OSK OPTICAL SOCIETY OF KOREA 사단법인 한국광학회 Optical Society of Korea

광과학 분과 Online Lecture Series

Metaphotonics for Next-Generation Photonic Devices

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Fri. Oct 15th, 2021, 11:00 AM

https://korea-ac-kr.zoom.us/j/86286075798?pwd=cVIxVGlKSkd3eVlPcDlBQTk2VWpydz09

Metasurface science is further expanding field of optics and photonics by providing alternative device platform of ultra-compact and multifunctional flat optical devices. Along with the advances in design principles for metasurfaces, the metasurface can realize multi-functionality within a single optical element, in which multiple degrees of freedoms of light can be modulated simultaneously at will.

In this talk, I will introduce recent progress in metasurface enabled display and imaging applications. First, I will present high-efficiency interactive meta-holographic displays, which can switch holographic images according to external stimuli like voltage, heat and touch sensing [1]. For examples, the voltage-responsive metahologram is able to switch the holographic images within few milliseconds promising for real-time video holographic displays demanding 60 ~ 120 frames/s. Also, the heat or touch-responsive metaholograms can monitor external temperature and impact by visualizing different hologram images according to the pre-programmed external stimuli standard. Such demonstrated systems may permit a diverse range of smart sensing and display applications such as smart hologram labels monitoring temperature/pressure/touch changes and interactive holographic displays recognizing haptic motions. Secondly, I will propose a compact gas sensor platform to autonomously sense the existence of a toxic volatile gas and provide an immediate visual holographic alarm [2]. By combining the advantage of the rapid responses to gases realized by liquid crystals with the compactness of holographic metasurfaces, we develop ultra-compact gas sensors without the requirement of additional complex instruments or machinery to report the visual information of gas detection. Thirdly, I will introduce a vectorial holographic color print for advanced security application [3]. The electrically tunable optical security platform aims advanced two-level encryption: Color printing image that can be decrypted by camera scanning provides first key and corresponding information will be used to fully unlock the double-encrypted information via projected vectorial hologram images. Also, such a strategy enables real-time video holographic displays with a single flat-optical device that does not demand a further external light modulator (e.g. spatial light modulator) or additional optical components. Finally, I will show an electrically tunable varifocal metalens that operates at visible wavelengths [4]. By combining a metalens with a liquid crystal cell, we are able to successfully demonstrate active switching between focal planes on the scale of milliseconds. Also, a point cloud generating metasurface for advanced 3D depth imaging or LiDAR application will be introduced.

We believe such dynamic metaphotonic devices will further accelerate real-life applications such as video holographic displays, photorealistic full-color reflective displays, focus-tunable metalenses for AR/VR display, LiDAR [5], unconventional photonic sensors, wearable gas sensors and photonic security platforms.

[1] I. Kim *et al.*, *Advanced Materials* 32, 2004664 (2020)
[2] I. Kim *et al.*, *Science Advances* 7, eabe9943 (2021)
[3] I. Kim *et al.*, *Nature Communications* 12, 3614 (2021)
[4] I. Kim* *et al.*, *Advanced Science* 9, (2021)
[5] I. Kim *et al.*, *Nature Nanotechnology* 16, 508 (2021)

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