Chang-Hua Liu
Jiajiu Zheng, Shane Colburn, Taylor K. Fryett, Yueyang Chen, Xiaodong Xu, Arka Majumdar
Institute of Photonics Technologies, National Tsing Hua University

chliu@ee.nthu.edu.tw

Developing ultrathin light emitters and metalenses based on van der Waals materials

Van der Waals (vdW) materials have generated strong interest in recent years due to their unusual and superior optoelectronic properties. These materials can be integrated on any substrate without needing explicit lattice matching. This presents new opportunities for creating hybrid nano-structures which can take advantage of industrial semiconductor manufacturing technologies, while benefiting from the unique properties of vdW materials. Here, we will outline an architecture of ultrathin light emitter, composed of 2D heterostructures light emitting diode stacked with a photonic crystal cavity. The light emission near the cavity area is highly linear polarized with the degree of polarization ~84%. More importantly, its emission intensity is enhanced by more than 4 times. As applying voltage pulses, we show the emitter can be modulated at 1 MHz speed at room temperature, faster than most of optoelectronics based on transition metal chalcogenides.

In addition to light emitters, we will demonstrate dielectric metalenses with their thickness approaching ~0.14 λ. Such features are realized by exploiting two-dimensional (2D) materials as dielectrics while leveraging incomplete phase design. Based on these design schemes, the developed ultrathin devices not only can be applied at 1310, 650 and 450 nm wavelength regimes, showing near diffraction-limited focusing, but also exhibit their capabilities for imaging applications. Due to the van der Waals (vdWs) nature of 2Ds, the fabricated dielectric metalenses can be transferred onto different substrates, including flexible substrates, for stretching and tunable focusing applications. Our work enables further downscaling of optical elements and opens the door for future imaging, spectroscopy, and energy harvesting applications.

References

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