Materials for Space Environments: What will it take to colonize other planets?

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ABSTRACT

The idea of living on Mars or the Moon has been a staple of science fiction since the 19th century. The justification is that we need to go there if we want to create a backup location for humanity, in the event that life on Earth becomes untenable due to issues like climate change. We could also go there to search for additional resources such as water or precious metals. However, if this sci-fi dream were to ever become reality, what would it be like to actually live there? Conditions make living on Mars extremely challenging. In particular, materials needed for such extreme environments need to be discovered and designed. In this talk, we will present an overview and current research on carbide and boride materials for potential uses at extreme environments, including ultra-high and ultra-low temperatures, impact, and radiation. High-entropy carbides and hexaborides will be a particular focus of attention.

Integrated Metaphotonics for Sustainable and Smart Cities

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ABSTRACT

Nowadays, more than half of world's population lives in urban environments, making cities and metropolitan areas the center of economic, social, and cultural growth of humanity. Therefore, it is necessary to generate new technologies that guarantee sustainable and equitable growth in these areas. In this sense, sensor networks have gained relevance in recent years, as they take advantage of real-time monitoring of various factors that can affect this growth, such as air quality monitoring networks, weather stations, seismological sensors, road traffic monitors, to mention a few.

In this context, a state-of-the-art alternative for the detection of environmental disturbances are the so-called integrated metaphotonic systems, which consist of the integration of micro and nanostructured metamaterials to photonic waveguides compatible with commercial optical fibers. These systems present several advantages, like high specificity and sensitivity, high speed detection, portability, interconnectivity, and compatibility with information and communication technologies.

In this talk, we will provide a broad explanation of the aforementioned concepts, as well as the physical concepts involved in the development of integrated metaphotonic systems. In addition, we will show some of the research advances developed in the Metaphotonics Group of the Monterrey Unit of CICESE, focusing on the design, fabrication and characterization techniques required for the development of these systems and the perspectives of our group to contribute to sustainable development of urban environments.

Laser Induced Periodic Surface Structures on Metals

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ABSTRACT

The ultrashort-pulse laser material processing is a powerful technique for precise nano and microstructuring that allow us to modify the material properties for various applications. Particularly, the formation of Laser Induced Periodic Surface Structures (LIPSS) is a potentially strong method to fabricate micro/nano-structured surfaces, which are of high interest for biomedical applications, texturing of metals, solar cells, plasmonics, etc. The nanostructures can be generated in a single step process and allow us to modify the optical, mechanical and chemical surface properties. However, due to the high sensitivity of the LIPSS formation process to the type of substrate material, environment, and laser parameters, accomplishing fine control over the structure formation is a difficult task. Different theoretical models have been proposed to explain the LIPSS formation, however, all of them are under debate. In this talk, the effect of different irradiation parameters on the LIPSS formation on bismuth and titanium thin films will be discussed.

Silicon oxide growth by RTA, assessment of the thickness and determination of oxidation states

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ABSTRACT

X-ray Photoelectron Spectroscopy (XPS) is a valuable tool for assessing the thickness of surface layers in the first nanometers. The prediction of a core-level XPS signal from a solid requires assuming a specific volumetric distribution of such core levels. The semiconductor industry widely employs SiO2 films of thicknesses in the range of a few Angstroms to a few nanometers, depending on the application. An accurate measurement of the physical width is of technological importance. In addition, it is desired to have the same structure; with this technique it is possible to identify the oxidation states involved in the structure. Sputtering layer is done to identify these chemical changes in depth profile.

Controlling and enhancing light-matter interaction at the nanoscale

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ABSTRACT

Recent progress in optics and photonics is driven by the development of new optical materials and nanostructures that allow us to manipulate light in unusual ways. In this talk I will present new platforms of nano materials with extraordinary electromagnetic properties for the control of light at the nano scale with applications in devices for biosensing, photocatalysis, optical information processing, Raman spectroscopy as well as control of fluorescence and spontaneous emission.

The physical quantity that characterizes the light-matter interaction is the local density of states (LDOS), it is directly related to the decay rate of an emitter in the weak coupling regime with the local environment. The enhancement of the decay rate with respect to a homogeneous medium is known as the Purcell factor and it can be extremely improved by adapting the local environment of the quantum emitter. Thus, by engineering dielectric and metallic nanostructures, great improvements in the confinement of the electromagnetic field can be achieved, leading to enhancements in the Purcell factor along the nanostructured media at specific frequencies in wide spectral ranges. Until recently, the LDOS modification by nanostructured materials has been measured by performing far-field optical microscopy measurements. The spatial resolution of such measurements is limited by diffraction to ~ 250 nm, which gives access to partial information, averaged over all possible dipole orientations. In this talk a novel technique to measure the LDOS modification at the nanoscale is also presented, by combining super-resolution microscopy and direct decay rate measurements, we achieved super spatial and temporal resolution; with this technique it is possible not only to obtain an LDOS map on the nanometric scale, but also to distinguish the position of the emitters. Unprecedented high non-averaged Purcell factors are quantified, giving us access to observe the fine details of the light-matter interaction at the nanoscale, simultaneously mapping the position of the emitters and their decay rate modified by the localization of the electric field in dielectric nano antennas and plasmonic metamaterials.