All-dielectric taper rod antenna with non-uniformly distributed sub-wavelength gratings

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The terahertz spectrum is capable of supporting wireless communications at high speed owing to its wide absolute bandwidth. To achieve the terabit transmission speeds with high efficiency, broadband antennas are essential. One promising approach is to use all dielectric structure, since without metals ohmic losses can be avoided and high efficiency can be achieved. In the field of dielectric antenna, there are already devices with board bandwidth and high gain, but they often have a large footprint [1-2]. Therefore, we present a compact all-dielectric taper rod antenna with non-uniformly distributed sub-wavelength gratings, which maintains both moderate gain in broadband and low profile in scale.

Research in optics on sub-wavelength gratings (SWG) [3] has demonstrated that by adopting the SWG, the refractive index along the propagation direction can be controlled through manipulating the parameters of the gratings including period, width and length. Consequently, diffraction effects can be suppressed, which helps the leakage of power along the taper, leading to gain enhancement when combined with taper antenna. To further increase the gain, here we designed a non-uniformly distributed SWG by using genetic algorithm to optimize the structure for maximized gain. The design is shown in Fig. 1(a). The distribution of the SWG is initially parabolic. However, when the spacing between two adjacent gratings is larger than wavelength, back-reflection occurs. In order to avoid that, we split the large spacings and large gratings into half to satisfy the sub-wavelength conditions.

In order to measure the performance, the antenna is fed by an effective medium clad waveguide, which supports both in and out of plane polarizations [5]. As shown in Fig. 1(b), simulated results show that the average gain for the E_x-mode is 14.7 dB and for E_y-mode is 13 dB. On average, the proposed structure enhances 2 dB gain for the E_x-mode and 1.5 dB for E_y-mode when compared to the same-length bare taper rod antenna. Fig.1(c) shows the radiation pattern of the proposed antenna on E-plane and H-plane, showing the low sidelobe characteristics. For both modes, the side level reaches -15 dB. The 3 dB angular width of E_x-mode is 37 degrees, and for E_y-mode, it reaches 47 degrees. Fig.1(c) also shows that the mainlobe level reaches nearly 15 dB in E_x-mode and 14 dB in E_y-mode at 275 GHz, which corresponds to Fig.1(b). The devices have been fabricated with DRIE etching from high-resistivity float-zone silicon, and measurements are on-going.

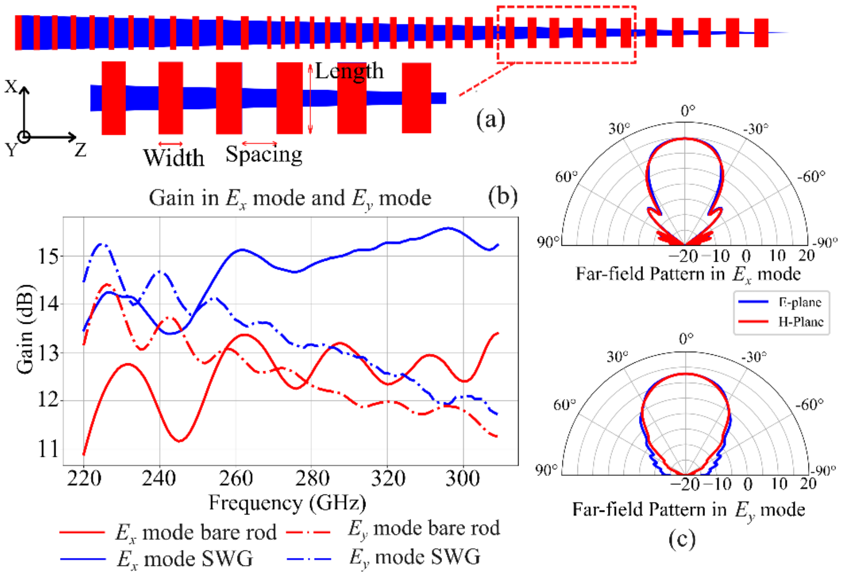

Fig. 1: (a) Antenna Structure and parameters. (b) Gain in E_x -mode and E_y-mode over 220 GHz to 330 GHz. (c) Far-field radiation pattern at 275 GHz in E_y-mode and E_x-mode at E-plane and H-plane

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