

**2023****Temperature-Dependent Amplified Spontaneous Emission in CsPbBr<sub>3</sub> Thin Films Deposited by Single-Step RF-Magnetron Sputtering (2023)**A. Vinattieri<sup>1</sup>, F. Biccari<sup>1</sup> et al.<sup>1</sup> 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<sub>3</sub> 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 μJ/cm<sup>2</sup>), 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>**CsPbBr<sub>3</sub> Perovskite Thin Films by Magnetron Sputtering: The Role of the Substrate on Texture and Morphology (2023)**N. Calisi<sup>1</sup>, S. Caporali<sup>1</sup> et al.<sup>1</sup> 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, CsPbBr<sub>3</sub> 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 CsPbBr<sub>3</sub> were obtained by magnetron sputtering and the texture*

and the morphology of the deposited films were evaluated as function of the film thickness. Furthermore, the effect of the substrate on which the films were deposited was evaluated. The deposited films shown a high textured structure, especially in the firsts atomic layers deposited, 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](https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4387088)

## Flexible CsPbCl<sub>3</sub> inorganic perovskite thin-film detectors for real-time monitoring in protontherapy (2023)

M. Bruzzi<sup>1</sup>, N. Calisi<sup>1</sup>, A. Vinattieri<sup>1</sup> et al.

<sup>1</sup>Department of Physics and Astronomy and LENS, University of Florence, Via G. Sansone<sup>1</sup>, 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, CsPbCl<sub>3</sub>, 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 10<sup>7</sup>–10<sup>9</sup> 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](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 Nanoscale Thick Films on Flexible Substrates (2023)

A.Xomalis<sup>1</sup>, C. Hain<sup>1</sup>, A. Groetsch<sup>1</sup> et al.

<sup>1</sup>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 architected 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 architected metamaterials to strain-resilient flexible electronics and wearable devices.

Link to Paper: <https://pubs.acs.org/doi/pdf/10.1021/acsnm.2c05161>

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

Charles Maphanga<sup>1</sup>, Saturnin Ombinda-Lemboumba<sup>1</sup>, et al.

<sup>1</sup> 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<sup>1</sup> and James A. Forrest<sup>1</sup>

<sup>1</sup> Department of Physics and Astronomy, University of Waterloo, Waterloo, Ontario, Canada

**Abstract:**

We report measurements of the onset temperature of rejuvenation,  $T_{onset}$ , and the fictive temperature,  $T_f$ , for ultrathin stable polystyrene with thicknesses from 10 to 50 nm prepared by physical vapor deposition. We also measure the  $T_g$  of these glasses on the first cooling after rejuvenation as well as the density anomaly of the as-deposited material. Both the  $T_g$  in rejuvenated films and the  $T_{onset}$  in stable films decrease with decreasing film thickness. The  $T_f$  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  $T_g$  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<sup>1</sup>, Jian Wang<sup>1</sup>, et al.

<sup>1</sup> 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 ( $\sigma_i \sim 1.0 \times 10^{-6} \text{ S cm}^{-1}$  vs.  $7.7 \times 10^{-7} \text{ S cm}^{-1}$ ), lower activation energy ( $E_A \sim 0.39 \text{ eV}$  vs.  $0.46 \text{ eV}$ ) and larger electrochemically stable window (ESW  $\sim 4.2 \text{ V}$  vs.  $3.9 \text{ V}$ ). Moreover, the LiPON@F electrolyte film also presents superior chemical stability than the LiPON one ( $\sigma_i$  degradation after exposure to 50%RH humidity for 120 h  $\sim 14.5\%$  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  $\text{Li}^+$  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<sup>1</sup>, Xin Song<sup>1</sup>, Kun Zhou<sup>1</sup> et al.

<sup>1</sup> 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<sup>1</sup>, V. V. Glagolev<sup>1</sup> et al.

<sup>1</sup> 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  $0.18 \mu\text{m}^{-1}$  for a laser beam spot diameter of  $8.8 \mu\text{m}$  displaced over  $2.4 \mu\text{m}$  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  $\pm 0.030 \text{ nm}$ . Application of the Dividing Plates method for position-sensitive measurements allows to build a compact version of the Precision Laser Inclinator, the Compact PLI, with reduced overall dimensions of  $20 \times 20 \times 20 \text{ cm}^3$  and weight of approximately 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<sup>1</sup>, Saturnin Ombinda-Lemboumba<sup>1</sup>, et al.

<sup>1</sup> 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<sup>1</sup>, Jian Wang<sup>1</sup>, et al.

<sup>1</sup> 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 ( $\sigma_i \sim 1.0 \times 10^{-6} \text{ S cm}^{-1}$  vs.  $7.7 \times 10^{-7} \text{ S cm}^{-1}$ ), lower activation energy (EA  $\sim 0.39 \text{ eV}$  vs.  $0.46 \text{ eV}$ ) and larger electrochemically stable window (ESW  $\sim 4.2 \text{ V}$  vs.  $3.9 \text{ V}$ ). Moreover, the LiPON@F electrolyte film also presents superior chemical stability than the LiPON one ( $\sigma_i$  degradation after exposure to 50%RH humidity for 120 hours  $\sim 14.5\%$  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<sup>+</sup> 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](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<sup>1,2</sup>, et al.

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

<sup>2</sup> 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-HiPIMS film, however, was stoichiometric and exhibited (0002) direction texturing, with an optical bandgap of approx. 1.5 eV, electron concentration of  $2.72 \times 10^{20} \text{ cm}^{-3}$  and electron mobility of  $7.16 \text{ cm}^2 \text{ V}^{-1} \text{ s}^{-1}$  (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<sup>1</sup>, Y. Huang<sup>1</sup> et al.

<sup>1</sup>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 ( $\sim 2$ ) 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 SF<sub>6</sub>/O<sub>2</sub> 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  $\mu$ A 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/acsnm.2c04457>

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

L. Lapeyre<sup>1,2</sup>, C.Hain<sup>1,2</sup>, et al.

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

<sup>2</sup> 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](https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4300055)

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

R. Sun<sup>1</sup>, X. Song<sup>1</sup>, Y. Zuo<sup>2</sup>, et al.

<sup>1</sup>Department of Materials, 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 <sup>1</sup>, L. Donati <sup>1</sup>, E. Galvanetto <sup>2</sup>, et al.

<sup>1</sup> Department of Chemistry “Ugo Schiff”, University of Florence, 50019 Sesto Fiorentino, Italy

<sup>2</sup> 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](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](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<sub>3</sub> Perovskite Detectors as Real-Time Dosimeters for Clinical Radiotherapy (2022)**

M. Bruzzi<sup>1</sup>, N. Calisi<sup>2</sup>, A. Vinattieri<sup>1</sup>, et al.

<sup>1</sup>Dipartimento di Fisica e Astronomia, Università degli Studi di Firenze, Via G. Sansone 1, 50019, Sesto Fiorentino, FI, Italy

<sup>2</sup>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 ( $\approx 1 \mu\text{m}$ ) layers of a high sensitivity, wide bandgap semiconductor, the inorganic perovskite CsPbCl<sub>3</sub>, 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<sup>1</sup>, K. Wiczerzak<sup>2</sup>, C. Hain<sup>1,2</sup>, et al.

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

<sup>2</sup>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  $\mu$ s) 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  $\mu$ s, resulting in compact and smooth morphology for Cu-rich films, whereas short 25  $\mu$ s pulses provided porous columnar films with rough surfaces, as the result from Ar<sup>+</sup> 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 <sup>1</sup>, A. barbot <sup>2</sup>, F. Seichepine <sup>2</sup>, et al.

<sup>1</sup>University of Bristol, UK

<sup>2</sup>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 Al<sub>2</sub>O<sub>3</sub> 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 Al<sub>2</sub>O<sub>3</sub> flexible tapes were produced through Tape Casting technique and used as substrates to produce Co<sub>2</sub>FeAl/GnP doped Al<sub>2</sub>O<sub>3</sub> heterostructures. The Co<sub>2</sub>FeAl 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 Co<sub>2</sub>FeAl 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<sub>3</sub> 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<sub>3</sub> 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.

<sup>1</sup>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  $e_0$ ) and a large charge-to-mass ratio ( $\sim 2400 e_0/m_0$ ). 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 ( $\text{BaTiO}_3$ , 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<sup>1</sup>, J. Forrest<sup>1</sup>, T. Salez<sup>2</sup> et al.*

<sup>1</sup>Department of Physics & Astronomy, University of Waterloo, 200 University Ave. W, Waterloo, ON, N2L 3G1, Canada

<sup>2</sup>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 spincoated 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  $Ti_{1-x}Cu_x$  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  $Ti_{0.70}Cu_{0.30}$  has better characteristics to act as RTD, especially the  $\alpha TCR$  of  $1990 \times 10^{-6} \text{ } ^\circ\text{C}^{-1}$ . The antimicrobial properties of the  $Ti_{1-x}Cu_x$  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  $Ti_{1-x}Cu_x$  thin films showed bactericidal effects, by  $\log_{10}$  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  $Ti_{1-x}Cu_x$  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 $ReSe_2$ Nanosheets (2022)

Christy Roshini Paul Inbaraj<sup>1</sup>, Kai-Hsiang Cheng<sup>1</sup>, Yit-Tsong Chen<sup>1</sup>

<sup>1</sup>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 ( $\approx 984$  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<sup>1</sup>, G. Gao<sup>1</sup> et al.

<sup>1</sup>Department of Physics, The University of Hong Kong, Hong Kong, 999077 P. R. China

### Abstract:

Oxide dielectrics, such as  $HfO_2$ ,  $Al_2O_3$ , 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 ( $\kappa$ ) to reduce the leakage current, and these super-high- $\kappa$  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 ( $\kappa > 50$ ) 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  $SnS_2$  field-effect transistor reveals that the high- $\kappa$   $Al_2O_3$ /GCZO gate dielectric stack is suitable for 2D electronic devices. This GCZO dielectric films not only show higher  $\kappa$  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,<sup>1</sup> Won Jin Choi, Ivan Fotev, Eva Bittrich<sup>1</sup>, Petra Uhlmann<sup>1,2</sup>, Mathias Schubert<sup>1,2</sup>, Denys Makarov, Jens Wagner, Alexej Pashkin, and Andreas Fery<sup>1</sup>

<sup>1</sup> Institut für Polymerforschung Dresden e.V Hohe Straße 6, 01069 Dresden, Germany

<sup>2</sup> University of Nebraska-Lincoln Lincoln, Nebraska 68588, USA

#### Abstract:

*“Mechanical-strain-gated switches are cornerstone components of material embedded 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, mechanical-strain-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 identification using surface enhanced Raman spectroscopy active filters (2021)

Simon D. Dryden<sup>1</sup>, Salzitsa Anastasova<sup>2</sup>, Alex J. Thompson<sup>1,2</sup>, et al.

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

<sup>2</sup> 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 identification. Surface enhanced Raman spectroscopy (SERS) has the potential to overcome these*

issues by providing immediate bacterial classification. To date, achieving accurate classification 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 filters 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 filters was assessed using phantom urine infection samples at clinically relevant concentrations (10<sup>5</sup> CFU/ml). Infected and uninfected (control) samples were identified with an accuracy of 91.1%. Amongst infected samples only, classification 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 plasmothermal 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 plasmothermal 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<sup>1</sup>, N. Calisi<sup>2</sup>, and A. Vinattieri<sup>1</sup>

<sup>1</sup>Department of Physics and Astronomy, University of Florence, via G. Sansone 1, Sesto Fiorentino, I-50019, Italy

<sup>2</sup>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 CsPbBr<sub>3</sub> and CsPbCl<sub>3</sub> 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. Gupta, 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<sub>2</sub>) 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<sub>2</sub> 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<sup>1</sup>, N. Calisi<sup>2</sup>, C. Barri<sup>3</sup> et al.

<sup>1</sup>Department of Physics and Astronomy, University of Florence, Via G. Sansone 1, I-50019 Sesto Fiorentino, Italy

<sup>2</sup>Department of Industrial Engineering (DIEF), University of Florence, Via S. Marta 3, I-50139 Florence

<sup>3</sup>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<sub>3</sub> and CsPbI<sub>3</sub>, the realization of high-quality thin films of CsPbCl<sub>3</sub>, 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<sub>3</sub> 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<sup>2</sup>). 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<sup>1</sup>, P. Petrov<sup>1</sup>, B. Moffat<sup>2</sup>, J. Phair<sup>2</sup>, L. Allers<sup>3</sup> and R.W. Whatmore<sup>1</sup>

<sup>1</sup>Department of Materials, Imperial College London, London SW7 2AZ, United Kingdom

<sup>2</sup>Pyreos Ltd., Heriot Watt Research Park, Edinburgh EH14 4AP, United Kingdom

<sup>3</sup>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<sup>-1</sup> 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<sup>1</sup>, Raman Sankar<sup>1</sup>, Monika Katarina<sup>1</sup>, Yang-Fang Chen<sup>1</sup>, Yit-Tsong Chen<sup>1</sup>

<sup>1</sup>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<sup>1,2</sup>, Krzysztof Wiczerzak<sup>2</sup>, Johann Michler<sup>2</sup>, et al.

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

<sup>2</sup>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,<sup>1</sup> Ivan Fotev, Eva Bittrich<sup>1</sup>, Won Jin Choi, Petra Uhlmann<sup>1</sup>, Mathias Schubert<sup>1,2</sup>, Alexej Pashkin, and Andreas Fery<sup>1</sup>

<sup>1</sup>-Institut für Polymerforschung Dresden e.V Hohe Straße 6, 01069 Dresden, Germany

<sup>2</sup> 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 ( $\sim 10^9$ ) 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](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<sup>1</sup>, N. Calisi<sup>1</sup>, E. Galvanetto<sup>1</sup>, et al.

<sup>1</sup> University of Florence

### Abstract:

*“The present work reports the application of RF-magnetron sputtering technique to realize CsPbBr<sub>3</sub> 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<sub>3</sub> and a subordinate CsPb<sub>2</sub>Br<sub>5</sub>. Finally, XPS data reveals surface bromine depletion respect to the stoichiometrical CsPbBr<sub>3</sub> 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](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 <sup>1</sup>, S. Caporali <sup>1</sup>, A. Vinattieri <sup>1</sup>, et al.

<sup>1</sup>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<sub>3</sub> and CsPbCl<sub>3</sub> 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](https://www.researchgate.net/publication/348027732_A_New_Route_for_Caesium_Lead_Halide_Perovskite_Deposition)

## **Investigation of Open Air Stability of CsPbBr<sub>3</sub> 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, CsPbBr<sub>3</sub> 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](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 N<sub>2</sub>/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 N<sub>2</sub>/Ar ratio in the chamber during the deposition, reaching a maximum value of about 35% with a 30% N<sub>2</sub>/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](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  $7 \times 10^3$  enhancement in Raman signal (analytical enhancement factor, AEF) at a wavenumber of  $600 \text{ cm}^{-1}$ . 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/acsp Photonics.8b00072>

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

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

Research centre for experimental biomedicine, University of Wurzburg

### 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–matter 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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### 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 MoS<sub>2</sub> Quantum Dots for High-Performance Broadband Photodetectors and Photovoltaic Cells (2018)

Rajesh Kumar Ulaganathan<sup>1</sup>, Raman Sankar<sup>1</sup>, Yit-Tsong Chen<sup>1</sup>

<sup>1</sup>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<sub>2</sub>) QDs to possess the photoresponsivity ( $R_\lambda$ ) of  $9304 \text{ A W}^{-1}$ , which is  $\approx 10^3$  times higher than  $R_\lambda \approx 12.3 \text{ A W}^{-1}$  of the previously reported InSe photodetector. The escalated  $R_\lambda$  of this hybrid photodetector is due to the additional injection of photoexcited charge carriers from MoS<sub>2</sub> QDs to the InSe phototransistor. Finally, the photovoltaic performance of this MoS<sub>2</sub>/InSe hybrid device is investigated. The open-circuit voltage ( $V_{oc}$ ) and short-circuit current density ( $J_{sc}$ ) are determined to be  $0.52 \text{ V}$  and  $15.6 \text{ mA cm}^{-2}$ , respectively, rendering the photovoltaic efficiency of 3.03%. The development of this MoS<sub>2</sub>/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)**

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<sup>2</sup>Department of Microtechnology and Nanoscience, MC2, Chalmers University of Technology

<sup>3</sup>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<sub>str</sub> 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>