p-aminothiophenol and subsequent surfactant-assisted formation of a poly(aniline) (PANI) shell as a means to access gold/PANI core–shell-type nanoparticles with enhanced conductive properties. Controlled surface deposition of these hybrid nanoparticles is achieved via template-assisted self-assembly. For these surface-deposited nanoparticles, charge transport properties are characterized at the nanoscale by conductive atomic force microscopy measurements and show a significant conductivity increase of our core–shell particles as compared to reference particles formed by conventional surfactant-assisted PANI-shell formation.

Link to Paper: https://link.springer.com/article/10.1007/s00396-024-05262-x

Diblock bottlebrush polymer in a non-polar medium: Self-assembly, surface forces, and superlubricity (2024)

Stevens, M.C., Taylor, N.M., Guo, X., Hussain, H., Mahmoudi, N., Cattoz, B.N., Leung, A.H., Dowding, P.J., Vincent, B. and Briscoe, W.H.,

School of Chemistry, University of Bristol, Cantock's Close, Bristol BS8 1TS, UK

Abstract:

Whilst bottlebrush polymers have been studied in aqueous media for their conjectured role in biolubrication, surface forces and friction mediated by bottlebrush polymers in non-polar media have not been previously reported. Here, small-angle neutron scattering (SANS) showed that a 4eblock bottlebrush copolymer (oligoethyleneglycol acrylate/ethylhexyl acrylate; OEGA/EHA) formed spherical core–shell aggregates in n-dodecane (a model oil) in the polymer concentration range 0.1–2.0 wt%, with a radius of gyration $R_g \sim 7$ nm, comprising 40–65 polymer molecules per aggregate. The surface force apparatus (SFA) measurements revealed purely repulsive forces between surfaces bearing inhomogeneous polymer layers of thickness $L \sim 13$–23 nm, attributed to adsorption of a mixture of polymer chains and surface-deformed micelles. Despite the surface inhomogeneity, the polymer layers could mediate effective lubrication, demonstrating superlubricity with the friction coefficient as low as $\mu \sim 0.003$. The analysis of velocity-dependence of friction using the Eyring model shed light on the mechanism of the frictional process. That is, the friction mediation was consistent with the presence of nanoscopic surface aggregates, with possible contributions from a gel-like network formed by the polymer chains on the surface. These unprecedented results, correlating self-assembled polymer micelle structure with the surface forces and friction the polymer layers mediate,

highlight the potential of polymers with the 5eblock bottlebrush architecture widespread in biological living systems, in tailoring desired surface interactions in non-polar media.

Link to Paper: https://www.sciencedirect.com/science/article/pii/S0021979723023767

Surface forces and friction between Langmuir-Blodgett polymer layers in a nonpolar solvent (2024)

Taylor, N.M., Pilkington, G.A., Snow, T., Dowding P.J., Cattoz, B.N., Schwarz, A.D., Bikondoa, O., Vincent, B., Briscoe, W.H.,

School of Chemistry, University of Bristol, Cantock's Close, Bristol BS8 1TS, UK

Abstract:

Optimization of boundary lubrication by tuning the confined molecular structures formed by surface-active additives such as surfactants and polymers is of key importance to improving energy efficiency in mechanical processes. Here, using the surface forces apparatus (SFA), we have directly measured the normal and shear forces between surface layers of a functionalised olefin copolymer (FOCP) in n-dodecane, deposited onto mica using the Langmuir-Blodgett (LB) technique. The FOCP has an olefin backbone decorated with a statistical distribution of polar-aromatic groups, with a structure that we term as "centipede". The effect of lateral confinement, characterised by the surface pressure, Π_{dep}, at the air–water interface at which the LB films are transferred, was examined. Normal force profiles revealed that the thickness of the LB films increased significantly with Π_{dep}, with the film thickness (t > 20 nm) inferring a multi-layered film structure, consistent with the interfacial characterisation results from synchrotron X-ray reflectivity (XRR) measurements. The coefficient of friction, μ, between the LB films spanned two orders of magnitude from superlubricity (μ ∼0.002) to much higher friction (μ > 0.1) depending nonlinearly on Π_{dep}, with the lowest friction observed at the intermediate Π_{dep}. Molecular arrangement upon LB compression leads to the multilayer film with a structure akin to an interfacial gel, with transient crosslinking facilitated by the intra- and inter-molecular interactions between the functional groups. We attribute the differences in frictional behaviour to the different prevalence of the FOCP functional groups at the lubricating interface, which depends sensitively on the degree of compression at the air–water interface prior to the LB deposition. The LB films remain intact after repeated compression (up to pressures of 10 MPa) and shear cycles, indicating strong surface anchorage and structural robustness as a load-bearing and shear-mediating boundary layer. These unprecedented results from the friction measurements between LB films of a statistical copolymer in oil point towards new strategies for tailoring macromolecular architecture for mediating efficient energy dissipation in oil-based tribological applications.

Link to Paper: https://www.sciencedirect.com/science/article/pii/S0021979723018441

Fiber Optic SPR Sensor Modified with Copper Oxide Nanoparticles for Highly Sensitive and Selective Detection of Dopamine (2024)

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Abstract:

In modern biomedical technology, the fabrication of high-performance sensors for dopamine detection is an important issue because dopamine is a major neurotransmitter and abnormal level of its concentration in the human body is accountable for several neurological diseases. Here, we report a highly sensitive and selective surface plasmon resonance (SPR) sensor modified with small copper oxide nanoparticles (CuO NPs) for experimentally detecting dopamine. Fiber optic sensing probes were fabricated by depositing a 50-nm-thick gold film over the unclad portion of a multimode optical fiber using magnetron sputtering and then further modified with synthesized CuO NPs (~7 nm). Detection of dopamine with the designed SPR sensor was achieved for a wide range of concentrations from very low concentrations with a limit of detection at 1.11 nM and up to 50 nM. The maximum sensitivity was achieved as 0.787 nm/nM and the limit of quantification was at 1.43 nM. To evaluate the selectivity of the studied sensor, experiments were also performed with ascorbic acid and uric acid, which usually coexist with dopamine in the biological fluids. Moreover, sensing characteristics, such as repeatability, linearity, and response time, were studied in detail. Taken together, these findings show that CuO NPs are excellent candidates as SPR sensitizer effectively improving the sensing performance of dopamine.

Link to Paper: https://ieeexplore.ieee.org/abstract/document/10387160

Phase stability and energy storage properties of polycrystalline antiferroelectric $BaTiO_3$-substituted $NaNbO_3$ thin films (2024)

Kobald, A.M., Kobald, H., Deluca, M.,

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Abstract:

Lead-free sodium niobate (NN) thin films with varying barium titanate (BT) content and 1 mol% manganese were deposited on platinized silicon substrates by chemical solution deposition. Microstructural analysis reveals a change in nucleation mechanism, and X-ray diffraction and Raman spectroscopy confirmed a composition-driven antiferroelectric (AFE) to ferroelectric (FE) phase transition at $0.01 < x < 0.03$, providing a stability interval for the AFE phase despite increasing the tolerance factor. The thin films show well-shaped ferroelectric response under applied electric field, indicating an irreversible field-induced phase transition. The composition with 7 mol% $BaTiO_3$ showed the most promising energy storage properties (W_{rec} ~5.7 J/cm^3 and 68% efficiency (η)), along with excellent thermal stability up to 120 °C and largely improved cyclic stability up to

*5 * 10^6 bipolar cycles. These findings highlight the potential of NN-based thin films as lead-free candidates for energy storage, emphasizing the importance of stabilizing the AFE phase under electric fields for practical applications.*

Link to Paper: https://www.sciencedirect.com/science/article/pii/S0955221923009755

Characterization of GLAD-grown TiCu thin films for thermo-resistive sensing applications (2024)

Spârchez, C., Lopes, C., Gabor, C., Munteanu, D., Correa, M., Vaz, F., Ferreira, A.,

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Abstract:

Titanium-copper thin films were prepared by Glancing Angle Deposition (GLAD) to assess their suitability for temperature sensors, by measuring the temperature resistance coefficient (TCR). The films were deposited with zigzag and spiral architectures, while the substrate holder was maintained at a fixed angle of α = 20º relative to the incident flux of the sputtered particles. The films were produced through DC co-deposition magnetron sputtering, using two targets of pure Ti and Cu. A wide range of compositions was achieved by varying the current on the Cu target from 6 mA up to 20 mA. The obtained architectures were stabilized through in-vacuum annealing treatments to minimize the hysteresis effects of the temperature on the electrical resistance of the films. The sheet resistance showed a direct correlation with the formation/precipitation of the Ti-Cu intermetallic phases in the film. The measured Temperature Coefficient of Resistance (TCR) values ranged from -1.08×10^{-3} to -5.1×10^{-3} °C^{-1}, closely resembling the absolute value of platinum's TCR (3.93×10^{-3} °C^{-1}). Moreover, the elimination of hysteresis from the TCR plot and consistent results obtained during multiple cycles of heating and cooling highlight the potential of titanium copper thin films as promising alternatives for temperature sensors.

Link to Paper https://www.sciencedirect.com/science/article/abs/pii/S0924424724006551

Non-Pinned, Reversible Spin Crossover in Self-Assembled Monolayers of a Functionalized Fe(II) Scorpionate Complex (2024)

Miranda, R.R., Giaconi, N., Pénicaud, M., Biwandu, L., Buffeteau, T., Cortigiani, B., Mannini, M., Otero, E., Ohresser, P., Hillard, E., Poggini, L., Gonidec, M., Rosa, P.,

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Abstract:

The spin crossover (SCO) behaviour of molecules in (sub)monolayers is typically significantly altered from that of the bulk: in particular, the SCO can be quenched by direct contact between the SCO molecules and the substrate, known as pinning, which causes problems for potential device applications. Here, an Fe (II) complex is presented that exhibits fully reversible, non-pinned SCO in self-assembled monolayers (SAMs) on template stripped gold substrates. The complex, [Fe(Tp(4-NHCOC10H20SCOCH3))(Tp)] where Tp = tris(1H-pyrazol-1-yl borohydride), has a broad SCO with a T½ of 366 K. The SAMs are uniform and homogeneous, as indicated by Atomic Force Microscopy, and contain the target molecules in a well-oriented layer with the expected thickness for a monolayer of the complex, as revealed by polarization modulation infrared reflection-absorption spectroscopy, time-of-flight secondary ion mass spectrometry and cyclic voltammetry. Variable temperature X-ray photoelectron spectroscopy, as well as X-ray absorption spectroscopy at the Fe L2,3 edges, indicates a reversible SCO in the monolayers that is identical to the bulk behaviour.

Link to Paper: https://chemrxiv.org/engage/chemrxiv/article-details/66a09475c9c6a5c07ab770b7

BiMg2/3Nb1/3O3-based thin films from Chemical Solution Deposition - A study on the influence of the process parameters on the structure and the electrical properties (2024)

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Abstract:

Enhancing the energy storage properties of lead-free dielectric capacitors is a key focus in today's microelectronic industry. This objective is gaining importance in the quest to develop lead-free devices that align with lead-based property standards while minimizing the toxicity associated with processing and the end products. BiMg2/3Nb1/3O3-based thin films show promising energy storage properties due to the disruption of the long-range ferroelectric order. The relaxor-like behaviour results in slimmer polarization vs. electric field hysteresis loops (PE loops) compared to ferroelectrics and leading to a significant reduction in energy losses while maintaining a high permittivity. The use of thin film technology, as opposed to bulk ceramics, is a crucial step in the miniaturization of devices. In addition, this technique increases energy density and breakdown fields by improving microstructure and promoting texture. In this thesis, thin films based on (1-x)Bi(Mg2/3Nb1/3)O3–xBi0.5Na0.5TiO3 (BMN-BNT, x = 0.85) and (1-x)Bi(Mg2/3Nb1/3)O3–xNaNbO3 (BMN-NN, x = 0.78) systems were produced by chemical solution deposition (CSD) on Pt/TiO2/SiO2/Si substrates. All films have been successfully synthesized and the influence of different heating rates and crystallization temperatures on the microstructure and electrical properties have been investigated and characterized. Characterization analysis was carried out using Raman spectroscopy, X-ray diffraction (XRD), scanning electron microscopy (SEM) and Energy-Dispersive X-ray (EDX) analysis. Electrical measurements (PE loops) were conducted to evaluate the energy storage properties and to gain

insights into the temperature-dependent response and cyclic fatigue behaviour of the various films. Both thin film systems show a phase pure and highly crystalline perovskite structure in both XRD and Raman spectroscopy. The BMN-BNT composition showed the most promising energy storage properties (Wrec ~ 20 J/cm3 and 69% efficiency), coupled with excellent thermal stability up to 140°C. However, superior cyclic fatigue stability, extending up to 106 unipolar cycles, and low leakage currents were observed for the BMN-NN system. In a broader context, it can be confirmed that varying process parameters significantly impact both the microstructure and the electrical properties of the two material systems. The complex interplay between structural characteristics and electrical behaviour underscores the need of thorough exploration of processing conditions in achieving tailored material properties.

Link to Paper: https://pureadmin.unileoben.ac.at/ws/portalfiles/portal/26834759/AC17143048.pdf

Rapid test for platelet viability relying on a quartz crystal microbalance assay (2024)

Their, F., Lieberzeit, P.A.,

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Abstract:

Sensing systems provide a fast and cost-effective way to monitor health parameters and can thus help medical personnel to ensure optimal care for patients. In this study, we present a sensor based on quartz crystal microbalances (QCMs) with bare, non-modified gold electrodes to monitor viability of platelets in stored platelet concentrates used in transfusion medicine. The system is useful to determine cell viability both in static and continuous flow experiments. Sensor responses correlate with platelet viability: viable cells have the ability to activate and aggregate and, thus, firmly attach to the QCM gold surface, in turn causing high frequency shifts due to a change in viscoelastic properties. For instance, on the fifth day of storage, platelet samples led to QCM frequency shifts less than 40% of the signal obtained from the fresh concentrate. Sensor results correlate well with a resazurin-based fluorescence viability assay. This also correlates with optical and atomic force microscopy (AFM) images that reveal changes in platelet morphology during the storage period, namely cessation of extensive pseudopodia formation and platelet spreading. Platelet size in solution significantly increased during storage, most likely due to a pH drop in the medium. The straightforward system is thus in principle useful to detect storage lesions and viability of platelets directly before transfusion

Link to Paper:
https://web.archive.org/web/20240429084328id_/https://pubs.rsc.org/en/content/articlepdf/2024/sd/d3sd00269a

Fillable Magnetic Microrobots for Drug Delivery to Cardiac Tissues In Vitro (2024)

Chen, M.S., Sun, R.S., Wang, R., Zuo, Y., Zhou, K., Kim, J., Stevens, M.M.,

Department of Materials, Department of Bioengineering, Institute of Biomedical Engineering, Imperial College London, London SW7 2AZ, UK

Abstract:

Many cardiac diseases, such as arrhythmia or cardiogenic shock, cause irregular beating patterns that must be regulated to prevent disease progression toward heart failure. Treatments can include invasive surgery or high systemic drug dosages, which lack precision, localization, and control. Drug delivery systems (DDSs) that can deliver cargo to the cardiac injury site could address these unmet clinical challenges. Here, a microrobotic DDS that can be mobilized to specific sites via magnetic control is presented. This DDS incorporates an internal chamber that can protect drug cargo. Furthermore, the DDS contains a tuneable thermosensitive sealing layer that gradually degrades upon exposure to body temperature, enabling prolonged drug release. Once loaded with the small molecule drug norepinephrine, this microrobotic DDS modulated beating frequency in induced pluripotent stem-cell derived cardiomyocytes (iPSC-CMs) in a dose-dependent manner, thus simulating drug delivery to cardiac cells in vitro. The DDS also navigates several maze-like structures seeded with cardiomyocytes to demonstrate precise locomotion under a rotating low-intensity magnetic field and on-site drug delivery. This work demonstrates the utility of a magnetically actuating DDS for precise, localized, and controlled drug delivery which is of interest for a myriad of future opportunities such as in treating cardiac diseases.

Link to Paper: https://onlinelibrary.wiley.com/doi/full/10.1002/smll.202402200

Revealing the Role of Mo Leaching in the Structural Transformation of NiMo Thin Film Catalysts upon Hydrogen Evolution Reaction (2024)

Neumüller, D., Rafailović, L.D., Pašti, I.A., Griesser, T., Gammer, C., Eckert, J.,

Materials Center Leoben Forschung GmbH, Roseggerstraße 12, 8700 Leoben, Austria

Abstract:

NiMo alloys are considered highly promising non-noble Hydrogen Evolution Reaction (HER) catalysts. Besides the synergistic effect of alloying elements, recent attention is drawn to the Mo leaching from the catalyst. This work investigates the role of Mo in NiMo alloys during HER, aiming to understand the interplay between compositional, structural, and electronic factors on the activity, and their effects on the electrode material and catalyst properties. For this purpose, sputter-deposited low roughness Ni_xMo_{100-x} thin films are produced. The investigation of catalyst performance depending on

their chemical composition shows a volcano-shaped plot, peaking for the $Ni_{65}Mo_{35}$ alloy with the highest intrinsic activity in alkaline HER. A comprehensive electrode surface analysis combining transmission electron microscopy, X-ray photoelectron spectroscopy and atomic force microscopy identifies the leaching of Mo on a structural level and indicates the formation of a $Ni(OH)_2$-rich surface area. The ultimate surface characteristics of the NiMo catalysts depend on the initial composition and the electrochemical procedure. Based on the findings, it concludes that the observed catalytic properties of NiMo alloys in HER are determined by a complex interplay of increasing roughness, available surface species and their synergies. The leaching of Mo has a proven structural effect and is considered one of several factors contributing to the enhanced catalyst activity.

Link to Paper: https://pubs.rsc.org/en/content/articlehtml/2024/sd/d3sd00269a

Localized Surface Plasmon Resonance Optical Biosensor for Simple Detection of Deoxyribonucleic Acid Mismatches (2024)

Lugongolo, M.Y., Ombinda-Lemboumba, S., Hlekelele, L., Nyokana, N., Mthunzi-Kufa, P.,

Photonics Centre Council for Scientific and Industrial Research PO Box 395, Pretoria 0001, South Africa

Abstract:

Optical biosensors are optical technologies that evaluate changes in the refractive index as they monitor non-covalent molecular interactions in real time. These make use of unsophisticated, label-free analytical approaches, which do not require dyes to produce a visible signal. In this study, the efficiency of localized surface plasmon resonance (LSPR) biosensor in detecting a single nucleotide mismatch in deoxyribonucleic acid is examined. The detection is based on the hybridization of a target DNA at 100 ng μL^{-1} with a complementary biotinylated probe as well as a partially complementary biotinylated with one nucleotide mismatch probe on a gold-coated surface. Both probes are used at a concentration of 0.1 µm. The LSPR exhibited sensitivity by differentiating sample M+ from sample C+ through varying transmission intensities of 0.28 and 0.26 µA, respectively. Based on these findings, this approach demonstrates a great potential due to its ability to distinguish samples that differ with a single base pair, and its efficiency will be explored in the development of a point-of-care device as a simpler and cost-effective approach for detection of various biologically and medically significant mutations such as antimicrobial resistance mutations. More work is underway to determine the robustness of the LSPR biosensor using the biotin–neutravidin approach.

Link to Paper: https://onlinelibrary.wiley.com/doi/full/10.1002/adpr.202300283

Microstructure and mechanical properties of Ti-Nb alloys: comparing conventional powder metallurgy, mechanical alloying, and high-power impulse magnetron sputtering processes for supporting materials screening (2024)

Marczewski, M., Wieczerzak, K., Maeder, X., Lapeyre, L., Hain, C., Jurczyk, M., Nelis, T.,

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Abstract:

At the interface of thin film development and powder metallurgy technologies, this study aims to characterise the mechanical properties, lattice constants and phase formation of Ti-Nb alloys (8–30 at.%) produced by different manufacturing methods, including conventional powder metallurgy (PM), mechanical alloying (MA) and high power impulse magnetron sputtering (HiPIMS). A central aspect of this research was to investigate the different energy states achievable by each synthesis method. The findings revealed that as the Nb content increased, both the hardness and Young's modulus of the PM samples decreased (from 4 to 1.5 and 125 to 85 GPa, respectively). For the MA alloys, the hardness and Young's modulus varied between 3.2 and 3.9 and 100 to 116 GPa, respectively, with the lowest values recorded for 20% Nb (3.2 and 96 GPa). The Young's modulus of the HiPIMS thin film samples did not follow a specific trend and varied between 110 and 138 GPa. However, an increase in hardness (from 3.6 to 4.8 GPa) coincided with an increase in the β_2 phase contribution for films with the same chemical composition (23 at.% of Nb). This study highlights the potential of using HiPIMS gradient films for high throughput analysis for PM and MA techniques. This discovery is important as it provides a way to reduce the development time for complex alloy systems in biomaterials as well as other areas of materials engineering.

Link to Paper: https://link.springer.com/article/10.1007/s10853-024-09715-0

2023

Surface forces and friction between Langmuir-Blodgett polymer layers in a nonpolar solvent (2023)

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Abstract:

"Optimization of boundary lubrication by tuning the confined molecular structures formed by surface-active additives such as surfactants and polymers is of key importance to improving energy efficiency in mechanical processes. Here, using the surface forces apparatus (SFA), we have directly measured the normal and shear forces between surface layers of a functionalised olefin copolymer (FOCP) in n-dodecane, deposited onto mica using the Langmuir-Blodgett (LB) technique. The FOCP has an olefin backbone decorated with a statistical distribution of polar-aromatic groups, with a structure that we term as "centipede". The effect of lateral confinement, characterised by the surface pressure, Пdep, at the air–water interface at which the LB films are transferred, was examined. Normal force profiles revealed that the thickness of the LB films increased

significantly with Πdep, with the film thickness (t > 20 nm) inferring a multi-layered film structure, consistent with the interfacial characterisation results from synchrotron X-ray reflectivity (XRR) measurements. The coefficient of friction, μ, between the LB films spanned two orders of magnitude from superlubricity (μ ∼0.002) to much higher friction (μ > 0.1) depending nonlinearly on Πdep, with the lowest friction observed at the intermediate Πdep. Molecular arrangement upon LB compression leads to the multilayer film with a structure akin to an interfacial gel, with transient crosslinking facilitated by the intra- and inter-molecular interactions between the functional groups. We attribute the differences in frictional behaviour to the different prevalence of the FOCP functional groups at the lubricating interface and suggest that the prevalence of the FOCP functional groups at the interfacial gel surface depends sensitively on the degree of compression at the air–water interface prior to the LB deposition. The LB films remain intact after repeated compression (up to pressures of 10 MPa) and shear cycles, indicating strong surface anchorage and structural robustness as a load-bearing and shear-mediating boundary layer. These unprecedented results from the friction measurements between LB films of a statistical copolymer in oil point towards new strategies for tailoring macromolecular architecture for mediating efficient energy dissipation in oil-based tribological applications."

Link to Paper: https://www.sciencedirect.com/science/article/pii/S0021979723018441

Ohmic Contact to n-GaN Using RT-Sputtered GaN:O (2023)

M.Maslyk[1] , P.Prystawko[1]

[1] Institute of High Pressure Physics, Polish Academy of Sciences, Sokolowska 29/37, 01-142 Warsaw, Poland

Abstract:

"One of the key issues in GaN-based devices is the resistivity and technology of ohmic contacts to n-type GaN. This work presents, for the first time, effective intentional oxygen doping of sputtered GaN films to obtain highly conductive n+-GaN:O films. We have developed a novel and simple method to obtain these films. The method is based on the room temperature magnetron sputtering of a single crystal bulk GaN target doped with oxygen. The n+-GaN:O films exhibit a polycrystalline structure with a crack-free surface and a free electron concentration of 7.4 × 1018 cm3. Ohmic contact to GaN:Si with n+-GaN:O sub-contact layer achieves specific contact resistance of the order of 10−5 Ωcm2 after thermal treatment. The obtained results are very promising for the development of the technology of a whole new class of ohmic contacts to n-GaN."

Link to Paper: https://www.mdpi.com/1996-1944/16/16/5574

Precise determination of Young's modulus of amorphous CuZr/nanocrystalline Cu multilayer via nanoindentation (2023)

A.Lassnig[1] , S.Zak[1]

[1] Erich Schmid Institute of Materials Science, Austrian Academy of Sciences, 8700, Leoben, Austria

Abstract:

"Extracting mechanical data of thin films on rigid substrates using nanoindentation is compromised by the mechanical properties of underlying substrates, which may falsify the obtained results. With ongoing

miniaturization, the substrate influence becomes more pronounced. In this study we present an experimental approach to extract the true Young's modulus of crystalline-amorphous multilayers by means of nanoindentation. We used 1 µm thick multilayers comprised of amorphous CuZr and nanocrystalline Cu. All films were deposited onto two rigid substrate types with Young's moduli below and above the ones expected for the deposits (film-to-substrate hardness and elastic moduli ratios between 0.3 to 1.1 and 0.6 to 1.5, respectively). Linear extrapolation of indentation data to zero indentation depth allows to precisely determine the real film's Young's modulus. Same investigations were performed on monolithic Cu and CuZr films of same thickness. While the hardness values change with the variation of the bilayer thickness of the multilayer structures, the Young's modulus is not affected by the interfaces."

Link to Paper: https://link.springer.com/article/10.1557/s43578-023-01057-y

Photoconductive Response to Pulsed UV Light of CsPbCl3 Flexible Thin Films Grown by Magnetron Sputtering (2023)

M. Bruzziu[1] , A. Vinattieri, et al.

[1] Dipartimento di Fisica e Astronomia, Università Degli Studi di Firenze, 50019 Florence, Italy

Abstract:

"CsPbCl3 perovskite is attracting increasing interest in ultraviolet (UV) detection due to its optical band gap and superior intrinsic optoelectronic properties. In this study, a novel one-step magnetron sputtering technique was applied for fabricating CsPbCl3 polycrystalline films on flexible plastic substrates with interdigitated contacts. The photoconductive response of 500 nm and 1 µm thick films to pulsed ultraviolet (UV) light in the 0.1–100 Hz frequency range and intensity of 10–500 W/m2 was tested at room temperature. The experimental results demonstrated the good performances of the CsPbCl3 films in terms of signal stability, fast response to transient signal, detectivity, light dynamic range, and dark current noise for the photodetection of pulsed UV light."

Link to Paper: https://www.mdpi.com/2079-6412/13/6/1128

Magnetron Sputtering Deposition of High Quality Cs3Bi2I9 Perovskite Thin Films (2023)

S. Caporali[1] , S.Martinuzzi[1], L.Gabellini[1] and N. Calisi[1]

[1] Department of Industrial Engineering (DIEF), University of Florence, Via di Santa Marta n. 3, 50139 Florence, Italy

Abstract:

"Nontoxic all-inorganic perovskites are among the most promising materials for the realization of optoelectronic devices. Here, we present an innovative way to deposit lead-free, totally inorganic Cs3Bi2I9 perovskite from vapor phase. Taking use of a magnetron sputtering system equipped with a radiofrequency working mode power supply and a single target containing the correct ratio of CsI and BiI3 salts, it was possible to deposit a Cs3Bi2I9 perovskitic film on silicon and soda-lime glass. The target composition was optimized to obtain a stoichiometric deposition, and the best compromise was found with a mix enriched with 20% w/w of CsI. Secondly, the effect of post-deposition thermal treatments (150 °C and 300 °C) and of the deposition on a

preheat substrate (150 °C) were evaluated by analyzing the chemical composition, the morphology, the crystal structure, and the optical properties. The thermal treatment at 150 °C improved the uniformity of the perovskite film; the one at 300 °C damaged the perovskite deposited. Depositing on a preheated substrate at 150 °C, the obtained film showed a higher crystallinity. An additional thermal treatment at 150 °C on the film deposed on the preheated substrate showed that the crystallinity remains high, and the morphology becomes more uniform.."

Link to Paper: https://www.mdpi.com/1996-1944/16/15/5276

Characterization of bacteria swarming effect under plasmonic optical fiber illumination (2023)

Jang Ah Kim[1] et al.

[1] Imperial College London (United Kingdom)

Abstract:

"Plasmo-thermo-electrophoresis (PTEP) involves using plasmonic microstructures to generate both a large-scale convection current and a near-field attraction force (thermo-electrophoresis). These effects facilitate the collective locomotion (i.e., swarming) of microscale particles in suspension, which can be utilized for numerous applications, such as particle/cell manipulation and targeted drug delivery. However, to date, PTEP for ensemble manipulation has not been well characterized, meaning its potential is yet to be realized.

Our study aims to provide a characterization of PTEP on the motion and swarming effect of various particles and bacterial cells to allow rational design for bacteria-based microrobots and drug delivery applications.

Plasmonic optical fibers (POFs) were fabricated using two-photon polymerization. The particle motion and swarming behavior near the tips of optical fibers were characterized by image-based particle tracking and analyzing the spatiotemporal concentration variation. These results were further correlated with the shape and surface charge of the particles defined by the zeta potential.

The PTEP demonstrated a drag force ranging from a few hundred fN to a few tens of pN using the POFs. Furthermore, bacteria with the greater (negative) zeta potential ($|\zeta| > 10$ mV) and smoother shape (e.g., Klebsiella pneumoniae and Escherichia coli) exhibited the greatest swarming behavior.

The characterization of PTEP-based bacteria swarming behavior investigated in our study can help predict the expected swarming behavior of given particles/bacterial cells. As such, this may aid in realizing the potential of PTEP in the wide-ranging applications highlighted above."

Link to Paper: https://www.spiedigitallibrary.org/journals/journal-of-biomedical-optics/volume-28/issue-7/075003/Characterization-of-bacteria-swarming-effect-under-plasmonic-optical-fiber-illumination/10.1117/1.JBO.28.7.075003.full?SSO=1

Hydrogen Evolution Reaction on Ultra-Smooth Sputtered Nanocrystalline Ni Thin Films in Alkaline Media- From Intrinsic Activity to the Effects of Surface Oxidation (2023)

D. Neumuller[1], L. Rafailovic[1], et al.

[1] Department of Materials Science, Montanuniversität Leoben, 8700 Leoben, Austria

Abstract:

"Highly effective yet affordable non-noble metal catalysts are a key component for advances in hydrogen generation via electrolysis. The synthesis of catalytic heterostructures containing established Ni in combination with surface NiO, Ni(OH)2, and NiOOH domains gives rise to a synergistic effect between the surface components and is highly beneficial for water splitting and the hydrogen evolution reaction (HER). Herein, the intrinsic catalytic activity of pure Ni and the effect of partial electrochemical oxidation of ultra-smooth magnetron sputter-deposited Ni surfaces are analyzed by combining electrochemical measurements with transmission electron microscopy, selected area electron diffraction, X-ray photoelectron spectroscopy, and atomic force microscopy. The experimental investigations are supplemented by Density Functional Theory and Kinetic Monte Carlo simulations. Kinetic parameters for the HER are evaluated while surface roughening is carefully monitored during different Ni film treatment and operation stages. Surface oxidation results in the dominant formation of Ni(OH)2, practically negligible surface roughening, and 3–5 times increased HER exchange current densities. Higher levels of surface roughening are observed during prolonged cycling to deep negative potentials, while surface oxidation slows down the HER activity losses compared to as-deposited films. Thus, surface oxidation increases the intrinsic HER activity of nickel and is also a viable strategy to improve catalyst durability.."

Link to Paper: https://www.mdpi.com/2079-4991/13/14/2085

Temperature-Dependent Amplified Spontaneous Emission in CsPbBr3 Thin Films Deposited by Single-Step RF-Magnetron Sputtering (2023)

A.Vinattieri[1], F. Biccari[1] et al.

[1] Department of Physics and Astronomy and LENS, University of Florence, Via G. Sansone1, 50125 Sesto Fiorentino (FI), Italy

Abstract:

"Due to their high optical efficiency, low-cost fabrication and wide variety in composition and bandgap, halide perovskites are recognized nowadays as real contenders for the development of the next generation of optoelectronic devices, which, among others, often require high quality over large areas which is readily attainable by vacuum deposition. Here, we report the amplified spontaneous emission (ASE) properties of two $CsPbBr_3$ films obtained by single-step RF-magnetron sputtering from a target containing precursors with variable compositions. Both the samples show ASE over a broad range of temperatures from 10 K up to 270 K. The ASE threshold results strongly temperature dependent, with the best performance occurring at about 50 K (down to 100 $\mu J/cm^2$), whereas at higher temperatures, there is evidence of thermally induced optical quenching. The observed temperature dependence is consistent with exciton detrapping up to about 50 K. At higher temperatures, progressive free exciton dissociation favors higher carrier mobility and increases trapping at defect states with consequent emission reduction and increased thresholds. The reported results open the

way for effective large-area, high quality, organic solution-free deposited perovskite thin films for optoelectronic applications, with a remarkable capability to finely tune their physical properties."

Link to Paper: https://www.mdpi.com/2079-4991/13/2/306

CsPbBr3 Perovskite Thin Films by Magnetron Sputtering: The Role of the Substrate on Texture and Morphology (2023)

N.Calisi[1], S. Caporali[1] et al.

[1] Department of Physics and Astronomy and LENS, University of Florence, Via G. Sansone1, 50125 Sesto Fiorentino (FI), Italy

Abstract:

Perovskites are one of the most promising materials to produce the new generation of solar cells and LEDs. Among the fully inorganic ones, CsPbBr3 is the most studied in owe to its favorable band gap and stability under mild atmospheric conditions, moisture, and visible radiation exposure. In the lab scale, by using this material high efficiency thin film solar cells have been produced and the research is aiming to scale the process up to industrial level. Here, ultra-thin films of CsPbBr3 were obtained by magnetron sputtering and the texture and the morphology of the deposed films were evaluated as function of the film thickness. Furthermore, the effect of the substrate on which the films were deposed was evaluated. The deposed films shown a high textured structure, especially in the firsts atomic layers deposed, moving to a less textured situation for thicker depositions. The films resulted composed by homogeneously distributed crystals of sub-micrometric size.

Link to Paper: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4387088

Flexible CsPbCl3 inorganic perovskite thin-film detectors for real-time monitoring in protontherapy (2023)

M. Bruzzi[1], N. Calisi[1], A. Vinattieri[1] et al.

[1] Department of Physics and Astronomy and LENS, University of Florence, Via G. Sansone1, 50125 Sesto Fiorentino (FI), Italy

Abstract:

This paper deals with the class of versatile semiconducting materials called perovskites, which have been deposited for the first time on flexible substrates and then tested for radiation detection monitoring applications. Lead halide inorganic perovskite, CsPbCl3, 0.4–1 µm-thick films have been grown on plastic flexible substrates equipped with interdigitated electrodes (IDEs) by magnetron sputtering at room temperature. First measurements in realtime configuration are reported for a 1–µm thick prototype under proton beams with energy in the range 100–228 MeV and 1–10 nA extraction currents, of interest for protontherapy applications. Experimental results evidence good performances of our sample as a realtime monitoring device. Current stability under UV and proton beam exposure has been tested in the range 0.1–120 s, as well as reproducibility under multiple exposures. The measured current signal proved to be linearly dependent on the extraction currents at a given proton energy. Linearity of the current signal of the device with proton fluxes was also proved within two order of magnitude range, about 107 –109 p/s. These promising results, when coupled with easyness of fabrication, low processing costs and high versatility of electrode

configurations, all features characterizing the manufacturing process, put into evidence lead halide perovskites as promising candidates for real-time radiation detection in protontherapy.

Link to Paper:
https://www.frontiersin.org/articles/10.3389/fphy.2023.1126753/full?utm_source=dlvr.it&utm_medium=twitter

Resist-Free E-beam Lithography for Patterning Nanosale Thick Films on Flexible Substrates (2023)

A.Xomalis[1], C. Hain[1], A. Groetsch[1] et al.

[1] Empa, Swiss Federal Laboratories for Materials Science and Technology, Laboratory for Mechanics of Materials and Nanostructures, Thun 3602, Switzerland

Abstract:

Resist-based lithographic tools, such as electron beam (e-beam) and photolithography, drive today's state-of-the-art nanoscale fabrication. However, the multistep nature of these processes, expensive resists, and multiple other consumables limit their potential for cost-effective nanotechnology. Here, we report a one-step, resist-free, and scalable methodology for directly structuring thin metallic films on flexible polymeric substrates via e-beam patterning. Controlling e-beam dose results in nanostructures as small as 5 nm in height with a sub-micrometer lateral resolution. We structure nanoscale thick films (100 nm) of Al, TiN, and Au on standard Kapton tape to highlight the universal use of our nanopatterning methodology. Further, we utilize direct e-beam writing to create various high-resolution biomimetic surfaces directly onto ceramic thin films. In addition, we assemble architectured mechanical metamaterials comprising crack "traps", which confine cracks and prevent overall material/device failure. Such a resist-free lithographic tool can reduce fabrication cost dramatically and may be used for different applications varying from biomimetic and architectured metamaterials to strain-resilient flexible electronics and wearable devices.

Link to Paper: https://pubs.acs.org/doi/pdf/10.1021/acsanm.2c05161

Optical biosensing of mycolic acid biomarker for TB diagnosis (2023)

Charles Maphanga[1], Saturnin Ombinda-Lemboumba[1], et al.

[1] Council for Scientific and Industrial Research, National Laser Centre, P O BOX 395, Pretoria 0001, South Africa

Abstract:

When it comes to diagnostics for various microorganisms, biosensors offer great advantages over conventional analytical techniques. Specifically, they can provide multiple capabilities such as user-friendly operation, real-time analysis, rapid response, high sensitivity and specificity, portability, label-free detection, and cost-effectiveness. As a result, this diagnostic approach possesses suitable features to develop point-of-care (POC) diagnostics and monitoring technologies. In this study, for the first time, an optical biosensor chip was developed and analysed using a localised surface plasmon resonance (LSPR) optical biosensing technique to monitor biomolecular interactions between mycolic acid TB antigen and anti-mycobacterium tuberculosis antibody. Mycolic acid was successfully immobilised on a gold-coated biosensor chip and allowed to react with an anti-mycobacterium tuberculosis antibody. To enhance the detection signal from biomolecular binding events, AuNPs were used and successfully bioconjugated with goat anti-rabbit IgG H&L secondary antibody and

characterised using ultraviolet-visible (UV-vis) spectroscopy and subsequently introduced on the biosensing layer. Scanning electron microscopy (SEM) and energy-dispersive x-ray (EDX) spectroscopy were used to characterise the biosensing surface. The optimised biosensor chip was analysed using a custom-built biosensing transmission spectroscopy setup to perform LSPR biosensing. From our findings, it was realised that mycolic acid was successfully immobilised on the biosensing surface and made it possible to capture anti-mycobacterium tuberculosis antibodies. The LSPR optical biosensing technique was indeed successful in the detection of anti-mycobacterium tuberculosis antibodies.

Link to Paper: https://www.spiedigitallibrary.org/conference-proceedings-of-spie/12387/123870E/Optical-biosensing-of-mycolic-acid-biomarker-for-TB-diagnosis/10.1117/12.2650013.short?SSO=1

Film Thickness Dependent Stability and Glass Transition Temperature of Polymer Films Produced by Physical Vapor Deposition (2023)

Junjie Yin[1] and James A. Forrest[1]

[1] Department of Physics and Astronomy, University of Waterloo, Waterloo, Ontario, Canada

Abstract:

We report measurements of the onset temperature of rejuvenation, Tonset, and the fictive temperature, Tf, for ultrathin stable polystyrene with thicknesses from 10 to 50 nm prepared by physical vapor deposition. We also measure the Tg of these glasses on the first cooling after rejuvenation as well as the density anomaly of the as-deposited material. Both the Tg in rejuvenated films and the Tonset in stable films decrease with decreasing film thickness. The Tf value increases for decreasing film thickness. The density increase typical of stable glasses also decreases with decreasing film thickness. Collectively, the results are consistent with a decrease in apparent Tg due to the existence of a mobile surface layer, as well as a decrease in the film stability as the thickness is decreased. The results provide the first self-consistent set of measurements of stability in ultrathin films of stable glass.

Link to Paper: https://journals.aps.org/prl/abstract/10.1103/PhysRevLett.130.168101

Improved Electrochemical Performance and Chemical Stability of Thin-Film Lithium Phosphorous Oxynitride Electrolyte by Appropriate Fluorine Plasma Treatment (2023)

Xinyi He[1], Jian Wang[1], et al.

[1] Key Laboratory of MEMS of the Ministry of Education, Southeast University, Nanjing 210096, China

Abstract:

Fluorine plasma treatment is proposed to incorporate fluorine into thin-film lithium phosphorus oxynitride (LiPON@F) electrolyte and its effects on the electrolyte performance and stability are also investigated. Due to strong reactivity of fluorine plasma, fluorine can be easily incorporated into LiPON with negligible effects on its

morphologies and amorphousness by appropriate plasma treatment. The LiPON@F electrolyte film displays better performance than the LiPON one mainly in terms of its higher ionic conductivity ($\sigma_i \sim 1.0 \times 10^{-6}$ S cm^{-1} vs. 7.7×10^{-7} S cm^{-1}), lower activation energy ($E_A \sim 0.39$ eV vs. 0.46 eV) and larger electrochemically stable window (ESW ~4.2 V vs. 3.9 V). Moreover, the LiPON@F electrolyte film also presents superior chemical stability than the LiPON one (σ_i degradation after exposure to 50%RH humidity for 120 h ~14.5% vs. 35.4%). Due to strong electronegativity and reactivity of the fluorine plasma, fluorine incorporation passivates defective bonds in the film and breaks the bridging bonds in the phosphate network. These facilitate the Li^+ migration and enhance the capability against the moisture, thus improving both the electrochemical performance and chemical stability of the electrolyte films.

Link to Paper: https://www.sciencedirect.com/science/article/abs/pii/S0013468623005893

Assembly of Fillable Microrobotic Systems by Microfluidic Loading with Dip Sealing (2023)

Rujie Sun[1], Xin Song[1], Kun Zhou[1] et al.

[1] Department of Materials, Imperial College London, SW7 2AZ, UK

Abstract:

Microrobots can provide spatiotemporally well-controlled cargo delivery that can improve therapeutic efficiency compared to conventional drug delivery strategies. Robust microfabrication methods to expand the variety of materials or cargoes that can be incorporated into microrobots can greatly broaden the scope of their functions. However, current surface coating or direct blending techniques used for cargo loading result in inefficient loading and poor cargo protection during transportation, which leads to cargo waste, degradation and non-specific release. Herein, a versatile platform to fabricate fillable microrobots using microfluidic loading and dip sealing (MLDS) is presented. MLDS enables the encapsulation of different types of cargoes within hollow microrobots and protection of cargo integrity. The technique is supported by high-resolution 3D printing with an integrated microfluidic loading system, which realizes a highly precise loading process and improves cargo loading capacity. A corresponding dip sealing strategy is developed to encase and protect the loaded cargo whilst maintaining the geometric and structural integrity of the loaded microrobots. This dip sealing technique is suitable for different materials, including thermal and light-responsive materials. The MLDS platform provides new opportunities for microrobotic systems in targeted drug delivery, environmental sensing, and chemically powered micromotor applications.

Link to Paper: https://onlinelibrary.wiley.com/doi/full/10.1002/adma.202207791

Position-Sensitive Measurements of a Single-Mode Laser Beam Spot Using the Dividing Plate Method (2023)

Yu. A. Budagov[1], V. V. Glagolev[1] et al.

[1] Joint Institute for Nuclear Research, Dubna, Moscow oblast, Russia

Abstract:

New position-sensitive experimental results have been obtained using the Dividing Plates method to detect the displacement of a single-mode laser beam spot of various diameters. Measurements show that with this method it is possible to attain sensitivities down to 0.18 μm^{-1} for a laser beam spot diameter of 8.8 µm displaced over 2.4 µm diameter zone, defined as the area where measurements non-linearities are within 1%. The achievable measurement accuracy is limited by ADC noise and corresponds to ±0.030 nm. Application of the Dividing Plates method for position-sensitive measurements allows to build a compact version of the Precision Laser Inclinometer, the Compact PLI, with reduced overall dimensions of 20 × 20 × 20 cm^3 and weight of approximatively 10 kg.

Link to Paper: https://link.springer.com/article/10.1134/S1547477122060061

2022

Localized surface plasmon resonance biosensing of Mycobacterium tuberculosis biomarker for TB diagnosis (2022)

Charles Maphanga[1], Saturnin Ombinda-Lemboumba[1], et al.

[1] Council for Scientific and Industrial Research, National Laser Centre, P O BOX 395, Pretoria 0001, South Africa

Abstract:

*"Biosensors offer great advantages over conventional analytical techniques. Specifically, they can provide multiple capabilities such as user-friendly operation, real-time analysis, rapid response, high sensitivity and specificity, portability, label-free detection, and cost-effectiveness. As a result, this diagnostic approach is a point-of-care (POC) diagnostic and monitoring technology. In this study, for the first time, an optical biosensor chip was developed and analyzed using a localized surface plasmon resonance (LSPR) optical biosensing technique to monitor biomolecular interactions between mycolic acid TB antigen and anti-*Mycobacterium tuberculosis *antibody. Mycolic acid was successfully immobilized on a gold-coated biosensor chip and allowed to react with anti-*Mycobacterium tuberculosis *antibody. To enhance the detection signal from biomolecular binding events, gold nanoparticles (AuNPs) were used and successfully bioconjugated with goat anti-rabbit IgG H&L secondary antibody and characterized using ultraviolet-visible (UV–vis) spectroscopy, dynamic light scattering (DLS), Fourier-transform infrared (FTIR) spectroscopy, and subsequently introduced on the biosensing layer. Scanning electron microscopy (SEM), energy-dispersive X-ray (EDX) spectroscopy, and atomic force microscopy (AFM) were used to characterize the biosensing surface. The optimized biosensor chip was analyzed using a custom-built biosensing transmission spectroscopy setup to perform LSPR biosensing. Our findings showed that mycolic acid was successfully immobilized on the biosensing surface and made it possible to capture anti-*Mycobacterium tuberculosis *antibodies. The LSPR optical biosensing technique was indeed successful in the detection of anti-*Mycobacterium tuberculosis *antibodies."*

Link to Paper: https://www.sciencedirect.com/science/article/pii/S2214180422000745

Improved Electrochemical Performance and Chemical Stability of Thin-Film Lithium Phosphorous Oxynitride Electrolyte by Appropriate Fluorine Plasma Treatment (2022)

Xinyi He[1], Jian Wang[1], et al.

[1] Key Laboratory of MEMS of the Ministry of Education, Southeast University, Nanjing 210096, China

Abstract:

"Fluorine plasma treatment is proposed to incorporate fluorine into thin-film lithium phosphorus oxynitride (LiPON@F) electrolyte and its effects on the electrolyte performance and stability are also investigated. Due to strong reactivity of fluorine plasma, fluorine can be easily incorporated into LiPON with negligible effects on its morphologies and amorphousness by appropriate plasma treatment. The LiPON@F electrolyte film displays better performance than the LiPON one mainly in terms of its higher ionic conductivity (σi ~ 1.0×10-6 S cm-1 vs. 7.7×10-7 S cm-1), lower activation energy (EA ~ 0.39 eV vs. 0.46 eV) and larger electrochemically stable window (ESW ~ 4.2 V vs. 3.9 V). Moreover, the LiPON@F electrolyte film also presents superior chemical stability than the LiPON one (σi degradation after exposure to 50%RH humidity for 120 hours ~ 14.5% vs. 35.4%). Due to strong electronegativity and reactivity of the fluorine plasma, fluorine incorporation passivates defective bonds in the film and breaks the bridging bonds in the phosphate network. These facilitate the Li+ migration and enhance the capability against the moisture, thus improving both the electrochemical performance and chemical stability of the electrolyte films."

Link to Paper: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4314641

Microwave plasma-assisted reactive HiPIMS to InN films: Plasma environment and material Characterisation (2022)

C.Hain[1,2], et al.

[1] Bern University of Applied Sciences, Institute for Applied Laser, Photonics and Surface Technologies ALPS, Quellgasse 21, 2502 Biel/Bienne, Switzerland

[2] Empa, Swiss Federal Laboratories for Materials Science and Technology, Laboratory for Mechanics of Materials and Nanostructures, Feuerwerkerstrasse 39, 3602 Thun, Switzerland

Abstract

"This work focuses on the low temperature fabrication process of InN thin films via microwave plasma-assisted reactive high power impulse magnetron sputtering (MAR-HiPIMS). The influence of microwave plasma on the HiPIMS discharge process at various nitrogen flows and microwave powers was monitored and characterised through in situ diagnostics, including following HiPIMS I(V,t) curves, optical emission spectroscopy (OES), as well as performing time-resolved Langmuir probe and time-of-flight mass spectroscopy (ToF-MS) measurements. This was followed by the deposition of InN films via standard reactive HiPIMS (reference sample) and MAR-HiPIMS and their characterisation via X-ray diffraction (XRD), reflectometry (XRR), as well as scanning and transmission electron microscopy (SEM, TEM). It was found that the microwave plasma facilitates the dissociation/activation of nitrogen species and supplies seed electrons to the magnetron discharge plasma. Furthermore, the energy of the incoming ions was determined via ToF-MS, and it was possible to identify their plasma origin and temporal behaviour. The produced R-HiPIMS sample was highly metallic, with no nitride phase detected. The MAR-HiPMS film, however, was stoichiometric and exhibited (0002) direction texturing,

with an optical bandgap of approx. 1.5 eV, electron concentration of 2.72 × 10^{20} cm^{-3} and electron mobility of 7.16 cm^2V^{-1} s^{-1} (in the range for polycrystalline InN).”

Link to paper: https://www.sciencedirect.com/science/article/pii/S0257897222011094

Fabrication of Spindt-Type Nanometer-Sized Chromium Tips for Application as Field-Electron Emitters by Releasing the Stress of the Deposited Thin Film (2022)

J. Huang[1], Y. Huang[1] et al.

[1]State Key Laboratory of Optoelectronic Materials and Technologies, Guangdong Province Key Laboratory of Display Material and Technology, School of Electronics and Information Technology, Sun Yat-sen University, Guangzhou510275, China

Abstract:

“Metal cone-shaped nanotip field-electron emitters which are fabricated by directional thin-film deposition (so-called Spindt-type tips) have shown promising potential for application in modern vacuum micro-/nanoelectronics. Although the fabrication processes of Spindt-type tips have been well established, the in situ release of the initial stress in the deposited metal thin film is still an open issue. Herein, an in situ stress-release process was developed to fabricate chromium (Cr) tip arrays. Patterned photoresist microcavities with surrounding trenches were designed. The microcavities were used as templates for forming the metal tips. Trenches were employed for the in situ internal stress release of the Cr film on the top of the resist. The trenches not only separated the deposited Cr film into small-sized slices (square film on the photoresist) for decreasing the deformation but also provided sufficient space for possible deformation. High-aspect-ratio (~2) tips were achieved by plasma etching the Si substrate using the Cr tip as the mask, forming a Cr tip on a Si pillar. The Cr tips maintaining a good tip shape demonstrated that the Cr nanotips possessed good etch resistance to the SF6/O2 plasma. The gated Cr-tip array was fabricated following a self-aligned microfabrication procedure. The fabrication process was compatible with the semiconductor manufacturing technology. The gated devices showed an emission current of 33 μA at a gate voltage of 137 V. This work provides a well-developed in situ stress-releasing fabrication process to obtain Spindt-type Cr-tip field-electron emitters, which has potential for application in ionization vacuum gauges and neutralizers for propulsion.”

Link to Paper: https://pubs.acs.org/doi/abs/10.1021/acsanm.2c04457

Deposition and Characterisation of C-Axis Oriented Alscn Thin Films Via Microwave Plasma-Assisted Reactive Hipims (2022)

L. Lapeyre[1,2], C.Hain[1,2], et al.

[1] Bern University of Applied Sciences, Institute for Applied Laser, Photonics and Surface Technologies ALPS, Quellgasse 21, 2502 Biel/Bienne, Switzerland

[2] Empa, Swiss Federal Laboratories for Materials Science and Technology, Laboratory for Mechanics of Materials and Nanostructures, Feuerwerkerstrasse 39, 3602 Thun, Switzerland

Abstract

"In this work, highly oriented c-axis aluminium scandium nitride (AlScN) piezoelectric thin films were deposited via microwave plasma-assisted reactive high power impulse magnetron sputtering (MAR-HiPIMS), without substrate heating. A combination of in situ plasma diagnostics, i.e. time-of-flight mass spectrometry (ToF-MS), modified quartz crystal microbalance (m-QCM), and magnetic field measurements allowed to optimise the deposition conditions, in turn maximising the nitrogen supply and ionic flux at the substrate region, while maintaining stable discharge conditions. The variously Sc-doped AlN films were characterised using scanning electron microscopy (SEM), energy-dispersive X-ray spectroscopy (EDX), and X-ray diffraction (XRD). Obtaining highly oriented films was made possible with the addition of MW plasma to the optimized HiPIMS discharge, where the hexagonal AlScN films (with up to 20 at. % Sc) exhibited a fibre texture in the (0002) orientation, i.e. the desired phase and orientation for piezoelectric properties. Additionally, the use of a microwave plasma led to a significant decrease in oxygen content in the films and increase in nitrogen content, ensuring stoichiometric compositions. With the above in mind, the AlScN thin films fabricated via MAR-HiPIMS are expected to provide a high piezoelectric response."

Link to paper: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4300055

Assembly of Fillable Microrobotic Systems by Microfluidic Loading with Dip Sealing (2022)

R. Sun[1], X. Song[1], Y. Zuo[2], et al.

[1]Department of Materials, Imperial College London, London SW7 2AZ, UK

[2]Department of Bioengineering, Imperial College London, London SW7 2AZ, UK

Abstract

"Microrobots can provide spatiotemporally well-controlled cargo delivery that can improve therapeutic efficiency compared to conventional drug delivery strategies. Robust microfabrication methods to expand the variety of materials or cargoes that can be incorporated into microrobots could greatly broaden the scope of their functions. However, current surface coating or direct blending techniques used for cargo loading result in inefficient loading and poor cargo protection during transportation, which leads to cargo waste, degradation, and non-specific release. Herein, we present a versatile platform to fabricate fillable microrobots using Microfluidic Loading and Dip Sealing (MLDS). MLDS enables the encapsulation of different types of cargoes within hollow microrobots and protection of cargo integrity. The technique is supported by high-resolution 3D printing with an integrated microfluidic loading system, which realises a highly precise loading process and improves cargo loading capacity. A corresponding dip sealing strategy was developed to encase and protect the loaded cargo whilst maintaining the geometric and structural integrity of the loaded microrobots. This dip sealing technique is suitable for different materials, including thermal and light responsive materials. The MLDS platform provides new opportunities for microrobotic systems in targeted drug delivery, environmental sensing, and chemically powered micromotor applications."

Link to paper: https://onlinelibrary.wiley.com/doi/abs/10.1002/adma.202207791

A Comparative Research on Corrosion Behavior of Electroplated and Magnetron Sputtered Chromium Coatings (2022)

S. Martinuzzi [1], L. Donati [1], E. Galvanetto [2], et al.

[1] Department of Chemistry "Ugo Schiff", University of Florence, 50019 Sesto Fiorentino, Italy

[2] Department of Industrial Engineering (DIEF), University of Florence, 50139 Firenze, Italy

Abstract:

"Chromium deposits rank among the most widespread metal coatings for functional and decorative purposes. However, electrodeposition from Cr(VI) aqueous solution, which is the industrial process currently used to achieve thin chromium deposits, presents several environmental issues, urging the development of alternative solutions. In this study, which aims to compare the functional and aesthetical properties of decorative coatings, 800 nm thick chromium layers were deposited directly onto copper substrates by means of magnetron sputtering (MS) and direct current electrodeposition (ED). The obtained coatings were characterized regarding their thickness, morphology, color index, chemical composition, and corrosion resistance viewpoints. With respect to the electroplated samples, which constitute the benchmark, the magnetron sputtered ones appeared to be darker but showed a pleasing reflective appearance and superior thickness homogeneity, as well as the absence of voids and macrocracks, as evidenced by scanning electron microscopy (SEM) investigation. Regarding the anticorrosion performances of the chromium layers, electrochemical and standard salt spray test (NSS test) were carried out at room temperature in 3.5% NaCl solution, and evidenced similar, if not better, results for the magnetron sputtered coatings. On the whole, the data displayed here demonstrates the suitability of magnetron sputtering technology for use as an industrially feasible finishing technology for both aesthetic and mild-condition anticorrosion purposes."

Link to Paper:
https://www.researchgate.net/publication/358640998_A_Comparative_Research_on_Corrosion_Behavior_of_Electroplated_and_Magnetron_Sputtered_Chromium_Coatings

Interplay between Polaritonic and Molecular Trap States (2022)

J. Mony, Y. Yu, C. Scafer, et al.

Department of Chemistry and Molecular Biology, University of Gothenburg, Kemigården 4, Gothenburg 41296, Sweden

Abstract:

"Strong exciton–photon coupling exhibits the possibility to modify the photophysical properties of organic molecules. This is due to the introduction of hybrid light–matter states, called polaritons, which have unique physical and optical properties. Those strongly coupled systems provide altered excited-state dynamics in comparison to the bare molecule case. In this study, we investigate the interplay between polaritonic and molecular trap states, such as excimers. The molecules used in this study show either prompt or delayed emission from trap states. For both cases, a clear dependency on the exciton–photon energy tuning was observed. Polaritonic emission gradually increased with a concurrent removal of aggregation-induced emission when the systems were tuned toward lower energies. For prompt emission, it is not clear whether the experimental results are best explained by a predominant relaxation toward the lower polariton after

excitation or by a direct excimer to polariton transition. However, for the delayed emission case, trap states are formed on the initially formed triplet manifold, making it evident that an excimer-to-polariton transition has occurred. These results unveil the possibility to control the trap state population by creating a strongly coupled system, which may form a mitigation strategy to counteract detrimental trap states in photonic applications."

Link to Paper: https://pubs.acs.org/doi/10.1021/acs.jpcc.2c01239

Puffball-Inspired Microrobotic Systems with Robust Payload, Strong Protection, and Targeted Locomotion for On-Demand Drug Delivery (2022)

X. Song, R. Sun, R. Wang, K. Zhou, R. Xie, J. Lin, D. Georgiev, A.-A. Paraschiv, R. Zhao, M. M. Stevens

Department of Materials Department of Bioengineering Institute of Biomedical Engineering Imperial College London London SW7 2AZ, UK

Abstract:

"Microrobots are recognized as transformative solutions for drug delivery systems (DDSs) because they can navigate through the body to specific locations and enable targeted drug release. However, their realization is substantially limited by insufficient payload capacity, unavoidable drug leakage/deactivation, and strict modification/stability criteria for drugs. Natural puffballs possess fascinating features that are highly desirable for DDSs, including a large fruitbody for storing spores, a flexible protective cap, and environmentally triggered release mechanisms. This report presents a puffball-inspired microrobotic system which incorporates an internal chamber for loading large drug quantities and spatial drug separation, and a near-infrared-responsive top-sealing layer offering strong drug protection and on-demand release. These puffball-inspired microrobots (PIMs) display tunable loading capacities up to high concentrations and enhanced drug protection with minimal drug leakage. Upon near-infrared laser irradiation, on-demand drug delivery with rapid release efficiency is achieved. The PIMs also demonstrate translational motion velocities, switchable motion modes, and precise locomotion under a rotating magnetic field. This work provides strong proof-of-concept for a DDS that combines the superior locomotion capability of microrobots with the unique characteristics of puffballs, thereby illustrating a versatile avenue for development of a new generation of microrobots for targeted drug delivery."

Link to Paper: https://www.researchgate.net/publication/363323847_Puffball-Inspired_Microrobotic_Systems_with_Robust_Payload_Strong_Protection_and_Targeted_Locomotion_for_On-Demand_Drug_Delivery

Magnetron Sputtered $CsPbCl_3$ Perovskite Detectors as Real-Time Dosimeters for Clinical Radiotherapy (2022)

M. Bruzzi [1], N. Calisi [2], A. Vinattieri [1], et al.

[1] Dipartimento di Fisica e Astronomia, Università degli Studi di Firenze, Via G. Sansone 1, 50019, Sesto Fiorentino, FI, Italy

[2]Dipartimento di Ingegneria Industriale, Università degli Studi di Firenze, Via S. Marta 3, 50139, Firenze, Italy

Abstract:

"The aim of this study is to investigate the feasibility of manufacturing thin real-time relative dosimeters for clinical radiotherapy (RT) with potential applications for transmission monitoring in vivo *dosimetry and pre-treatment dose verifications. Thin (≈1 µm) layers of a high sensitivity, wide bandgap semiconductor, the inorganic perovskite $CsPbCl_3$, have been grown for the first time by magnetron sputtering on plastic substrates equipped with electrode arrays. Prototype devices have been tested in real-time configuration to evaluate the dose delivered by a 6MV photon beam from a linear accelerator. Linearity of the charge with the dose has been verified over three order of magnitudes, linearity of the current signal with the dose rate has been also successfully tested in the range 0.5-4.3 Gy/min. The combination of high sensitivity per unit volume and wide bandgap provides high signal-to-noise ratios, up to 70, even at moderate applied voltages. The Schottky diode configuration allows the detector to operate without bias voltage (null bias).The blocking-barrier structure allows to confine the active volume within sub-millimetric sizes, a quite attractive feature in view to increase granularity and achieve the high spatial resolutions required in modern RT techniques. All the above-mentioned features indeed pave the way to a novel generation of flexible, transmission, real time dosimeters for clinical radiotherapy."*

Link to Paper: https://www.sciencedirect.com/science/article/pii/S0939388922000265

Influence of HiPIMS pulse widths on the deposition behaviour and properties of CuAgZr compositionally graded films (2022)

L. Lapeyre [1], K. Wieczerzak [2], C. Hain [1,2], et al.

[1] Bern University of Applied Sciences, Institute for Applied Laser, Photonics and Surface Technologies ALPS, Quellgasse 21, 2502 Biel/Bienne, Switzerland

[2]Empa, Swiss Federal Laboratories for Materials Science and Technology, Laboratory for Mechanics of Materials and Nanostructures, Feuerwerkerstrasse 39, 3602 Thun, Switzerland

Abstract:

"In this work, the influence of different pulse widths (25, 50 and 100 µs) during high power impulse magnetron sputtering (HiPIMS) of copper, silver and zirconium was investigated in terms of plasma properties and properties of combinatorial composition gradient CuAgZr film libraries. In situ plasma diagnostics via optical emission spectroscopy (OES), time-of-flight mass spectrometry (TOFMS), and modified quartz crystal microbalance (m-QCM), followed by film ex situ X-ray diffraction (XRD) and scanning electron microscopy (SEM) investigations allowed to determine the effect of deposition parameters on the thin films' microstructural changes. Changing the pulse width, while keeping the duty cycle constant, modified the discharge composition in the target region and the ionised fraction of the sputtered species in the substrate region. The maximum Cu ionised fraction (19 %) was found for 50 µs, resulting in compact and smooth morphology for Cu-rich films, whereas short 25 µs pulses provided porous columnar films with rough surfaces, as the result from Ar+ bombardment. For Ag-rich films, Ag segregation allowed the deposition of dense layers, regardless of the used pulse width.

Furthermore, low Ag (<10 at.%) CuAgZr films produced via HiPIMS and direct-current magnetron sputtering (DCMS) were compared in terms of structural and mechanical property changes as a function of Zr contents. For the studied chemical composition range, a linear relationship between Zr content, XRD phase shift and mechanical properties was observed for HiPIMS films, in contrast to DCMS's more abrupt transitions. An increase in hardness and elastic modulus (up to 44 % and 22 %, respectively) was found for the HiPIMS films compared to DCMS ones. The obtained results highlight HiPIMS's flexibility in providing a wide range of

tailoring possibilities to meet specific application requirements, such as crystalline microstructure, density and associated mechanical properties."

Link to Paper: https://www.sciencedirect.com/science/article/pii/S0257897222009239

Micro-object pose estimation with sim-to-real transfer learning using small dataset (2022)

D. Zhang [1], A. barbot [2], F. Seichepine [2], et al.

[1] University of Bristol, UK

[2] Imperial College London, UK

Abstract:

"Three-dimensional (3D) pose estimation of micro/nano-objects is essential for the implementation of automatic manipulation in micro/nano-robotic systems. However, out-of-plane pose estimation of a micro/nano-object is challenging, since the images are typically obtained in 2D using a scanning electron microscope (SEM) or an optical microscope (OM). Traditional deep learning based methods require the collection of a large amount of labeled data for model training to estimate the 3D pose of an object from a monocular image. Here we present a sim-to-real learning-to-match approach for 3D pose estimation of micro/nano-objects. Instead of collecting large training datasets, simulated data is generated to enlarge the limited experimental data obtained in practice, while the domain gap between the generated and experimental data is minimized via image translation based on a generative adversarial network (GAN) model. A learning-to-match approach is used to map the generated data and the experimental data to a low-dimensional space with the same data distribution for different pose labels, which ensures effective feature embedding. Combining the labeled data obtained from experiments and simulations, a new training dataset is constructed for robust pose estimation. The proposed method is validated with images from both SEM and OM, facilitating the development of closed-loop control of micro/nano-objects with complex shapes in micro/nano-robotic systems."

Link to Paper: https://www.nature.com/articles/s42005-022-00844-z

Role of graphene doped Al2O3 flexible sheets as the substrate for Anomalous Nernst Effect study (2022)

A.Ferreira et al.

Centro de Física, Universidade do Minho, 4710-057 Braga, Portugal

Abstract:

"GnP doped Al2O3 flexible tapes were produced through Tape Casting technique and used as substrates to produce Co2FeAl/GnP doped Al2O3 heterostructures. The Co2FeAl layers were grown using Magnetron Sputtering with a thickness of 30 nm. The integration of Tape Casting and Magnetron sputtering techniques allowed us to explore the thermomagnetic properties of the heterostructure through the Anomalous Nernst Effect. The structural and morphological properties of the substrates and the magnetization curves support the

thermomagnetic results. The Co2FeAl ferromagnetic films presented isotropic magnetic behavior, which was reflected in the thermomagnetic curves through the stability of the curve's shape irrespectively of the thermal gradient and angle of the external magnetic field used during the measurements. Our findings open new possibilities to produce flexible heterostructures with multifunctional properties, where the versatilities of the Tape casting and magnetron sputtering techniques bring new routes to build nanostructured materials."

Link to Paper: https://www.sciencedirect.com/science/article/pii/S0272884222041360#

Electrical and Optical Characterization of $CsPbCl_3$ Films around the High-Temperature Phase Transitions (2022)

M. Bruzzi et al.
Department of Physics and Astronomy, University of Florence, Via G. Sansone 1, 50019 Sesto Fiorentino, Italy

Abstract:

"Large-area $CsPbCl_3$ films in the range 0.1–1.5 µm have been grown by radio frequency (RF)-magnetron sputtering on glass substrates by means of a one-step procedure. Three structural phase transitions have been detected, which are associated with hysteresis behavior in the electrical current when measured as a function of temperature in the range 295–330 K. Similarly, photoluminescence (PL) experiments in the same temperature range bring evidence of a non-monotonic shift of the PL peak. Detailed electrical characterizations evidenced how phase transitions are not influencing detrimentally the electrical transport properties of the films. In particular, the activation energy (0.6–0.8 eV) extracted from the temperature-dependent film resistivity does not appear to be correlated with phase changes. A non-linear trend of the photoconductivity response as a function of a ultra violet (UV) 365 nm light emitting diode (LED) power has been interpreted considering the presence of an exponential tail of intragap defects. Thermally stimulated currents after exposure with the same LED measured from room temperature up to 370 K showed no evidence of trapping effects due to intragap states on the electrical transport properties at room temperature of the films. As a consequence, measured photocurrents at room temperature appear to be well reproducible and stable in time, which are attractive features for possible future applications in photodetection."

Link to Paper: https://www.mdpi.com/2079-4991/12/3/570

Organic charged polaritons in the ultrastrong coupling regime (2022)

M. Wang et al.

[1]Department of Chemistry and Molecular Biology, University of Gothenburg, 412 96 Gothenburg, Sweden

Abstract:

"We embedded an all-hydrocarbon-based carbocation in a metallic microcavity that was tuned to resonance with an electronic transition of the carbocation. The measured Rabi splitting was 41% of the excitation energy, putting the system well into the ultrastrong coupling regime. Importantly, due to the intrinsic charge on the carbocation, the polaritons that form carry a significant charge fraction (0.55 e0) and a large charge-to-mass ratio (~2400 e0/m0). Moreover, the ground state of the ultrastrongly coupled system is calculated to carry about 1% of one elementary charge. These unique properties of our system, together with its convenient preparation, provide a practical platform to study charged polaritons in the ultrastrong coupling regime."

Link to paper: https://journals.aps.org/prresearch/abstract/10.1103/PhysRevResearch.4.023016

FIB and Wedge Polishing Sample Preparation for TEM Analysis of Sol-Gel Derived Perovskite Thin Films (2022)

J. Sanz-Mateo et al.

Materials Center Leoben Forschung GmbH, 8700 Leoben, Austria
Department of Materials Science, Montanuniversität Leoben, 8700 Leoben, Austria

Abstract:

"In ceramic thin films, choosing an appropriate sample preparation method for transmission electron microscopy (TEM) analyses is of paramount importance to avoid preparation-induced damage and retain nanoscale features that require investigation. Here we compare two methods of TEM thin film sample preparation, namely conventional wedge polishing and focused ion beam (FIB) based lift out preparation applied to ferroelectric barium titanate ($BaTiO_3$, BT) thin films made by chemical solution deposition (CSD). The aim of the work is to determine the pros and cons of each method considering not only the quality of the TEM specimen, but also aspects such as availability, ease of use, and affordability. Besides some limitations on the selection of visualized area due to thickness constraints on the FIB-made sample, both methods offer the capability to prepare samples with very comparable quality, as indicated by achieving the same thickness, a largely agreeing microstructure, no secondary phases on the diffraction pattern, and good atomic resolution. This last observation is especially important in the current context of material science, where more nanoscale phenomena are becoming the subject of study. The wedge polishing method, however, is deemed more affordable in terms of instrumentation, as it only requires a tripod polisher, a polishing wheel, and a precision ion polishing system, whereas the lift out method requires a scanning electron microscope (SEM) equipped with an FIB system. We believe that this work serves groups working on ferroelectric thin films in preparing TEM samples in a more effective and uncomplicated manner, facilitating progress in understanding this fascinating class of materials."

Link to Paper: https://www.mdpi.com/2571-6131/5/3/23

Surface and Bulk Relaxation of Vapour-Deposited Polystyrene Glasses (2022)

J. Yin[1], J. Forrest[1], T. Salez[2] et al.

[1]Department of Physics & Astronomy, University of Waterloo, 200 University Ave. W, Waterloo, ON, N2L 3G1, Canada

[2]Univ. Bordeaux, CNRS, LOMA, UMR 5798, F-33400, Talence, France

Abstract:

"We have studied the liquid-like response of the surface of vapour-deposited glassy films of polystyrene to the introduction of gold nanoparticles on the surface. The build-up of polymer material was measured as a function of time and temperature for both as-deposited films, as well as films that have been rejuvenated to become normal glasses cooled from the equilibrium liquid. The temporal evolution of the surface profile is well described by the characteristic power law of capillary-driven surface flows. In all cases, the surface evolution of the as-deposited films and the rejuvenated films are enhanced compared to bulk and are not easily distinguishable from each other. The temperature dependence of the measured relaxation times determined

from the surface evolution is found to be quantitatively comparable to similar studies for high molecular weight spincast polystyrene. Comparisons to numerical solutions of the glassy thin film equation provide quantitative estimates of the surface mobility. For temperatures sufficiently close to the glass-transition temperature, particle embedding is also measured and used as a probe of bulk dynamics, and in particular bulk viscosity."

Link to Paper: https://arxiv.org/abs/2211.04873

High Performance of Metallic Thin Films for Resistance Temperature Devices with Antimicrobial Properties (2022)

A.Souza, M. Correa, A. Ferreira et al.

Centro de Física das Universidades do Minho e do Porto (CF-UM-UP), Universidade do Minho, 4710-057 Braga, Portugal

Abstract:

"Titanium-copper alloy films with stoichiometry given by Ti1−xCux were produced by magnetron co-sputtering technique and analyzed in order to explore the suitability of the films to be applied as resistive temperature sensors with antimicrobial properties. For that, the copper (Cu) amount in the films was varied by applying different DC currents to the source during the deposition in order to change the Cu concentration. As a result, the samples showed excellent thermoresistivity linearity and stability for temperatures in the range between room temperature to 110 °C. The sample concentration of Ti0.70Cu0.30 has better characteristics to act as RTD, especially the αTCR of 1990 ×10−6∘C−1. The antimicrobial properties of the Ti1−xCux films were analyzed by exposing the films to the bacterias S. aureus and E. coli, and comparing them with bare Ti and Cu films that underwent the same protocol. The Ti1−xCux thin films showed bactericidal effects, by log10 reduction for both bacteria, irrespective of the Cu concentrations. As a test of concept, the selected sample was subjected to 160 h reacting to variations in ambient temperature, presenting results similar to a commercial temperature sensor. Therefore, these Ti1−xCux thin films become excellent antimicrobial candidates to act as temperature sensors in advanced coating systems."

Link to paper: https://www.mdpi.com/1424-8220/22/19/7665/htm

Near-Infrared Electroluminescent Light-Emitting Transistors Based on CVD-Synthesized Ambipolar ReSe2 Nanosheets (2022)

Christy Roshini Paul Inbaraj[1], Kai-Hsiang Cheng[1], Yit-Tsong Chen[1]

[1]*National Taiwan University, Taipei*

Abstract

"Near-infrared light-emitting technology is ideal for noncontact diagnostic medical imaging and high-speed data communications. High-quality $ReSe_2$ nanosheets of anisotropic single-crystal structure with a bandgap of 1.26 eV (≈984 nm) are synthesized with an atmospheric pressure chemical vapor deposition (APCVD) method. The as-synthesized $ReSe_2$ nanosheets-fabricated light-emitting transistors (LETs) exhibit nearly symmetric ambipolar characteristics in electrical transport. Judicious selection of asymmetric platinum (Pt)/chromium (Cr) electrodes, with their work functions matching respectively the conduction- and valence-band edges of

ambipolar $ReSe_2$, generates a low turn-on voltage $ReSe_2$-LET with the balanced number density and field-effect mobility of bipolar carriers (i.e., electrons and holes). Room-temperature near-infrared electroluminescence (NIR EL) from the frequency-modulated $ReSe_2$-LET has been observed unprecedentedly with the assistance of a lock-in detection system. The NIR EL intensity is tested by varying the bias voltage applied to the $ReSe_2$-LET devices with different channel lengths. The wavelength of the NIR EL from $ReSe_2$-LET is differentiated with optical bandpass filters. Room-temperature angle-dependent two lobe-shaped EL pattern manifests the inherent anisotropic in-plane excitonic polarization of the $ReSe_2$ crystal. The highly stable NIR EL from $ReSe_2$-LETs provides prospective 2D material-based ultrathin scalable data communication electronics for future development."

Link to Paper: https://onlinelibrary.wiley.com/doi/epdf/10.1002/adom.202102580

Wafer-Scale PLD-Grown High-K GCZO Dielectrics for 2D Electronics (2022)

J. Yu[1], G. Gaoet[1] al.

[1]Department of Physics, The University of Hong Kong, Hong Kong, 999077 P. R. China

Abstract:

Oxide dielectrics, such as HfO2, Al2O3, etc, are widely used to improve the performance of 2D semiconductors in electronic devices. However, future low-power electronic devices need a higher dielectric constant (κ) to reduce the leakage current, and these super-high-κ materials are challenging to produce on wafer-scale. Here, the preparation of wafer-scale (Ga, Cu) co-doping ZnO films is reported with super-high dielectric constant (κ > 50) and good homogeneity by a pulsed laser deposition method. By regulating the (Ga, Cu) co-doping concentration, the dielectric constants can range from 9 to 207. In addition, the performance of SnS2 field-effect transistor reveals that the high-κ Al2O3/GCZO gate dielectric stack is suitable for 2D electronic devices. This GCZO dielectric films not only show higher κ than other conventional dielectrics in terms of compatibility to CMOS processes, but also keep their comparative advantages in the fabrication of high-performance electronic devices over conventional dielectrics.

Link to Paper: https://onlinelibrary.wiley.com/doi/abs/10.1002/aelm.202200580

2021

Stretchable Thin Film Mechanical-Strain-Gated Switches and Logic Gate Functions Based on a Soft Tunneling Barrier (2021)

Soosang Chae,[1] Won Jin Choi, Ivan Fotev, Eva Bittrich[1], Petra Uhlmann[1, 2], Mathias Schubert[1,2], Denys Makarov, Jens Wagner, Alexej Pashkin, and Andreas Fery[1]

[1] Institut für Polymerforschung Dresden e.V Hohe Straße 6, 01069 Dresden, Germany

[2] University of Nebraska-Lincoln Lincoln, Nebraska 68588, USA

Abstract:

"Mechanical-strain-gated switches are cornerstone components of materialembedded circuits that perform logic operations without using conventional electronics. This technology requires a single material system to

exhibit three distinct functionalities: strain-invariant conductivity and an increase or decrease of conductivity upon mechanical deformation. Herein, mechanicalstrain-gated electric switches based on a thin-film architecture that features an insulator-to-conductor transition when mechanically stretched are demonstrated. The conductivity changes by nine orders of magnitude over a wide range of tunable working strains (as high as 130%). The approach relies on a nanometer-scale sandwiched bilayer Au thin film with an ultrathin poly(dimethylsiloxane) elastomeric barrier layer; applied strain alters the electron tunneling currents through the barrier. Mechanical-force-controlled electric logic circuits are achieved by realizing strain-controlled basic (AND and OR) and universal (NAND and NOR) logic gates in a single system. The proposed material system can be used to fabricate material-embedded logics of arbitrary complexity for a wide range of applications including soft robotics, wearable/implantable electronics, human–machine interfaces, and Internet of Things."

Link to Paper: https://onlinelibrary.wiley.com/doi/10.1002/adma.202170320

Rapid uropathogen identifcation using surface enhanced Raman spectroscopy active filters (2021)

Simon D. Dryden [1], Salzitsa Anastasova [2], Alex J. Thompson [1,2], et al.

[1] Department of Surgery and Cancer, Imperial College London, St Mary's Hospital, 10Th Floor, QEQM Wing, London W2 1NY, UK.

[2] Hamlyn Centre for Robotic Surgery, Imperial College London, London SW1 2AZ, UK

Abstract:

"Urinary tract infection is one of the most common bacterial infections leading to increased morbidity, mortality and societal costs. Current diagnostics exacerbate this problem due to an inability to provide timely pathogen identifcation. Surface enhanced Raman spectroscopy (SERS) has the potential to overcome these issues by providing immediate bacterial classifcation. To date, achieving accurate classifcation has required technically complicated processes to capture pathogens, which has precluded the integration of SERS into rapid diagnostics. This work demonstrates that gold-coated membrane flters capture and aggregate bacteria, separating them from urine, while also providing Raman signal enhancement. An optimal gold coating thickness of 50 nm was demonstrated, and the diagnostic performance of the SERS-active flters was assessed using phantom urine infection samples at clinically relevant concentrations (105 CFU/ml). Infected and uninfected (control) samples were identifed with an accuracy of 91.1%. Amongst infected samples only, classifcation of three bacteria (Escherichia coli, Enterococcus faecalis, Klebsiella pneumoniae) was achieved at a rate of 91.6%."

Link to Paper: https://www.nature.com/articles/s41598-021-88026-9

Plasmonic optical fiber for bacteria manipulation—characterization and visualization of accumulation behavior under plasmo-thermal trapping (2021)

J. Kim, E. Yeatman and A. Thompson

Hamlyn Centre for Robotic Surgery, Imperial College London, London SW1 2AZ, UK

Abstract:

"In this article, we demonstrate a plasmo-thermal bacterial accumulation effect using a miniature plasmonic optical fiber. The combined action of far-field convection and a near-field trapping force (referred to as thermophoresis)—induced by highly localized plasmonic heating—enabled the large-area accumulation of Escherichia coli. The estimated thermophoretic trapping force agreed with previous reports, and we applied speckle imaging analysis to map the in-plane bacterial velocities over large areas. This is the first time that spatial mapping of bacterial velocities has been achieved in this setting. Thus, this analysis technique provides opportunities to better understand this phenomenon and to drive it towards in vivo applications."

Link to Paper: https://opg.optica.org/boe/fulltext.cfm?uri=boe-12-7-3917&id=451732

A new route for caesium lead halide perovskite deposition (2021)

N. Falsini[1], N. Calisi[2], and A. Vinattieri[1]

[1]Department of Physics and Astronomy, University of Florence, via G. Sansone 1, Sesto Fiorentino, I-50019, Italy

[2]Industrial Engineering Department, University of Florence, via S. Marta 3, Florence, I-50139, Italy

Abstract:

"Inorganic metal halide perovskites are relevant semiconductors for optoelectronic devices. The successful deposition of thin films of CsPbBr3 and CsPbCl3 has recently been obtained by Radio-Frequency magnetron sputtering. In this work we compare the morphological, structural and optical characteristics of the two materials obtained with this deposition technique. A detailed photoluminescence (PL) spectroscopy study of the as-grown samples was conducted at the macro and micro scale in a wide temperature range (10-300 K) to fully characterize the PL on sample areas of square centimeters, to assess the origin of the inhomogeneous broadening and to quantify the PL quantum yield quenching. Our results prove that this technique allows for the realization of high quality nanometric films with controlled thickness of relevance for optoelectronic applications."

Link to Paper: https://link.springer.com/article/10.1186/s41476-021-00153-y

Nanoimprint Lithography Facilitated Plasmonic-Photonic Coupling for Enhanced Photoconductivity and Photocatalysis (2021)

V. Guptra, S. Sarkar, O. Aftenieva, et al.

Leibniz-Institut für Polymerforschung Dresden e.V. (IPF) Institute for Physical, Chemistry and Polymer Physics, Hohe Str. 6, 01069 Dresden, Germany

Abstract:

"Imprint lithography has emerged as a reliable, reproducible, and rapid method for patterning colloidal nanostructures. As a promising alternative to top-down lithographic approaches, the fabrication of nanodevices has thus become effective and straightforward. In this study, a fusion of interference lithography

(IL) and nanosphere imprint lithography on various target substrates ranging from carbon film on transmission electron microscope grid to inorganic and dopable polymer semiconductor is reported. 1D plasmonic photonic crystals are printed with 75% yield on the centimeter scale using colloidal ink and an IL-produced polydimethylsiloxane stamp. Atomically smooth facet, single-crystalline, and monodisperse colloidal building blocks of gold (Au) nanoparticles are used to print 1D plasmonic grating on top of a titanium dioxide (TiO_2) slab waveguide, producing waveguide-plasmon polariton modes with superior 10 nm spectral line-width. Plasmon-induced hot electrons are confirmed via two-terminal current measurements with increased photoresponsivity under guiding conditions. The fabricated hybrid structure with Au/TiO_2 heterojunction enhances photocatalytic processes like degradation of methyl orange (MO) dye molecules using the generated hot electrons. This simple colloidal printing technique demonstrated on silicon, glass, Au film, and naphthalenediimide polymer thus marks an important milestone for large-scale implementation in optoelectronic devices."

Link to Paper: https://onlinelibrary.wiley.com/doi/full/10.1002/adfm.202105054

Photoisomerization Efficiency of a Solar Thermal Fuel in the Strong Coupling Regime (2021)

J. Mony, A. Petersen, et al.

Department of Chemistry and Molecular Biology, University of Gothenburg, Gothenburg, 412 96 Sweden

Department of Chemistry and Chemical Engineering, Chalmers University of Technology, Gothenburg, 412 96 Sweden

Abstract:

"Strong exciton-photon coupling is achieved when the interaction between molecules and an electromagnetic field is increased to a level where they cannot be treated as separate systems. This leads to the formation of polaritonic states and an effective rearrangement of the potential energy surfaces, which opens the possibility to modify photochemical reactions. This work investigates how the strong coupling regime is affecting the photoisomerization efficiency and thermal backconversion of a norbornadiene–quadricyclane molecular photoswitch. The quantum yield of photoisomerization shows both an excitation wavelength and exciton/photon constitution dependence. The polariton-induced decay and energy transfer processes are discussed to be the reason for this finding. Furthermore, the thermal back conversion of the system is unperturbed and the lower polariton effectively shifts the absorption onset to lower energies. The reason for the unperturbed thermal backconversion is that it occurs on the ground state, which is unaffected. This work demonstrates how strong coupling can change material properties towards higher efficiencies in applications. Importantly, the experiments illustrate that strong coupling can be used to optimize the absorption onset of the molecular photoswitch norbonadiene without affecting the back reaction from the uncoupled quadricyclane."

Link to Paper: https://onlinelibrary.wiley.com/doi/full/10.1002/adfm.202010737

Barrier-free reverse-intersystem crossing in organic molecules by strong light-matter coupling (2021)

Yi Yu, Suman Mallick et al.

Department of Chemistry and Molecular Biology, University of Gothenburg, Gothenburg, Sweden

Abstract:

"Strong light-matter coupling provides the means to challenge the traditional rules of chemistry. In particular, an energy inversion of singlet and triplet excited states would be fundamentally remarkable since it would violate the classical Hund's rule. An organic chromophore possessing a lower singlet excited state can effectively harvest the dark triplet states, thus enabling 100% internal quantum efficiency in electrically pumped light-emitting diodes and lasers. Here we demonstrate unambiguously an inversion of singlet and triplet excited states of a prototype molecule by strong coupling to an optical cavity. The inversion not only implies that the polaritonic state lies at a lower energy, but also a direct energy pathway between the triplet and polaritonic states is opened. The intrinsic photophysics of reversed-intersystem crossing are thereby completely overturned from an endothermic process to an exothermic one. By doing so, we show that it is possible to break the limit of Hund's rule and manipulate the energy flow in molecular systems by strong light-matter coupling. Our results will directly promote the development of organic light-emitting diodes based on reversed-intersystem crossing. Moreover, we anticipate that it provides the pathway to the creation of electrically pumped polaritonic lasers in organic systems."

Link to Paper: https://www.nature.com/articles/s41467-021-23481-6

Polariton-assisted excitation energy channeling in organic heterojunctions (2021)

M. Wang, M. Hertzog and K. Borjesson

Department of Chemistry and Molecular Biology, University of Gothenburg, Gothenburg, Sweden

Abstract:

"Exciton-polaritons are hybrid light-matter states resulting from strong exciton-photon coupling. The wave function of the polariton is a mixture of light and matter, enabling long-range energy transfer between spatially separated chromophores. Moreover, their delocalized nature, inherited from the photon component, has been predicted to enhance exciton transport. Here, we strongly couple an organic heterojunction consisting of energy/electron donor and acceptor materials to the same cavity mode. Using time-resolved spectroscopy and optoelectrical characterization, we show that the rate of exciton harvesting is enhanced with one order of magnitude and the rate of energy transfer in the system is increased two- to threefold in the strong coupling regime. Our results exemplify two means of efficiently channeling excitation energy to a heterojunction interface, where charge separation can occur. This study opens a new door to increase the overall efficiency of light harvesting systems using the tool of strong light-matter interactions."

Link to Paper: https://www.nature.com/articles/s41467-021-22183-3

Exploring Plasmonic Resonances Toward "Large-Scale" Flexible Optical Sensors with Deformation Stability (2021)

A.Ghosh et al.

Leibniz-Institut für Polymerforschung Dresden e.V. (IPF), Hohe Str. 6, 01069 Dresden, Germany

Abstract:

"The next generation of sensors requires a simple yet compact lab on chip-based precise optical detection mechanism where data interpretation can be achieved with minimum effort. Hereby, cost-efficient strategies of manufacturing both propagating surface plasmon polariton (SPP) and localized surface plasmon resonance (LSPR) sensors on flexible platforms are explored via mechanical instabilities and oblique-angled metal evaporation. Centimeter scaled dielectric grating structures produced by plasma oxidation of pre-stressed polydimethylsiloxane film have comprised the substrates, thus imparting inherent flexibility. Subsequently, both continuous and discontinuous 1D-metallic lattices are obtained via vapor deposition of gold at different angles. The optical isotropy (gold surface-grating) and anisotropy (gold edge-grating) are distinctly observed as a difference between forward and backward diffraction efficiencies, backed by analytical correlation to the observed orders. Supported with electromagnetic modeling, the SPP and LSPR excitations are experimentally characterized under reflectance and transmittance measurements, along with a demonstration of their sensing capabilities. The LSPR supported flexible sensor provides superiority in terms of sensitivity, which is investigated under mechanical deformations to exhibit consistency of the resonant wavelength. Such consistency is strategically unraveled via "finite element method" based approaches, thus providing a new paradigm of cost-efficient, large-scaled flexible sensors."

Link to Paper: https://onlinelibrary.wiley.com/doi/full/10.1002/adfm.202101959

Large-Area Nanocrystalline Caesium Lead Chloride Thin Films: A Focus on the Exciton Recombination Dynamics (2021)

N. Falsini[1], N. Calisi[2], C. Barri[3] et al.

[1]Department of Physics and Astronomy, University of Florence, Via G. Sansone 1, I-50019 Sesto Fiorentino, Italy

[2]Department of Industrial Engineering (DIEF), University of Florence, Via S. Marta 3, I-50139 Florence

[3]Department of Physics, Polytechnic University of Milan, P.zza Leonardo 32, I-20133 Milano, Italy

Abstract:

"Caesium lead halide perovskites were recently demonstrated to be a relevant class of semiconductors for photonics and optoelectronics. Unlike $CsPbBr_3$ and $CsPbI_3$, the realization of high-quality thin films of $CsPbCl_3$, particularly interesting for highly efficient white LEDs when coupled to converting phosphors, is still a very demanding task. In this work we report the first successful deposition of nanocrystalline $CsPbCl_3$ thin films (70–150 nm) by radio frequency magnetron sputtering on large-area substrates. We present a detailed investigation of the optical properties by high resolution photoluminescence (PL) spectroscopy, resolved in time and space in the range 10–300 K, providing quantitative information concerning carriers and excitons recombination dynamics. The PL is characterized by a limited inhomogeneous broadening (~15 meV at 10 K) and its origin is discussed from detailed analysis with investigations at the micro-scale. The samples, obtained without any post-growth treatment, show a homogeneous PL emission in spectrum and intensity on large sample areas (several cm^2). Temperature dependent and time-resolved PL spectra elucidate the role of carrier trapping in determining the PL quenching up to room temperature. Our results open the route for the realization of large-area inorganic halide perovskite films for photonic and optoelectronic devices."

Link to Paper: https://www.mdpi.com/2079-4991/11/2/434

Pyroelectric and photovoltaic properties of Nb-doped PZT thin films (2021)

A.Berenov[1], P. Petrov[1], B. Moffat[2], J. Phair[2], L. Allers[3] and R.W. Whatmore[1]

[1]Department of Materials, Imperial College London, London SW7 2AZ, United Kingdom

[2]Pyreos Ltd., Heriot Watt Research Park, Edinburgh EH14 4AP, United Kingdom

[3]Korvus Technology Ltd., Tavistock PL19 8AB, United Kingdom

Abstract:

"Nb-doped lead zirconate titanate (PZT) films with up to 12 at. % of Nb were co-sputtered from oxide PZT and metallic Nb targets at a substrate temperature of 600 °C. Up to 4 at. % of Nb was doped into the perovskite structure with the formation of B-site cation vacancies for charge compensation. The preferential (111) PZT orientation decreased with Nb-doping within the solid solution region. The ferroelectric response of the films was affected by the large values of the internal field present in the samples (e.g., −84.3 kV cm^{-1} in 12 at. % Nd doped films). As-deposited unpoled films showed large values of the pyroelectric coefficient due to self-poling. The pyroelectric coefficient increased with Nb-doping and showed a complex dependence on the applied bias. The photovoltaic effect was observed in the films. The value of the photocurrent increased with the A/B ratio. The combined photovoltaic–pyroelectric effect increased the values of the measured current by up to 47% upon light illumination"

Link to Paper: https://aip.scitation.org/doi/abs/10.1063/5.0039593

A Bi-Anti-Ambipolar Field Effect Transistor (2021)

Christy Roshini Paul Inbaraj[1], Raman Sankar[1], Monika Katarina[1], Yang-Fang Chen[1], Yit-Tsong Chen[1]

[1]National Taiwan University, Taipei

Abstract

"Multistate logic is recognized as a promising approach to increase the device density of microelectronics, but current approaches are offset by limited performance and large circuit complexity. We here demonstrate a route toward increased integration density that is enabled by a mechanically tunable device concept. Bi-anti-ambipolar transistors (bi-AATs) exhibit two distinct peaks in their transconductance and can be realized by a single 2D-material heterojunction-based solid-state device. Dynamic deformation of the device reveals the co-occurrence of two conduction pathways to be the origin of this previously unobserved behavior. Initially, carrier conduction proceeds through the junction edge, but illumination and application of strain can increase the recombination rate in the junction sufficiently to support an alternative carrier conduction path through the junction area. Optical characterization reveals a tunable emission pattern and increased optoelectronic responsivity that corroborates our model. Strain control permits the optimization of the conduction efficiency through both pathways and can be employed in quaternary inverters for future multilogic applications."

Link to Paper: https://pubs.acs.org/doi/10.1021/acsnano.1c00762#

From pulsed-DCMS and HiPIMS to microwave plasma-assisted sputtering: Their influence on the properties of diamond-like carbon films (2021)

Caroline Hain[1,2], Krzysztof Wieczerzak[2], Johann Michler[2], et al.

[1]Bern University of Applied Sciences, Institute for Applied Laser, Photonics and Surface Technologies ALPS, Quellgasse 21, 2502 Biel/Bienne, Switzerland

[2]Empa, Swiss Federal Laboratories for Materials Science and Technology, Laboratory for Mechanics of Materials and Nanostructures, Feuerwerkerstrasse 39, 3602 Thun, Switzerland

Abstract

The fabrication of high-hardness non-hydrogenated diamond-like carbon (DLC) via standard magnetron sputtering (MS) is often hindered by the low sputtering yields and ionisation rates of carbon, therefore investigations into pulsed alternatives of MS, else sputtered species post-ionisation methods, are of particular interest. This work focuses on investigating the influence of pulsed-direct current MS (pDCMS), high power impulse magnetron sputtering (HiPIMS) and their microwave plasma-assisted (MA-pDCMS, MA-HiPIMS) variants on the properties of the fabricated DLC films. Two setups were used for the pDCMS- and HiPIMS-based methods, respectively. The films were characterised using Raman spectroscopy, nanoindentation, X-ray reflectometry and scanning electron microscopy, where the pDCMS-produced films were additionally characterised by film-stress measurements. Moreover, in situ *time-resolved Langmuir probe plasma analysis was performed under HiPIMS and MA-HiPIMS conditions to analyse the influence of the magnetron and microwave plasmas on one another. For both DCMS- and HiPIMS-based procedures, it was found that the addition of microwave plasma did not facilitate attaining hardnesses beyond 30 GPa, however, it did enable modifying the morphology of the films. Furthermore, this study shows the potential of synchronised sputtering with substrate biasing, as well as the importance of microwave plasma source positioning in relation to the substrate.*

Link to Paper: https://www.sciencedirect.com/science/article/pii/S0257897221011026

2020

Negative Piezoresistive Effect in a Stretchable Device Based on a Soft Tunneling Barrier (2020)

Soosang Chae,[1] Ivan Fotev, Eva Bittrich[1], Won Jin Choi, Petra Uhlmann[1], Mathias Schubert[1, 2], Alexej Pashkin, and Andreas Fery[1]

[1]-Institut für Polymerforschung Dresden e.V Hohe Straße 6, 01069 Dresden, Germany

[2] University of Nebraska-Lincoln Lincoln, Nebraska 68588, USA

Abstract:

"Piezoresistive soft composite materials are widely used in strain sensing and typically exhibit a decrease in conductivity upon elongation—the so-called positive gauge effect. We demonstrate a thin-film architecture that features the inverse behavior: a strain-induced transition from insulating to metallic conductivity, spanning

nine orders of magnitude in conductivity. Our approach is based on a nanometer-scale sandwiched bilayer Au thin film with a polydimethylsiloxane elastomeric barrier layer. Upon application of strain, the thickness of the thin soft barrier decreases because of the strain governed by the Poisson effect, followed by electron-tunneling currents through the barrier, forming an interconnected bilayer metal electrode. An extremely high on–off electrical conductivity ratio (~ 10^9) is observed over a wide range of working strains (as high as 130%), which mimics the ideal features of a mechanical-force-controlled electric transistor. This conceptual design strategy is expected to benefit a wide range of applications in which operation under minimal standby power could be an essential feature, such as in implantable soft strain sensors and in prosthetic long-term monitoring systems for detecting sudden a swelling/volume expansion of human body organs or blood vessels, thereby helping to avoid acute and severe syndromes."

Link to Paper:
https://www.researchgate.net/publication/346525372_Negative_Piezoresistive_Effect_in_a_Stretchable_Device_Based_on_a_Soft_Tunneling_Barrier

First Proof-of-Principle of Inorganic Lead Halide Perovskites Deposition by Magnetron-Sputtering (2020)

C. Borri [1], N. Calisi [1], E. Galvanetto [1], et al.

[1] University of Florence

Abstract:

"The present work reports the application of RF-magnetron sputtering technique to realize CsPbBr 3 70 nm thick films on glass substrate by means of a one-step procedure. The obtained films show highly uniform surface morphology and homogeneous thickness as evidenced by AFM and SEM investigations. XRD measurements demonstrate the presence of two phases: a dominant orthorhombic CsPbBr 3 and a subordinate CsPb 2 Br 5 . Finally, XPS data reveals surface bromine depletion respect to the stoichiometrical CsPbBr 3 composition, nevertheless photoluminescence spectroscopy results confirm the formation of a highly luminescent film. These preliminary results demonstrate that our approach could be of great relevance for easy fabrication of large area perovskite thin films. Future developments, based on this approach, may include the realization of multijunction solar cells and multicolor light emitting devices."

Link to Paper: https://www.researchgate.net/publication/338192184_First_Proof-of-Principle_of_Inorganic_Lead_Halide_Perovskites_Deposition_by_Magnetron-Sputtering

A New Route for Caesium Lead Halide Perovskite Deposition (2020)

N. Calisi [1], S. Caporali [1], A. Vinattieri [1], et al.

[1] University of Florence

Abstract:

"Inorganic metal halide perovskites are relevant semiconductors for optoelectronic devices. In this work the successful deposition of thin films of CsPbBr 3 and CsPbCl 3 have been obtained by Radio-Frequency magnetron

sputtering. A detailed photoluminescence (PL) spectroscopy study of the as-grown samples was conducted at the macro and micro scale in a wide temperature range (10-300 K) to fully characterize the PL on sample areas of square centimeters, to assess the origin of the inhomogeneous broadening and to quantify the PL quantum yield quenching. Our results prove that this technique allows for the realization of high quality nanometric films with controlled thickness of relevance for optoelectronic applications."

Link to Paper:
https://www.researchgate.net/publication/348027732_A_New_Route_for_Caesium_Lead_Halide_Perovskite_Deposition

Investigation of Open Air Stability of CsPbBr3 Thin-Film Growth on Different Substrates (2020)

Nicola Calisi and Stefano Caporali

Department of Industrial Engineering, University of Florence, Via di Santa Marta 3, 50139 Firenze (FI), Italy;

Abstract:

"Originally developed out of scientific curiosity, lead halide perovskites are rapidly gaining success due to their broad tenability and ease of fabrication. Despite these advantages and the considerable progress made in the efficiency of perovskite-based devices, the stability of such materials remains a challenge. In this research paper, the role of substrate materials on which thin films of perovskites were deposited was examined, highlighting their critical importance for atmosphere-induced degradation. Indeed, CsPbBr3 thin films sputtered on glass (soda lime and quartz) and indium tin oxide (ITO) resulted more stable, while those deposited on polycrystalline gold-coated glass were much more prone to degradation in a temperature- and moisture-controlled (43% relative humidity (RH)) atmosphere."

Link to Paper:
https://www.researchgate.net/publication/346662796_Investigation_of_Open_Air_Stability_of_CsPbBr3_Thin-Film_Growth_on_Different_Substrates

Anisotropy and anharmonicity in polystyrene stable glass (2020)

Adam N. Raegen, Qi Zhou and James A. Forrest

Department of Physics and Astronomy, University of Waterloo, Waterloo, Ontario N2L 3G1, Canada

Abstract:

"We have used ellipsometry to characterize the anisotropy in stable polymer glasses prepared by physical vapor deposition. These measurements reveal birefringence values (as measured by the magnitude of in-plane vs out-of-plane refractive index) less than 0.002 in vapor-deposited polystyrenes with N from 6 to 12 and with fictive temperatures between 10 K and 35 K below the T_g values. We have measured the thermal expansivity of these stable glasses and compared to ordinary rejuvenated glass. The thermal expansivity of the stable glasses is less than that of ordinary glass with a difference that increases as the fictive temperature T_f decreases.

The authors would like to acknowledge many helpful discussions with M. Ediger and Z. Fakhraai. Financial support from the Natural Sciences and Research Council of Canada is gratefully acknowledged. Research at

Perimeter Institute was supported, in part, by the Government of Canada through the Department of Innovation, Science and Economic Development Canada and by the Province of Ontario through the Ministry of Colleges and Universities."

Link to Paper: https://aip.scitation.org/doi/10.1063/5.0032153

Fiber-Optic SERS Probes Fabricated Using Two-Photon Polymerization For Rapid Detection of Bacteria (2020)

J. Kim, D. Wales, A. Thompson, G. Yang

The Hamlyn Centre, Bessemer Building, Imperial College London, South Kensington, London, SW7 2AZ UK

Abstract:

"This study presents a novel fiber-optic surface-enhanced Raman spectroscopy (SERS) probe (SERS-on-a-tip) fabricated using a simple, two-step protocol based on off-the-shelf components and materials, with a high degree of controllability and repeatability. Two-photon polymerization and subsequent metallization are adopted to fabricate a range of SERS arrays on both planar substrates and end-facets of optical fibers. For the SERS-on-a-tip probes, a limit of detection of 10^{-7} M (Rhodamine 6G) and analytical enhancement factors of up to 1300 are obtained by optimizing the design, geometry, and alignment of the SERS arrays on the tip of the optical fiber. Furthermore, strong repeatability and consistency are achieved for the fabricated SERS arrays, demonstrating that the technique may be suitable for large-scale fabrication procedures in the future. Finally, rapid SERS detection of live Escherichia coli cells is demonstrated using integration times in the milliseconds to seconds range. This result indicates strong potential for in vivo diagnostic use, particularly for detection of infections. Moreover, to the best of our knowledge, this represents the first report of detection of live, unlabeled bacteria using a fiber-optic SERS probe."

Link to Paper: https://onlinelibrary.wiley.com/doi/full/10.1002/adom.201901934

The Effect of Coupling Mode in the Vibrational Strong Coupling Regime (2020)

Manuel Hertzog and Dr. Karl Börjesson

Department of Chemistry and Molecular Biology, University of Gothenburg, Kemigården 4, 412 96 Gothenburg, Sweden

Abstract:

"Hybrid light-matter states, known as polaritons, are the result of strong coupling between light and matter. The formation of polaritons yields a new method to tune the energetics of molecular systems, thus enabling the modification of physical and chemical properties without the need for chemical synthesis. To date, only proof-of-principle studies have been demonstrated, and, to increase the relevance of earlier achievements, bridging the gap between quantum electrodynamic length scales and chemical synthesis length scales is necessary. In

the present study, we show that the coupling strength of the light-matter interaction is independent of the thickness of the Fabry-Pérot cavity used, and that the energy dissipation rate falls with increasing cavity thickness. Using planar microcavities of different thicknesses, we have shown that the size of the cavities can be upscaled without reducing the strength of the strong interaction between light and matter. This can be done up to a length scale commonly used in flow chemistry, thus paving the way for a new optofluidic method that may help to overcome challenges in organic chemistry."

Link to paper: https://chemistry-europe.onlinelibrary.wiley.com/doi/full/10.1002/cptc.202000047

Ultrastable monodisperse polymer glass formed by physical vapour deposition (2020)

Adam N. Raegen, Qi Zhou and James A. Forrest

Department of Physics and Astronomy, University of Waterloo, Waterloo, Ontario N2L 3G1, Canada

Abstract:

"Stable glasses prepared by vapour deposition are an analogue of glassy materials aged for geological timescales. The ability to prepare such materials allows the study of near-ideal glassy systems. We report the preparation and characterization of stable glasses of polymers prepared by physical vapour deposition. By controlling the substrate temperature, deposition rate and polydispersity, we prepared and characterized a variety of stable polymer glasses. These materials display the kinetic stability, low fictive temperatures and high-density characteristic of stable glasses. Extrapolation of the measured transformation times between the stable and normal glass provides estimates of the relaxation times of the equilibrium supercooled liquid at temperatures as much as 30 K below the glass transition temperature. These results demonstrate that polymer stable glasses are an exciting and powerful tool in the study of ultrastable glass and disordered materials in general."

Link to Paper: https://www.nature.com/articles/s41563-020-0723-7

Energy relaxation pathways between light-matter states revealed by coherent two-dimensional spectroscopy (2020)

M. Wang et al.

Department of Chemistry and Molecular Biology, University of Gothenburg, Kemigården 4, 41296, Gothenburg, Sweden

Abstract:

"Coupling matter excitations to electromagnetic modes inside nano-scale optical resonators leads to the formation of hybrid light-matter states, so-called polaritons, allowing the controlled manipulation of material properties. Here, we investigate the photo-induced dynamics of a prototypical strongly-coupled molecular exciton-microcavity system using broadband two-dimensional Fourier transform spectroscopy and unravel the mechanistic details of its ultrafast photo-induced dynamics. We find evidence for a direct energy relaxation

pathway from the upper to the lower polariton state that initially bypasses the excitonic manifold of states, which is often assumed to act as an intermediate energy reservoir, under certain experimental conditions. This observation provides new insight into polariton photophysics and could potentially aid the development of applications that rely on controlling the energy relaxation mechanism, such as in solar energy harvesting, manipulating chemical reactivity, the creation of Bose–Einstein condensates and quantum computing."

Link to Paper: https://www.nature.com/articles/s42005-020-00424-z

Direct Evidence of a Transition from Triplet Excitons to Hybrid Light-Matter States via Triplet-Triplet Annihilation (2020)

Chen Ye et al.

University of Gothenburg

Abstract:

"In the enclosed manuscript, we embed a triplet-triplet annihilator inaccessible molecule inside an optical cavity. The system reaches the strong coupling regime, and the formed polariton has a reduced energy compared to the molecular singlet excited state, making triplet-triplet annihilation exothermic and readily observable. By the experimentally realized on-off effect, we show unambiguously that triplet excitons can annihilate directly into exciton-polaritons, without going through the singlet manifold. We further demonstrate that the total angular momentum is conserved in exciton to polariton triplet-triplet annihilation, thus theoretically explaining the feasibility of annihilating excitonic states to hybrid light-matter states."

Link to Paper: https://chemrxiv.org/engage/chemrxiv/article-details/60c74ed3bdbb890418a39c5e

2019

Nitrogen Rich Stainless Steel Coatings Obtained by RF Sputtering Process (2019)

Claudia Borri, Stefano Caporali, Francesca Borgioli and Emanuele Galvanetto

Department of Industrial Engineering, University of Florence, via S. Marta 3, 50139 Florence, Italy;

Abstract:

"Magnetron sputtering is a useful tool for producing coatings on various substrates at low temperature. The use of an austenitic stainless steel target in a nitrogen-containing plasma mixture allows to obtain nanostructured coatings with the formation of the so-called S phase, supersaturated interstitial solid solution of nitrogen in the expanded and distorted austenite lattice, which shows improved hardness and higher corrosion resistance in comparison with the bulk alloy. In the present research, RF magnetron sputtering deposition of austenitic stainless steel coatings using an AISI 316L target in nitrogen-containing plasma gas was studied. The effect of the N2/Ar gas ratio and the deposition temperature on nitrogen content, phase composition and crystallite size is investigated by mean of XPS, XRD and electron microscopy analyses. The results show that the

nitrogen content in the resulting deposit slightly depends on the N2/Ar ratio in the chamber during the deposition, reaching a maximum value of about 35% with a 30% N2/Ar gas composition mixture in the chamber. Data obtained on different substrates are presented and a preliminary evaluation of the corrosion resistance behaviour is also reported."

Link to Paper:
https://www.researchgate.net/publication/331575479_Nitrogen_Rich_Stainless_Steel_Coatings_Obtained_by_RF_Sputtering_Process

Towards development of fiber optic surface enhanced Raman spectroscopy probes using 2-photon polymerization for rapid detection of bacteria (2019)

J. Kim, D. Wales, A. Thompson, G. Yang

The Hamlyn Centre, Bessemer Building, Imperial College London, South Kensington, London, SW7 2AZ UK

Abstract:

"In this study, a variety of direct laser written surface-enhanced Raman spectroscopy (SERS) micro-structures, designed for bacteria detection, are presented. Various SERS micro-structures were designed to achieve both a high density of plasmonic hot spots and a strong probability of interaction between the hot spots and the target bacterial cells. Twophoton polymerization was used for initial fabrication of the polymeric skeletons of the SERS micro-structures, which were then coated with a 50 nm-thick gold layer via e-beam evaporation. The micro-structures were fabricated on glass coverslips and were assessed using a confocal Raman microscope. To this end, Rhodamine 6G was used as an analyte under 785 nm laser illumination. The optimal SERS micro-structures showed approximately 7×10^3 enhancement in Raman signal (analytical enhancement factor, AEF) at a wavenumber of 600 cm^{-1}. Real-time detection of E. coli in solution was demonstrated using the fabricated SERS platform with low laser powers and a short acquisition time (785 nm, 5 mW, 50 ms)."

Link to Paper: https://www.spiedigitallibrary.org/conference-proceedings-of-spie/10894/108940F/Towards-development-of-fibre-optic-surface-enhanced-Raman-spectroscopy-probes/10.1117/12.2507961.short?SSO=1

Floating magnetic microrobots for fiber functionalization (2019)

A.Barbot, H. Tan, M. Power, et al.

Hamlyn Center, Imperial College London, UK

Abstract:

"Because minimally invasive surgery is increasingly used to target small lesions, demand is growing for miniaturized tools—such as microcatheters, articulated microforceps, or tweezers—that incorporate sensing and actuation for precision surgery. Although existing microfabrication techniques have addressed the construction of these devices, accurate integration and functionalization of chemical and physical sensors

represent major challenges. This paper presents a microrobotic platform for the functionalization of fibers of diameters from 140 to 830 micrometers, with a patterning precision of 5 micrometers and an orientation error below 0.4°. To achieve this, we developed two 2 millimeter–by–3 millimeter, 200-micrometer-thick microrobots to align floating electronic circuits on a fiber during a wet transfer process. The position and orientation of the microrobots were controlled at the air/water interface by a permanent magnet. The stiffness of the position controlled was 0.2 newton millimeter, leading to an average force of 0.5 newton. The nonhomogeneous magnetic field of the magnet, associated with different preferred magnetization directions recorded in the microrobots, allowed the distance between the two microrobots to be precisely controlled. This extra degree of freedom was used to control the microrobot pair as a tweezer to grab and release floating electronic patterns, whereas the others were used to align the pattern position and orientation with the fiber. A model of this control, as well as the microrobots' interaction through surface tension, is proposed. Detailed performance validation is provided, and various exemplar sensor embodiments on a 200-micrometer-diameter fiber and three-dimensional devices are demonstrated."

Link to Paper: https://www.science.org/doi/abs/10.1126/scirobotics.aax8336

Active Plasmonic Colloid-to-Film-Coupled Cavities for Tailored Light–Matter Interactions (2019)

F. Gobler, A. Steiner et al.

Leibniz-Institut für Polymerforschung Dresden e.V., Institute for Physical Chemistry and Polymer Physics, Hohe Str. 6, 01069 Dresden, Germany

Abstract:

"For large-scale fabrication of optical circuits, tailored subwavelength structures are required to modulate the refractive index. Here, we introduce a colloid-to-film-coupled nanocavity whose refractive index can be tailored by various materials, shapes, and cavity volumes. With this colloidal nanocavity setup, the refractive index can be adjusted over a wide visible wavelength range. For many nanophotonic applications, specific values for the extinction coefficient are crucial to achieve optical loss and gain. We employed bottom-up self-assembly techniques to sandwich optically active ternary metal-chalcogenides between a metallic mirror and plasmonic colloids. The spectral overlap between the cavity resonance and the broadband emitter makes it possible to study the tunable radiative properties statistically. For flat cavity geometries of silver nanocubes with sub-10 nm metallic gap, we found a fluorescence enhancement factor beyond 1000 for 100 cavities and a 112 meV Rabi splitting. In addition, we used gold spheres to extend the refractive index range. By this easily scalable colloidal nanocavity setup, gain and loss building blocks are now available, thereby leading to new generation of optical devices."

Link to Paper: https://pubs.acs.org/doi/full/10.1021/acs.jpcc.8b12566

2018

Enhanced Fluorescence Resonance Energy Transfer in G-Protein-Coupled Receptor Probes on Nanocoated Microscopy Coverslips (2018)

B. Schreiber, M. Kauk, Hannah S. Heil, et al.

Research centre for experimental biomedicine, University of Wurzburg

Abstract:

"The G-protein-coupled receptor (GPCR) superfamily mediates cellular responses and communication across cellular membranes and is the largest known class of molecular targets with proven therapeutic value. For probing conformational changes of GPCRs and others in a live cell setting, fluorescence resonance energy transfer (FRET) is usually the method of choice. FRET probes often require careful labeling procedures, elaborate characterization, and assay optimization to provide both physiologically relevant probes with unaltered pharmacology and a sufficient dynamic range of the FRET changes. Here, we present an approach to optimize the energy transfer without changing the design of the FRET probe. We show that gold-coated glass coverslips reinforce the otherwise forbidden donor–acceptor energy transfer by virtual optimization of the dipole orientation. First, we confirm the resulting enhanced FRET efficiency on our nanocoatings for the inactive M1 muscarinic acetylcholine receptor (mAChR) labeled with a FRET pair of cyan fluorescent protein and fluorescein arsenical hairpin binder in classical bleaching experiments. Second, we show the advantage of this enhanced FRET technique for ligand binding studies in live cells, by the increased dynamic FRET response between the inactive and active states of the muscarinic acetylcholine receptor M1 subtype. Our method is not limited to GPCRs and thus has general potential for surface-bound FRET approaches. We believe our technique is particularly suited for pharmaceutical drug screening to boost FRET probes, in which it is highly desired to amplify signal responses without interfering with the well-characterized assay."

Link to Paper: https://pubs.acs.org/doi/abs/10.1021/acsphotonics.8b00072

Live-cell fluorescence imaging with extreme background suppression by plasmonic nanocoatings (2018)

B. Schreiber, M. Kauk, Hannah S. Heil, et al.

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Abstract:

"Fluorescence microscopy allows specific and selective imaging of biological samples. Unfortunately, unspecific background due to auto-fluorescence, scattering, and non-ideal labeling efficiency often adversely affect imaging. Surface plasmon-coupled emission (SPCE) is known to selectively mediate fluorescence that spatially originates from regions close to the metal interface. However, SPCE combined with fluorescence imaging has not been widely successful so far, most likely due to its limited photon yield, which makes it tedious to identify the exact window of the application. As the strength of SPCE based imaging is its unique sectioning capabilities. We decided to identify its clear beneficial operational regime for biological settings by interrogating samples in the presence of ascending background levels. For fluorescent beads as well as live-cell imaging as examples, we show how to extend the imaging performance in extremely high photon background environments. In a common setup using plasmonic gold-coated coverslips using an objective-based total internal reflection fluorescence microscope (TIRF-M), we theoretically and experimentally characterize our fluoplasmonics (f-Pics) approach by providing general user guidance in choosing f-Pics over TIRF-M or classical wide-field (WF)."

Link to Paper: https://opg.optica.org/oe/fulltext.cfm?uri=oe-26-16-21301&id=395947

Angle-Independent Polariton Emission Lifetime Shown by Perylene Hybridized to the Vacuum Field Inside a Fabry–Pérot Cavity (2018)

J. Mony, M. Hertzog, K. Kushwaha and K. Borjesson

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Abstract:

"The formation of hybrid light–matter states in optical structures, manifested as a Rabi splitting of the eigenenergies of a coupled system, is one of the key effects in quantum optics. The hybrid states (exciton polaritons) have unique chemical and physical properties and can be viewed as a linear combination of light and matter. The optical properties of the exciton polaritons are dispersive by nature, a property inherited from the photonic contribution to the polariton. On the other hand, the polariton lifetime in organic molecular systems has recently been highly debated. The photonic contribution to the polariton would suggest a lifetime on the femtosecond time scale, much shorter than experimentally observed. Here, we increase the insights of light–mater states by showing that the polariton emission lifetime is nondispersive. A perylene derivative was strongly coupled to the vacuum field by incorporating the molecule into a Fabry–Pérot cavity. The polariton emission from the cavity was shown to be dispersive, but the emission lifetime was nondispersive and on the time scale of the bare exciton. The results were rationalized by the exciton reservoir model, giving experimental evidence to currently used theories, thus improving our understanding of strong coupling phenomena in molecules."

Link to paper: https://pubs.acs.org/doi/full/10.1021/acs.jpcc.8b07283

Selective manipulation of electronically excited states through strong light–matter interactions (2018)

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Department of Chemistry and Molecular Biology, University of Gothenburg, Kemigården 4, Gothenburg 41296, Sweden

Abstract:

"Strong coupling between light and matter leads to the spontaneous formation of hybrid light–matter states, having different energies than the uncoupled states. This opens up for new ways of modifying the energy landscape of molecules without changing their atoms or structure. Heavy metal-free organic light emitting diodes (OLED) use reversed intersystem crossing (RISC) to harvest light from excited triplet states. This is a slow process, thus increasing the rate of RISC could potentially enhance OLED performance. Here we demonstrate selective coupling of the excited singlet state of Erythrosine B without perturbing the energy level of a nearby triplet state. The coupling reduces the triplet–singlet energy gap, leading to a four-time enhancement of the triplet decay rate, most likely due to an enhanced rate of RISC. Furthermore, we anticipate that strong coupling can be used to create energy-inverted molecular systems having a singlet ground and lowest excited state."

Link to Paper: https://www.nature.com/articles/s41467-018-04736-1

Hybrid InSe Nanosheets and MoS2 Quantum Dots for High-Performance Broadband Photodetectors and Photovoltaic Cells (2018)

Rajesh Kumar Ulaganathan[1], Raman Sankar[1], Yit-Tsong Chen[1]

[1]*National Taiwan University, Taipei*

Abstract

"Hybrid structures-based phototransistors are intensively studied recently to achieve high-performance optoelectronic devices. The hybridization of 2D materials and quantum dots (QDs) is one of the ideal platforms for photodetection applications with the merits of high detection sensitivity and wide wavelength coverage. The broadband absorption of a hybrid device stems from various absorbers with multiple bandgaps to create high photocurrent from an efficient exciton generation mechanism under illumination. Here, a new optoelectronic hybrid device of an indium selenide (InSe) nanosheets-based phototransistor is introduced decorated with molybdenum disulfide (MoS_2) QDs to possess the photoresponsivity (R_λ) of 9304 A W^{-1}, which is ≈10^3 times higher than R_λ ≈ 12.3 A W^{-1} of the previously reported InSe photodetector. The escalated R_λ of this hybrid photodetector is due to the additional injection of photoexcited charge carriers from MoS_2 QDs to the InSe phototransistor. Finally, the photovoltaic performance of this MoS_2/InSe hybrid device is investigated. The open-circuit voltage (V_{oc}) and short-circuit current density (J_{sc}) are determined to be 0.52 V and 15.6 mA cm^{-2}, respectively, rendering the photovoltaic efficiency of 3.03%. The development of this MoS_2/InSe hybrid phototransistor with high device performance and wide wavelength photodetection will bring a new type of optoelectronic applications in the future."

Link to Paper: https://onlinelibrary.wiley.com/doi/epdf/10.1002/admi.201801336

2017

Voltage-Controlled Switching of Strong Light–Matter Interactions using Liquid Crystals (2017)

M. Hertzog[1], P. Rudquist[2], J. Hutchison[3], et al.

[1]Department of Chemistry and Molecular Biology, University of Gothenburg,

[2]Department of Microtechnology and Nanoscience, MC2, Chalmers University of Technology

[3]University of Strasbourg, CNRS, ISIS & icFRC

Abstract:
"We experimentally demonstrate a fine control over the coupling strength of vibrational light–matter hybrid states by controlling the orientation of a nematic liquid crystal. Through an external voltage, the liquid crystal is seamlessly switched between two orthogonal directions. Using these features, for the first time, we demonstrate electrical switching and increased Rabi splitting through transition dipole moment alignment. The

C–N_{str} vibration on the liquid crystal molecule is coupled to a cavity mode, and FT-IR is used to probe the formed vibropolaritonic states. A switching ratio of the Rabi splitting of 1.78 is demonstrated between the parallel and the perpendicular orientation. Furthermore, the orientational order increases the Rabi splitting by 41 % as compared to an isotropic liquid. Finally, by examining the influence of molecular alignment on the Rabi splitting, the scalar product used in theoretical modeling between light and matter in the strong coupling regime is verified."

Link to Paper: https://chemistry-europe.onlinelibrary.wiley.com/doi/10.1002/chem.201705461