PhD Thesis Defense KAVITHA KALAVOOR 'Optical Surfaces for Mid-Infrared Sensing'

KAVITHA KALAVOOR

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Monday, October 22, 11:00. ICFO Auditorium

KAVITHA KALAVOOR

Optoelectronics

ICFO-The Institute of Photonic Sciences

The mid-infrared (mid-IR) spectral region, with wavelengths between 3 and 15 m, is know for a wide range of applications ranging from spectroscopic sensing to thermal imaging However, despite the strong technological interest, optoelectronic devices in the mid-IR ar expensive and often inferior in performance compared to their visible and near-I counterparts

In this thesis, we combine ultrathin materials, e.g. graphene, and novel substrates to develo optical surfaces for applications in the mid-IR.First, we demonstrate a novel uncoole photodetector, combining graphene with a ferroelectric (pyroelectric) substrate. Mor specifically, we develop a graphene on z-cut lithium niobate (LiNbO3) pyro-resistive platfor that supports dynamic tunablity of the responsivity. We also develop a model to identify th key parameters that influence the performance of such detectors and can therefore provid guidelines to improve their performance.

Second, we introduce ultra-thin yttria-stabilized zirconia (YSZ), a ceramic material, as a novel platform for IR nano-optics. In particular, we combine YSZ substrates with metallic nanostructures and graphene to demonstrate plasmonic, polarizing and transparent heating devices, which enable high temperature processing and can withstand harsh environments thanks to the high thermal and chemical stabilities of YSZ. Additionally, the mechanical flexibility of YSZ substrates also makes them ideally suited for manufacturing foldable or bendable devices and for low cost large-scale roll-to-roll fabrication processes.

Finally, we investigate for the first time electrostatically tunable graphene nano-hole array surfaces by performing a detailed experimental study of structures with periods as low as 100 nm. We obtain a clear plasmonic response from these surfaces in the range 1300-1600 cm-1. We also demonstrated for the first time that these tunable nanostructures can be fabricated by scalable nano-imprint technique. Such large area plasmonic nanostructures are suitable for industrial applications, for example, surface-enhanced infrared absorption (SEIRA) sensing. This is because they combine an easy design, extreme field confinement and the possibility to excite multiple plasmon modes for multiband sensing, a feature not readily available in nanoribbons or other localized resonant geometries.

The results contained in this thesis are particularly relevant with regard to extending the use of materials, such as graphene combined with specific substrates (LiNbO3 or zirconia), to mid-IR photodetection, enhanced absorption and molecular sensing.

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Thesis Advisor: Prof Dr Valerio Pruneri