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Metaphotonics for Advanced Imaging Technologies

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Abstract – In recent years, interest in infrared (IR) imaging has grown significantly, driven by its applications in autonomous navigation, quality control, healthcare, and defence. However, conventional IR imaging devices face several challenges, including the requirement for low-temperature operation, high noise levels, and the inability to simultaneously detect visible light. An emerging all-optical approach, known as up-conversion IR imaging, offers a promising solution to these limitations. This technique employs bulk nonlinear crystals to convert IR images into visible ones through sum-frequency generation (SFG), a nonlinear optical process. By converting infrared wavelengths into the visible range, up-conversion imaging allows IR detection using conventional and cost effective visible-light detectors.

Resonant metasurfaces have recently demonstrated significant potential for enhancing parametric nonlinear optical processes, such as harmonic generation and SFG. Unlike bulk nonlinear crystals, metasurfaces leverage their resonant behaviour to increase the efficiency of frequency conversion processes, eliminating the need for phase matching and the associated wavelength constrains. In my talk, I will present the design and characterisation of resonant metasurfaces for efficient frequency conversion and up-conversion IR imaging. Our approach enables the development of compact, lightweight devices that can be seamlessly integrated into everyday eyewear, preserving visibility of ambient light while adding minimal weight. This miniaturisation is key to achieving practical, room temperature IR detection.