Broadband Terahertz All Silicon Rod Array Antenna Integrated with Photonic Crystal Waveguide and Half-Maxwell Fisheye Lens

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The terahertz (THz) range has significant potential for wireless communications due to large, underutilized spectral bandwidth. Broadband antennas are required to realize such applications. Previously, a compact rod array antenna with a gain of 20 dBi across 315 – 390 GHz was implemented in all-silicon photonic crystal waveguide platform [1]. However, the bandwidth of conventional photonic crystal waveguide is typically limited. Recently, a broadband THz photonic crystal waveguide was developed that suppresses Bragg mirror effects [2] and was integrated with a gradient-index (GRIN) effective medium half-Maxwell fisheye lens, for slab-mode beam collimation [3]. Here, this structure is employed to feed an array of dielectric rods, which provide index matching to free-space, to realize an antenna with broad bandwidth of 260 – 380 GHz. The antenna consists of a broadband photonic crystal waveguide, a half-Maxwell fisheye lens and an array of rod antennas (Fig. 1). All components are integrated together, and fabricated from a single low-loss intrinsic silicon wafer in the same etch process. THz waves are coupled to the antenna via a tapered spike at the termination of the waveguide in order to characterize its performance, and results are shown on Fig. 2. Measured antenna gain is in the vicinity of 20 dBi across the operation bandwidth and in reasonable agreement with simulation. This antenna gain is enhanced by the half-Maxwell fisheye lens which produces a broad, planar wavefront prior to radiation via the rod array. In simulation, reflection coefficient is found to be lower than -10 dB across the 120 GHz operation bandwidth. This broadband matching is owed to progressive matching structures at all interfaces, both in the form of the tapered spikes shown on Fig. 1(a) and (c), and GRIN structure shown on Fig. 1(d).

We have demonstrated a broadband photonic crystal integrated rod array antenna with ~20 dBi gain across a 120 GHz bandwidth, from 260 to 380 GHz, i.e. an increase of bandwidth of at least 60% compared to the previous work [1]. This device holds potential for applications in wireless THz communications.

References

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[2] D. Headland, M. Fujita, and T. Nagatsuma, *IEEE J. Quantum Electron.*, **26** (2020) 4900109.
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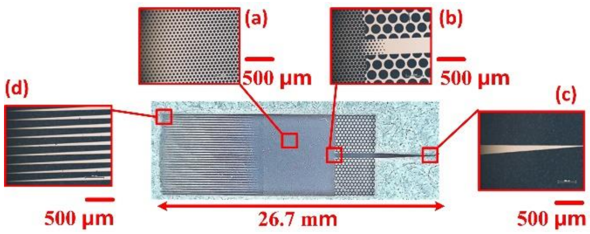

Figure 1. Fabricated antenna, (a) Maxwell fisheye lens, (b) lens – waveguide intersection, (c) taper for feed, (d) rod array

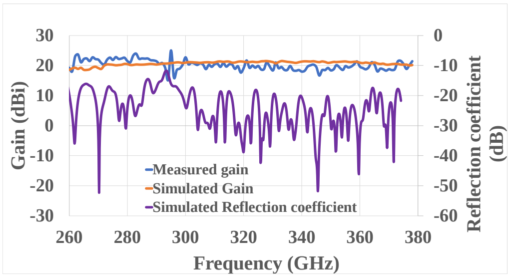

Figure 2. Test results of the fabricated antenna