A Photonic Transmitter for Beam Switching in mm-wave Wireless Links

A. J. Pascual[1], T. Batté[2], O. de Sagazan[1], G. Carpintero[3], R. Sauleau[1], and D. González-Ovejero[1]
[1]Univ Rennes, CNRS, IETR (Institut d'Electronique et de Télécommunications de Rennes) – UMR 6164, F-35000, Rennes, France
[2]Institut Foton, INSA (Institut National des Sciences Appliquées) – UMR 6082, Rennes, France
[3]Universidad Carlos III de Madrid, Leganés, Spain

***Abstract*—This abstract describes the first design and assembly of a photonically-excited antenna at E-band for beam switching in millimeter-wave wireless links. The designed antenna consists of two arrays of stacked patches, with one photodiode feeding each array. The stacked patch provides an impedance bandwidth larger than 23 % and a stable radiation pattern over the E-band. The array is combined with a lens to increase the overall gain. Excitation of either patch array allows beam steering between ±2.7º for accurate beam alignment.**

I. Introduction

INTENSE research efforts carried out over the last decades have put the photonic generation of millimeter (mm) and sub-mm wave radiation in the spotlight. Specifically, the seamless integration of photonic transmitters (*Tx*) with fiber optics, has led to numerous point-to-point wireless links demonstrations [1]. These links require stringent beam alignment control over approximately ±5º [2]. Antennas with fine beam steering could not only help to alleviate this limitation but also help to enlarge the range of applications for photonic *Tx* (reconfigurable links, imaging, etc.) However, only a few demonstrations of photonic beam steering may be found in the open literature [3]. In these cases, phased arrays are used to steer the beam, but the integration of many active elements, necessary to obtain values of gain (>25 dBi), can be challenging.

The E-band (71-76 GHz and 81-86 GHz) features promising characteristics to cope with the race to data rates in future wireless communications. Notably, it is located within an atmospheric transmission window; it offers an available bandwidth of 2×5 GHz; it is less susceptible to adverse meteorological conditions than optical wavelengths, and it presents lower free space loss than higher mm-wave frequencies. In this abstract, we propose a photonic *Tx* for beam switching at E-band to overcome the problem above.

II. Antenna Design and Assembly

The antenna consists of two independent arrays (Fig. 1). Each array is integrated with a photodiode (PD) [4] and is composed of four stacked patches. The bottom patches and the PD polarization network are printed on a 127μm-thick Duroid 5880 substrate, whereas the top patches are printed on a quartz superstrate. A 306 μm-thick micromachined silicon spacer controls the vertical spacing, and alignment marks printed on each layer enable an accurate superstrate positioning (better than ± 20 μm). An impedance bandwidth between 70.1 and 87.7 GHz is obtained for the array (S_{11} < -10 dB).

III. Results

Fig. 2 shows the schematic and ANSYS HFSS simulations of beam switching using the proposed antenna. It is placed at the back focal length (*bfl*) of a PTFE lens (*bfl* = 53mm, Φ = 5 cm) so that the two arrays lie symmetrically out-of-axis a distance *s*. The excitation of either independent array generates a tilted beam at $\theta \approx \pm s/bfl$. The tilt is controlled by their spacing or lens focal length. We achieve beam switching between ±2.7º, with crossing at -3 dB, and a stable pointing direction across the E-band. Note the antenna can be scaled in 1-D for an increased scanning range.

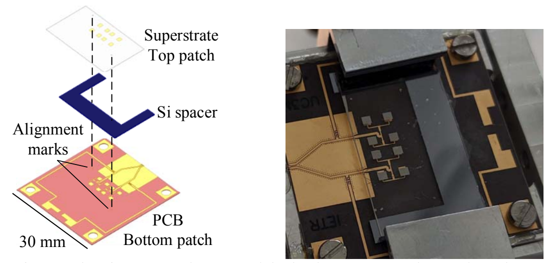

Fig. 1. Left: Stack of antenna layers with the bottom patches printed on the PCB and the top ones printed on a quartz superstrate. Right: assembled prototype.

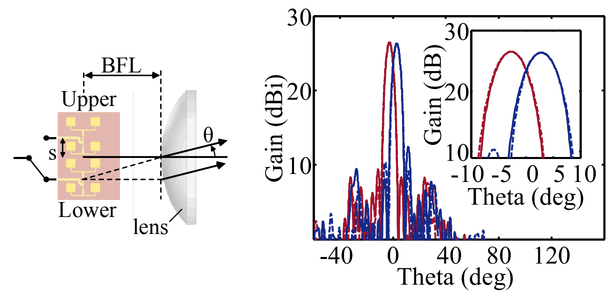

Fig. 2. Left: A 2×1 array of patches at the focal plane of a lens. Right: Simulated gain for the upper (red) and lower (blue) arrays. Continuous line: along the plane of the drawing. Dashed line: perpendicular to the plane to the drawing.

IV. Summary

This abstract proposes a broadband solution for beam switching by a photonic *Tx* at E-band. This feature is advantageous for beam alignment in several applications employing photonic *Tx* at mm or sub-mm wave frequencies. A prototype has been designed and assembled. Measurements of the radiation pattern and performance in a wireless link will be available by the time of the conference.

References

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