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# Recent Advances in Metasurface-based Optics for THz Imaging Systems

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The terahertz (THz) frequency range is emerging as a key enabler for next-generation wireless communications, sensing, and imaging systems due to its large available bandwidth and unique interaction with matter. However, practical implementation remains challenging due to high propagation losses, atmospheric absorption, alignment sensitivity, and the limited availability of compact, efficient, and “easy to fabricate” beam-control components. Metasurface-based optics have already attracted attention as a promising alternative to conventional refractive and reflective elements, offering ultrathin, lightweight, and customizable wavefront manipulation capabilities [1-4].

This contribution will highlight the current state and the recent achievements of the beam-shaping optics for THz and sub-THz frequencies. Recent developments have demonstrated that carefully engineered metasurfaces can simultaneously manipulate transmitted and reflected wavefronts, enabling beam steering, focusing, and structured beam generation within a single ultrathin device. Experimental studies in the sub-THz frequency range reveal that laser-fabricated metallic metasurfaces can be successfully integrated into various imaging systems, such as single-pixel direct or homodyne imaging, providing enhanced functionality while maintaining performance comparable to systems equipped with classical beam-shaping components. Dual-mode operation (reflection and transmission modes), as well as Gaussian and Bessel-beam-forming structures, will be presented and discussed. Such unique functionality, attributed to metasurface-based structures, is particularly attractive for non-line-of-sight communication links, beam routing, multi-channel architectures, and compact imaging systems. Finally, the potential of higher-order resonant modes to enable operation at increasingly higher THz frequencies without demanding prohibitively small fabrication features will be outlined.

REFERENCES

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