The 8th International Conference on Optical Terahertz Science and Technology, paper 97, Tu-P-22, USA, (2019)

Low-loss terahertz lens and vortex generator using planar porous components

Hichem Guerboukha[1], Kathirvel Nallappan[1], Mohamed Seghilani[2], Jose Azana[2], and Maksim Skorobogatiy[1]

1. Engineering physics, Polytechnique Montreal, Montreal (QC), Canada.
2. Institut National de la Recherche Scientifique – Énergie Matériaux et Télécommunications, Varennes, Canada.

Low-loss beamforming components such as lenses, polarizers, phase plates, beam steerers are needed to enable many applications in THz sensing, imaging and communications[1]. These devices modify the phase of the wave when it propagates following $\phi = (2\pi/\lambda)nh$, with n the refractive index (RI) and h the thickness. Conventional designs vary the thickness (convex lenses for example). However, the absorption losses can become important. Recently, several design of metamaterial beamforming devices have been proposed for the THz range, including lenses [2] and orbital angular momentum (OAM) phase plates [3]. Typically, these devices function with a resonance mechanism that can lead to high ohmic losses in metallic metamaterials. At the same time, effective medium theory (EMT) can be used to design porous devices at the THz frequency band. As air remains the material with the lowest absorption losses, artificial pores in a dielectric have been successfully used in the past for low-loss THz waveguiding [4]. In this work, we use the EMT to design, fabricate and characterize a planar lens and an OAM phase plate. We then show that in the losses are smaller than the losses in their variable-thickness counterparts.The planar components are designed by varying the local effective RI by introducing subwavelength holes in a host material (acrylic). When the hole diameter is smaller than the wavelength, the radiation will experience a complex effective refractive index between n_a and n_m (Fig. 1a). We design and fabricate a lens by varying the hole size as a function of the radius (Fig. 1b). Using a THz-TDS imaging system, we confirm that the beam is well focused (Fig. 1c). We also fabricate an OAM phase plate (Fig. 1d) and we confirm that we obtain a donut-shaped amplitude and an angular phase (Fig. 1e). We then theoretically demonstrate that the obtained components have larger transmission (T_{por}) than their variable thickness counterparts (T_{std}). For example, in Fig. 1f, the ratio T_{por}/T_{std} is larger than 1 for some of the material refractive index and losses.

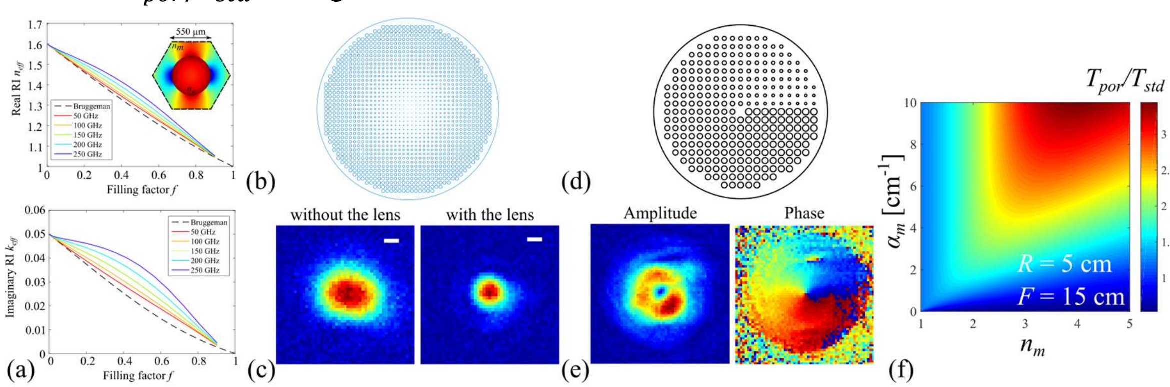

Fig. 1. (a) Effective refractive index when varying the hole size. (b) Porous lens. (c) THz imaging at 200 GHz with and without the lens. (d) Design of the OAM phase plate. (e) Amplitude and phase of the obtained OAM state. (f) Transmission ratio as a function of the absorption losses and refractive index

References

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