Planar Millimeter Wave Antenna Design for On-Chip Electro-Optical Sensing Devises

Abe Akhiyat* and John L. Volakis
Dept. of Electrical and Computer Engineering, College of Engineering and Computing
Florida International University, Miami, FL 33174, USA
Email:{ aakhiyat, jvolakis} @fiu.edu

A challenge with millimeter wave antennas is the efficient coupling for the received signal to the next device, usually a low noise amplifier. At low frequencies, matching signal to the next deice is not a issue. However , at 94 GHz, Ohmic losses in matching networks degrade signal strength. In most cases low noise amplifiers remedy this issue problem at a cost. However, in certain emerging sensing applications, the amplification process may not be an option and must, therefore, do away with the low noise amplifier. One of these applications relates to sensors that make use of optical up-conversion. In such cases, the millimeter wave antenna is integrated with an electro-optic modulators (EOM). Concurrently, it is necessary to preserve the signal's integrity all the way to the active region of the optical modulation. One way to improve efficiency and form factor of the anrenna-EOM design is to package the active EOM with an electro optic polymer waveguide. In this paper we present two planar topologies integrated with an EOM for sensing at 77 GHz and 94 GHz.

In absence of a 50Ω feed line, the case for the proposed EOM design architecture, conventional formulas and design procedure are no longer valid, and a new design method is warranted. Notably, we propose a design procedure that makes use of a TEM waveguide followed by an eigen analysis for verification. The polymer waveguide integration is presented herewith using two antennas. One antenna is a patch with an inserted slot through its middle to serve as the feed and EOM polymer insertation. For the second antenna, a conductor backed bowtie is employed with its apex forming a narrow slot. The later slot is also modified with an extended conductor bar, needed to increase EOM efficiency, viz millimeter to optical wave conversion.

For the proposed architecture, a key parameter for an efficient EOM modulation is the strength of the field within the slot. It is therefore important to ensure antenna feed designs that provide localized field enhancement (FE). Results shows, that even in absence of a feed line, an optimum field enhancement can be obtained while controlling the topology of the antenna design parameters such as the slot gap width and length, and even gain. To further improve field enhancement, we proposed the placement of an electromagnetic bandgap (EBG) surface into the design. At the meeting, we will show the optimization of the via-less planar EBG structure. It is demonstrated that the suppression of surface waves leads to a two-fold increase of the field within the antenna feed gap. We will use thi improvement to enable overall improve the efficiency of a millimeter wave imaging camera.