Université Côte d'Azur (Nice)
École doctoral sciences fondamentales et appliquées n°364
PhD thesis offer

Title: Metasurface enhanced endoscopy for in-vivo photodiagnostic

Endoscopy imaging techniques have attracted much attention thanks to their capability to non-invasively image deep in the living tissues surpassing the conventional imaging techniques limited by absorption and scattering. Their recent miniaturization allowed their application not only for probing hollow organs but also for dense living media such as in the brain [1]. For example, thanks to their ability to perform without additional imaging optical lenses, multicore fibers are very promising for further miniaturization and flexibility of endoscopic systems [2]. Although good performances have been achieved on miniaturized endoscopic systems, there is still non-solved issues that limit their use for clinical application. Most of these problems are related to the beam shaping through the fiber in order to focus and scan the light at the distal end of the fiber. Currently, bulky systems including scanning mirrors and SLM (spatial light modulator) are used.

In this project, we aim to explore the possibility of integrating metasurfaces inside the endoscope in order improve its performances. Metasurfaces are miniature, flat optical components made of arrangements of scattering objects (meta-atoms) of subwavelength size and periodicity capable to control the properties of the reflected and transmitted light in amplitude, phase, and polarization [3, 4]. During the last decade, metasurfaces have been studied and used for various applications in different domains including holography, AR/VR, Lidar, microscopy for both medical and non-medical use. However, despite the various advantages of metasurfaces, their implementation in miniaturized endoscopes is still scarce.

Metasurfaces gives the opportunity to arbitrary manipulate the light with extremely thin components. They can simply replace the bulky systems that are currently used for endoscopy, but furthermore, they are able to bring new functionalities that are not achievable with classical devices.

The successful candidate will have the opportunity to work at the interface between nanophotonics and advanced imaging techniques. She/He will have the opportunity to design, fabricate and characterize innovative metasurfaces adapted for endoscopy application. She/He will integrate the fabricated metasurfaces in the endoscopy imaging systems and study the final performances with physical and biological samples.

This project is in close collaboration between three laboratories: **CRHEA _ Nice (Dr. Samira KHADIR)** for metasurface development, **Institut Fresnel _ Marseille (Dr. Hervé Rigneault)** for the development of the endoscope and imaging application, and **PhLAM _Lille (Dr. Esben Andresen)** for design and optical fiber development.

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