Plasma and Vapor Deposition Processes
Room Palm 5-6 - Session PP6-MoM

Microfabrication Techniques with Lasers and Plasmas

Moderators: Carles Corbella, George Washington University, USA, **Uros Cvelbar**, Jozef Stefan Institute, Slovenia

10:00am **PP6-MoM-1 Laser Bioprinting: From the Breast Tumor Microenvironment to Migration in Wound Healing Assays**, ***Doug Chrisey (douglasbchrisey@gmail.com)***, Tulane University, USA **INVITED**

Laser bioprinting can be both additive (depositing cells) and subtractive (etching) and both have power to study the micro-physiological behavior of heterogeneous tissue constructs *in vitro*. The use of a UV laser in both these scenarios is shown to be very powerful and this presentation will show results over this wide range of applications. The most enriched cell types in the breast tumor microenvironment are cancer cells, cancer-associated fibroblasts, and tumor-associated macrophages. To recapitulate the cellular dynamics of the breast tumor microenvironment *in vitro*, the most abundant cell types need to be incorporated. Laser direct write bioprinting offers a precise, gentle, and reproducible method to print disparate cell types in user-defined geometries. Herein, we develop novel laser direct write cell printing protocols – first as a customizable generalized framework, which is then adapted to print homotypic and heterotypic cancer-stromal arrays, and human macrophages. We demonstrate the ability to fabricate *in vitro*heterocellular constructs for studying cell-cell signaling in healthy and diseased microenvironments, as well as the capability to print human immune cells with high fidelity to pave the way for bioprinting immunocompetent tissue models going forward. Traditional *in vitro* scratch assays lack standardization due to poor control over wound geometry and fail to account for cell proliferation. Here, we developed a novel scratch assay that enables precise control over wound geometry using CAD/CAM laser photoablation and takes cell proliferation into consideration using a simple reaction- diffusion based mathematical model. We demonstrated that diffusivity in precisely photoablated cell layers serves as a more accurate measure of cell motility than the rate of gap closure. Further, we biologically validated this assay using cells harvested from patients and patient-derived xenografts to gain insights into the influence of the presence stromal cells on metaplastic and non-metaplastic triple negative breast cancer metastasis.

10:40am **PP6-MoM-3 Plasma-Assisted Nanofabrication of Advanced Nanoplasmonic Surfaces for SERS Applications**, ***Uros Cvelbar (uros.cvelbar@ijs.si)***, Jozef Stefan Institute, Slovenia **INVITED**

In the realm of plasmonic detection, pivotal for applications such as food and water quality monitoring, theranostics, and virus and toxin analysis, Surface Enhanced Raman Scattering (SERS) stands out as a powerful technique. Employing vibrational spectroscopy and surface nanoengineering, SERS leverages metallic nanoparticles to enhance signals through the confinement effect of the electromagnetic field, creating intense 'hot spots' near nanoscale metal surfaces. The morphology and arrangement of plasmonic nanomaterials crucially influence the formation of hot spot networks. This presentation focuses on our recent research in the plasma-assisted fabrication of advanced nanoplasmonic surfaces, showcasing nanocarbon structures, metal-oxide nanotrees, and coupled nanogold. Utilizing various plasma setups, including low-pressure and atmospheric pressure, we demonstrate their versatility, reliability, and fast, one-step processing. These surfaces excel in detecting cancerogenic toxins at ppb levels, ultrafast recognition of trace chemicals, and even bacterial DNA detection with nanogram sample amounts. The talk underscores the significant potential of plasma-assisted nanofabrication in advancing nanoplasmonic surfaces for a broad spectrum of analytical applications.

References:

[1] Shvalya, V., Filipič, G., Zavašnik, J., Abdulhalim, I., & Cvelbar, U. (2020). Applied Physics Reviews, 7(3), 031307. [2] M. Santhosh, N., Shvalya, V., Modic, M., Hojnik, N., Zavašnik, J., Olenik, J., Košiček, M., Filipič, G., Abdulhalim, I. & Cvelbar, U. (2021). Small, 17(49), 2103677. [3] Shvalya, V., Vasudevan, A., Modic, M., Abutoama, M., Skubic, C., Nadižar, N., Zavašnik, J., Vengus, D., Zidanšek, A., Abdulhalim, I., Rozman, D. & Cvelbar, U. (2022). Nano Letters, 22 (23), 9757-9765.

11:20am **PP6-MoM-5 Enhancing Tribological Performance of Carbon-Based Coatings Through Pulsed Lasertexturation**, ***Constant Boris Rieille (constant.rieille@bfh.ch)***, *S. LeCoultre,* Berner Fachhochschule BFH, Switzerland

This presentation aims to explore laser-textured carbon-based coatings and their improved tribological properties for different applications against various materials, including brass, titanium, aluminum and steel. The study involves a comprehensive comparative analysis with benchmark carbon coatings from the market, focusing on the performance of these coatings in diverse conditions.

Moreover, our research delves deeper into the tribolayer that forms on counterpart surfaces and employs advanced analytical techniques such as Raman spectroscopy and Scanning Electron Microscopy coupled with Energy Dispersive X-ray Analysis (SEM+EDX) to gain insights into the intricate mechanisms at play.The contribution of topographical variations and structural changes to the carbon coating will be discussed.

We will also introduce a novel model to elucidate why laser textured carbon layers exhibit superior tribological performance compared to their untextured coatings and compare as well different possible mechanism for carbon transformation depending on laser pulse length between nano and femtosecond.

At the end of the presentation, we aim to present an innovative method for producing a high-performance coating that can be used for tribological applications in the cutting tool, watchmaking, and micromechanics industries.

11:40am **PP6-MoM-6 Designing Chiral Micropatterns via Ion Beam Colloidal Lithography**, *S. Portal,* ***Carles Corbella (ccorberoc@gwu.edu)***, George Washington University, USA*; O. Arteaga,* University of Barcelona, Spain*; A. Martin, T. Mandal,* New York University, USA*; V. Dinca,* National Institute for Laser, Plasma, and Radiation Physics, Romania*; B. Kahr,* New York University, USA

Optically anisotropic materials were fabricated via colloidal lithography and characterized by scanning electronic microscopy (SEM), confocal microscopy, and polarimetry. First, a mask consisting of hexagonal compact arrays of silica sub-micron particles (500-600 nm in diameter) was produced via Langmuir-Blodgett self-assembly. After that, the deposited mask pattern was transferred onto the underlying substrate by means of ion beam etching using an electron-cyclotron-resonance (ECR) plasma source. Monocrystalline silicon and commercial glass were used as substrates. In the etching processes, screw-like shaped pillars were carved into the substrates by irradiating their surfaces at oblique incidence and varying stepwise the azimuthal angle. Different chiral structures were obtained depending on the rotation direction of the azimuthal angle steps. Finally, thin gold films were deposited on top of the pillars to enhance the material optical properties through plasmon resonance effect. Polarimetric measurements were realized at normal and oblique incidences to assess the anisotropy of the samples. The etching directions have an influence on the value of the linear birefringence and linear dichroism. A dependence of the birefringent parameters on the angle of incidence of the light was found: an amplification of the chiroptical response of the material was observed at increasing angle of incidence. This fast, cost-effective technique is promising for the preparation of large micropatterned surfaces aimed at photonic and biological applications.

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