



Congratulations to New ICFO PhD graduate

Dr. Kavitha Kalavoor graduated with a thesis on "Optical Surfaces for Mid-Infrared Sensing"

October 21, 2018

Dr. Kavitha Kalavoor received her Master degree in Photonics from Cochin University of Science and Technology in India before joining the Optoelectronics research group led by ICREA Prof. at ICFO Dr. Valerio Pruneri. At ICFO, she centred her doctoral studies on the development of optical surfaces for applications in the mid-IR. Dr. Kalavoor's thesis, entitled "Optical Surfaces for Mid-Infrared Sensing", was supervised by Prof. Valerio Pruneri.

Abstract

The mid-infrared (mid-IR) spectral region, with wavelengths between 3 and 15 μm , is known 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 are expensive and often inferior in performance compared to their visible and near-IR counterparts.

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

Thesis Committee

Dr. Prantik Mazumder, Corning Inc.

Prof. Dr. Majid Ebrahim Zadeh

Prof. Dr. Javier Alda Serrano, Universidad Complutense de Madrid



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