Realization of Spatio-spectral Selectivity via Manipulating Radiation Asymmetry in Bilayer Metagratings

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Spatio-spectral selectivity, the capability to simultaneously select a specific wavevector (angle) and wavelength, is imperative for light emission and imaging. In fact, separately selecting a specific wavelength or angle has been investigated for a long time by designing resonant modes in photonic structures, such as photonic crystals and microcavities for wavelength selectivity [1], or zero-index structured material and Brewster angle-enabled effect for angular selectivity [2]. In contrast, concurrent selectivity of both angle and wavelength within a broad spectrum is still a problem remained to be solved. The challenge roots in the inherent dispersion relationship between resonant wavelength and angle for resonant modes in periodic photonic structures, which results in continuous angular resonance along the dispersion.

On the other hand, it′s known that the resonant spectrum is strongly related to the behavior of resonant modes, including intrinsic frequency, quality factor and radiation asymmetry in the upward and downward directions. In previous works, it has been well demonstrated that the intrinsic frequency and quality factor of resonant modes determine the resonant wavelength and bandwidth of resonant spectrum, respectively [3]. However, the role of radiation asymmetry in shaping the resonant spectrum still remains elusive.

Here, we reveal that radiation asymmetry actually gives a new dimension to tailor the resonant spectrum. Based on the bilayer metagratings, we achieve independent modulation of directionality and phase difference of resonant modes [4]. Then, through elaborate design of radiation asymmetry along the dispersion, we realize discrete resonance at the angle of zero, leading to spatio-spectral selectivity. Experimental characterization of spatio-spectral selective imaging shows a high-contrast selective imaging at the wavelength of 1342 nm and angle of 0°. Our findings shed light on the underlying mechanism of radiation asymmetry in shaping the resonant spectrum and will show broad applications in directional thermal emission, nonlocal beam shaping, augmented reality, precision bilayer nanofabrication, and biological spectroscopy.

References

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