

PhD THESIS DEFENSE: Application to Sensing, Imaging, and Cooling of Ultra-Thin Metal Films and Derived Nanostructured Glass Surfaces

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15:00

ICFO Auditorium and Online (Teams)

The continuous evolution of optoelectronic systems responds to the demand for higher efficiency, speed, and sensitivity. A key strategy is to modify material dimensions at the nanoscale, which alters their optical, electrical, and thermal properties and enables new functionalities.

A prominent example is ultra-thin metal films (UTMFs), with thicknesses below 10 nm, which exhibit properties different from thicker metal layers. This thesis explores the use of gold (Au) UTMFs deposited on copper oxide (CuO) seed layers, fabricated with industrial techniques such as physical vapor deposition (PVD). These ultra-thin films enable continuous and

ultrasmooth surfaces, as well as tunable properties through optical or electrical processes. The potential of these UTMFs in electrochemical sensors based on self-assembled monolayers (SAMs) is demonstrated. The results show that thinner films respond more rapidly to SAM formation, and that biotin functionalization enables the detection of streptavidin through measurable resistance changes.
The optical interaction between UTMFs and fluorophores is also investigated, focusing on fluorescence quenching caused by non-radiative energy transfer. Experiments reveal the dependence on film thickness and fluorophore-metal separation, confirming that these films can enhance the signal-to-noise ratio in fluorescence imaging of stained bacteria.
Finally, glass surfaces are nanostructured with nanopillars (NPs) generated via thermally dewetted UTMF masks and subsequent etching. These surfaces exhibit unique optical properties: anti-reflective coatings in the visible range and enhanced infrared emissivity. Moreover, they are combined with thin polymer coatings to preserve visible transparency while improving the efficiency of passive radiative cooling (PRC). Results confirm that nanostructured glass surfaces dissipate more heat than flat ones, opening opportunities in solar panels, displays, and windows.
This thesis therefore demonstrates the potential of Au UTMFs and nanostructured glass surfaces for the development of chemical sensors, advanced optical microscopy techniques, and radiative cooling applications.

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Thesis Director: Prof. Dr. Valerio Pruneri
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