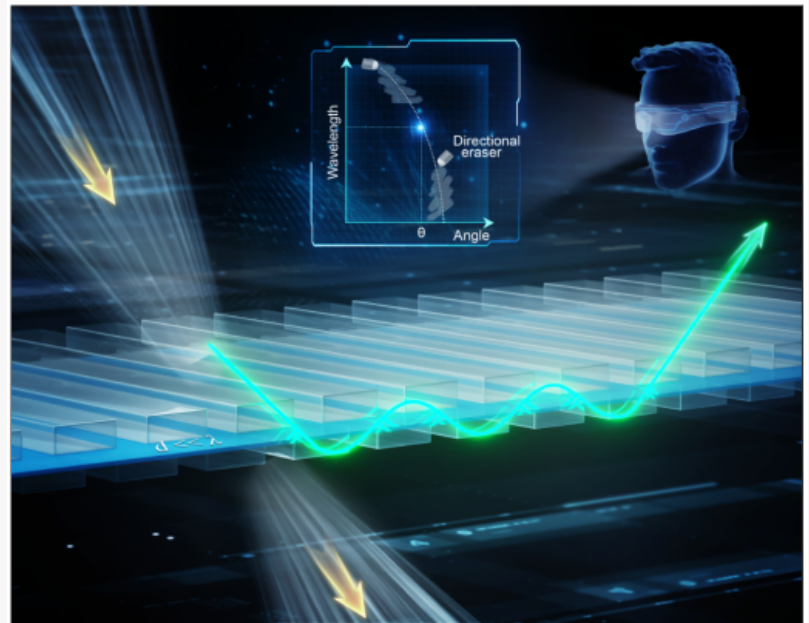


Overcoming Intrinsic Dispersion Locking by Misaligned Bilayer Metagratings

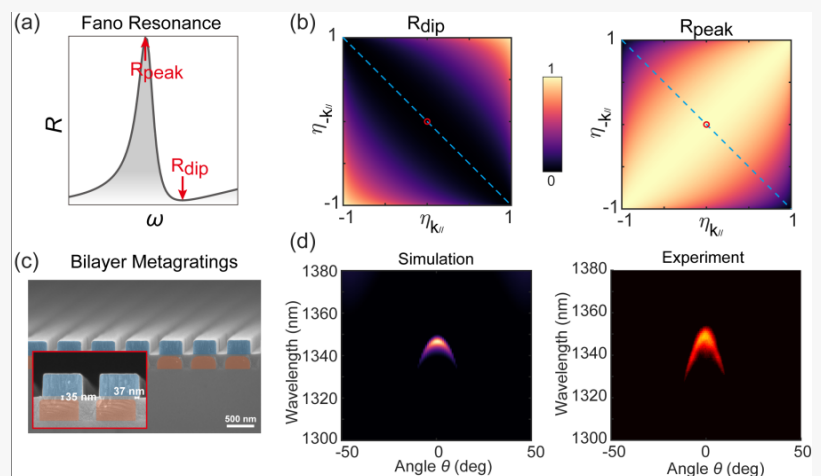
FAYETTEVILLE, GA, UNITED STATES, July 10, 2025 /EINPresswire.com/ -- [Intrinsic dispersion](#) in periodic systems sets a fundamental bound for independent selectivity of resonant angles and wavelengths. This hinders applications requiring concurrent selectivity of angles and wavelengths, such as AR/VR, coherent thermal emission and light detection. Scientists in China proposed a method to on-demand tailor the angle-dependent resonant reflection via radiation directionality in misaligned bilayer metagratings. This strategy enables perfect reflection at a single angle and a single wavelength, overcoming the intrinsic dispersion locking.

Wavelength and propagation direction (angle) are two fundamental properties of light. The ability to selectively control both a specific wavelength and a specific angle forms the physical foundation for many advanced optical applications. However, due to the intrinsic dispersion in periodic systems, there exists an intrinsic locking relationship between angle and wavelength in the resonant spectrum.

As a result, it has been widely accepted that changing the angle of incidence inevitably shifts the filtering wavelength of optical devices. This relationship between angle and wavelength in resonant spectra makes their independent control challenging and imposes fundamental limitations on optical applications. Examples



Schematic of tailoring the resonant reflection via radiation directionality in misaligned metagratings.



Theoretical design and experimental realization of the misaligned bilayer metagratings.

include rainbow artifacts in AR waveguides caused by dispersion, image quality degradation due to lateral chromatic dispersion in wide-field imaging, angular crosstalk in photodetectors reducing spectral reconstruction accuracy, and limitations in designing high-efficiency directional light sources.

In a new paper published in eLight, a team of scientists, jointly led by Professor Jian-Wen Dong from Sun Yat-sen University, and Lei Zhou from Fudan University, have discovered that the radiation directionality of optical modes is key to overcoming this fundamental challenge. Through theoretical analysis, they established a complete phase diagram for engineering resonant spectra via radiation directionality, revealing that spatial inversion symmetry and highly directional radiation of optical modes are the essential physical conditions for breaking angle-wavelength locking.

Based on this, they introduced a degree of lateral displacement in bilayer metagratings. This design preserves spatial inversion symmetry while breaking vertical mirror symmetry, enabling precise angular control of radiation directionality. Theoretically, they predicted that resonant reflection occurs only at normal incidence and near the central wavelength. They also proposed general designs for achieving spatio-spectral selectivity at arbitrary angles and wavelengths.

“Radiation directionality acts like a ‘magical eraser’, allowing us to precisely suppress light’s spectral signature along a dispersion curve. This capability allows for independent selectivity of angle and wavelength, overcoming the limitation imposed by intrinsic dispersion” they summarized.

“Experimental fabrication of the bilayer metagratings is another challenge, since achieving both the flatness of ultra-thin spacer layers and the precise lateral misalignment between layers requires sophisticated nanofabrication techniques” they added.

To address this, they have developed a novel fabrication approach involving multiple etching steps, indirect thickness measurements, and iterative deposition processes. This was combined with a high-precision bilayer alignment technique to successfully fabricate high-quality, near-infrared working bilayer metagratings. This method offers excellent spacer flatness and thickness tunability, ~10 nm alignment accuracy, and compatibility with various spacer materials, establishing a flexible experimental platform for studying bilayer photonic systems.

Using this platform, they experimentally demonstrated high reflectance happening only at a single angle and a single wavelength. To confirm that the novel reflectance roots in the radiation directionality, they also performed angle-resolved optical microscopy measurements to characterize the radiation directionality of the sample. By combining temporal coupled-mode theory with cross-polarization measurement techniques, they quantitatively measured the unidirectional radiation of the resonant modes.

Furthermore, the research team have pioneered the development of millimeter-scale, high-

precision bilayer metagratings and successfully achieved high-contrast imaging with concurrent spatial- and spectral-frequency selectivity at 0° and 1342 nm. This opens new opportunities for compact optical imaging and optical computing technologies.

“This research not only offers an innovative solution to address the fundamental challenge of independently controlling angle and wavelength, but also provides new insights for technological applications such as AR/VR displays, spectral imaging, coherent thermal radiation, and advanced semiconductor manufacturing” the scientists forecast.

References

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