Integrated Planar Antenna with High Field Enhancement for On-Chip Electro-Optical Modulator Design

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On chip antennas with integrated electro-optic modulators (EOMs) are attractive for millimeter wave applications. Such EOMs are placed at the antenna feed and enable the mixing of the incoming millimeter wave (mm-wave) signal with an optical carrier. As such, the mm-wave capture is turned into an optical signal that can be easily processed for imaging using standard infrared cameras. Our proposed on-chip antenna with the EOM modulator operated at 94 GHz or 77 GHz, with the antenna tuned at that frequency. For high modulation efficiency, it is critical that the modulator region is as small as possible with the optical waveguide leading to the EOM, also being well-matched. Notably, the enhanced field at the antenna feed leads to higher modulation efficiency and sensitivity. Therefore, an optimum antenna design must hasve as large as possible field strength at the feed.

In this paper, we present two optimum topologies, namely a microstrip patch with a slotted feed, and a bowtie antenna with extended bars at the apex/feed. To improve efficiency and form factor, the antennas are integrated directly onto the active region of the polymer-based EOM fed by an optical waveguide. Notably, conventional antennas had to be modified to achieve a feed port that is best suited for the selected EOM. Also, our design procedure takes into account the TEM optical waveguide and the eigen frequencies of the EOM for best performance. In absence of a feed lines, it is shown that an optimum field enhancement can be achieved by controlling the antenna topology, including the slot gap width and length. Notably, antenna gain and efficiency affect the overall EOM operation and sensitivity. An appropriate planar electromagnetic bandgap structure is also designed to suppress surface waves that can impact antenna gain. At the meeting, we will present design details for the EOM and associated materials, and achieved reception efficiency and sensitivity. Also, measurements of the specific mm-wave antenna with the integrated EOM will be presented.