Millimeter Wave Antenna Design for On-Chip Electro-Optical Sensing Devices Using Optical Up-Conversion

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Advances in Electro-Optics (EO) in terms of materials and micro-and-nanofabrication processes have provided new capabilities for EO sensing devices. These new capabilities include increased sensitivity, tolerance to electromagnetic interference, and higher bandwidth performance. One such widely used device is the electro-optic modulator (EOM). EOM makes use of an incident RF signal to modulate an optical carrier. In a functional EOM, the modulation take place within the active optical area of the nonlinear EO device material. These nonlinear EO materials have an electro-optic effect properties. Examples of these materials are nonlinear polymers and lithium niobate (LN).

For an electro-optic modulation to occur an RF signal is carried to the vicinity of the active area of a propagating optical signal. At low RF frequencies where signal power levels can be easily obtained or mitigated, routing an RF signal using traces and electrode suffice. However at millimeter (77GHz and higher) material and matching losses, have precluded the successful use of EOMs for imaging at mm-Waves and Electromagnetic sensing without recourse to demanding amplification, cost and additional circuitry.

To improve the EOM efficiency and RF-to-optical up-conversion performance, we consider the antenna integration directly onto the EOM and ovoid using electrodes and long conductor traces. An illustration is shown in figure1. Two suitable planar antenna topologies integrated onto an EOM architecture for electromagnetic radiation sensing and imaging at 77 GHz and 94 GHz are presented. These antennas have the characteristics of being planar and are realizable using a micro-fabrication processes. One of the antennas shown in figure 1 is a conductor backed microstrip bowtie with its apex forming a narrow slot. This slot is made longer using two extended conductor bars to increase the optical and RF signals interaction length, and therefore improve conversion efficiency.

Since the proposed EOM architecture is not a 50Ω system, conventional antenna design procedure is not applicable. Therefore, we will present a different design methodology. Notably, we propose a design that makes use of a TEM waveguide to achieve not only an optimal matching, but also an optimum field enhancement within the gap separating the antenna arms. This field enhancement property is the main contributor to modulation efficiency increase. Results will be shown to have a substantial increase in the field enhancement within the antenna feed gap. As well as the micro-fabrication process will be presented and discussed.

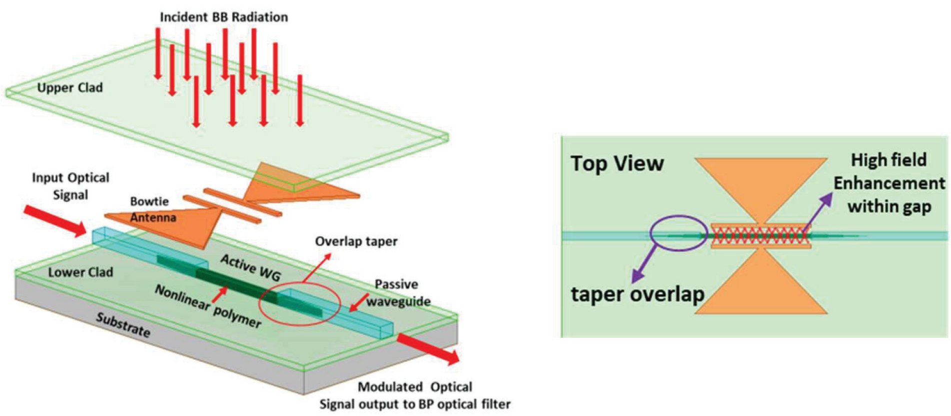

Figure 1. Electro-Optic Modulator with an integrated bow-tie microstrip patch antenna. Left: components stack. Right: Top view

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