Engineering the Optical Properties of Metasurfaces through Meta-Atom Structural Design

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Metasurfaces have recently garnered significant attention due to their ability to manipulate light properties. These thin layers, with subwavelength thicknesses, facilitate the development of diverse optical devices, including color reflectors, optical cavities, emitters, and meta-lenses. This manipulation is achieved by controlling fundamental properties. The optical characteristics of these devices are determined by underlying optical resonances, which dictate far-field properties and influence the overall optical response. Structural engineering of constituent meta-atoms allows meticulous tuning of these resonant modes. In particular, Mie resonances in dielectric meta-atoms have been extensively employed to achieve directional emission characteristics through constructive interference among multiple resonant modes.

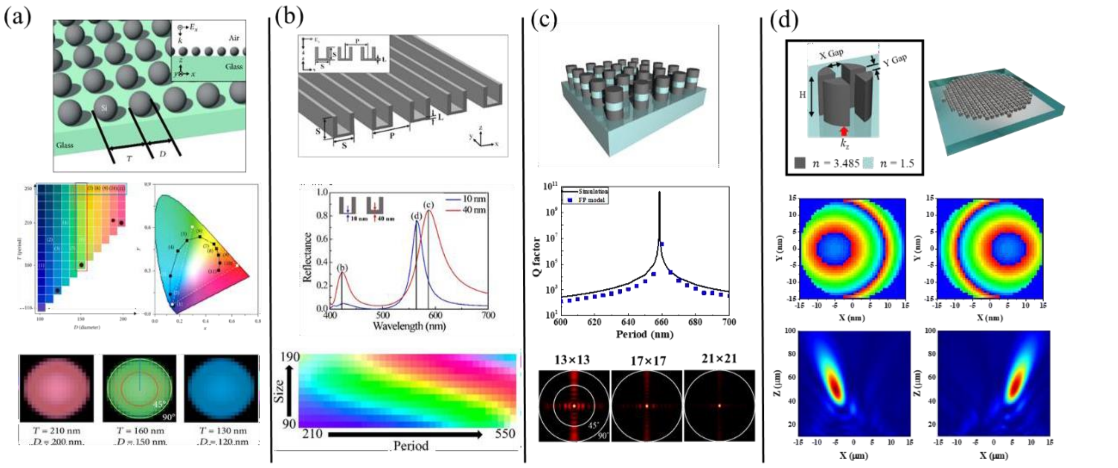

Figure (a) Color reflector metasurface, (b) Silicon U-shape metasurface, (c) Ultrahigh Q cavity metasurfaces, (d) Metalens

Our research investigated far-field properties by designing dielectric-based meta-atoms that combine multiple optical resonances. Leveraging these tailored resonances, we have developed metasurfaces capable of operating as color-reflective elements, optical resonant cavities, and metalenses. This work introduces systematic approaches to metasurface design, enabling precise control of optical responses and laying the groundwork for advanced optical device applications, including lasers, displays, and imaging lenses.

References

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