# Increasing the bandwidth of Dielectric Rod Waveguide Antennas for Terahertz Applications

Alejandro Rivera-Lavado[1], Luis Enrique García-Muñoz[1], Dmitri Lioubtchenko[2], Sascha Preu[3], Daniel Segovia-Vargas[1], and Antti V- Räisänen[2]

[1]Universidad Carlos III de Madrid. Departamento de Teoría de la Señal y Comunicaciones, Leganés, Madrid, Spain

[2]Department of Radio Science and Engineering, Aalto University School of Electrical Engineering, Espoo, Finland

[3]Fachbereich Elektrotechnik und Informationstechnik, Technische Universität Darmstadt, Darmstadt, Germany

***Abstract*—in this contribution, the combination of Dielectric Rod Waveguide DRW antennas with photomixer-based sources in the terahertz range is studied. They are a cost-affordable and more compact alternative to dielectric lenses, which makes them especially appealing for arrays configurations, either for increasing the generated power or for beam steering applications.**

**DRW antennas are limited in band, since such antennas radiates in the endfire direction only when the fundamental mode is supported. For avoiding such limitation, the use of embedded planar lenses is proposed.**

## I. Introduction

IMAGING applications at millimeter wave frequencies has become an attractive topic among several research groups in recent years. Typically, actually available room-temperature continuous-wave sources for cents of gigahertz are limited on such applications because of the little power-level achieved [1]. The use of Dielectric Rod Waveguide (DRW) antennas in combination to photomixer-based terahertz sources is proposed for achieving an efficient source, in term of both losses and costs.

Dielectric rod waveguide (DRW) antennas are made of low-losses high permittivity materials, such as Silicon, which leads to compact elements, in terms of free-space wavelength. At 100 GHz, only a small cross-sectional area of 0.5 x 1.27 $mm^2$ is required. This property is attractive since it can lead to arrays with lower sidelobes than other alternatives (such as lenses), and then, many discrete sources can be combined for either increasing available power or beamforming. Another desirable consequence is the low mutual coupling expected between elements, since most of the field is concentrated in the rod [2]. Moreover, the radiation pattern is frequency independent over a large frequency band [3], and they are scalable in frequency by reducing its dimensions.

A photomixer device with a printed ultra-wideband antenna (know as Antenna Emitter, AE) can produce higher-order modes in the dielectric antenna for frequencies where the DRW is electrically large [4]. For taking advantage of the inherent band of both AE and DRW antennas, only fundamental mode must be supported when a single-lobe endfire radiation pattern is desired. For achieving a single-mode regime, the use of an embedded planar dielectric lens is proposed.

## II. Proposed Design

Fig. 1 sketches the proposed topology. A DRW antenna with an elliptical planar dielectric lens is placed down the AE substrate of thickness $S_{THK}$. It is implemented by reducing the relative permittivity $\varepsilon_{ANT}$ around its shape. Lens permittivity $\varepsilon_{SC}$ is kept the same as the wafer one. Rod length $L_{TAPER}$ is chosen to be 17 mm and width $W_{ROD}$ 2.2 mm.

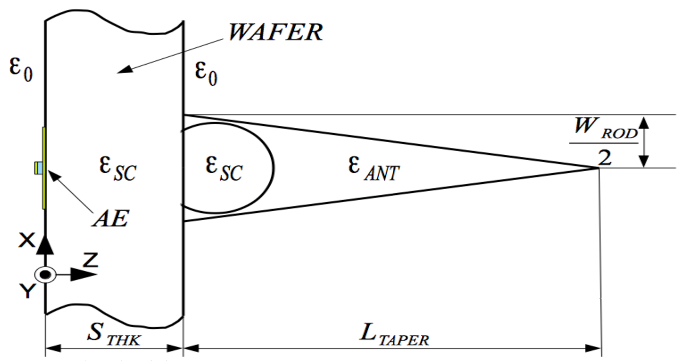


**Fig. 1.** Sketch of the system.

Fig. 2 shows a proof-of-concept manufactured and characterized in the 6-40 GHz band. Lens-based prototype (c) extends the working band from 6-12 GHz to 6-30 GHz. A sub-millimeter wave range demonstrator is being manufactured. Radiation pattern measurements will be provided in the full version of this manuscript.

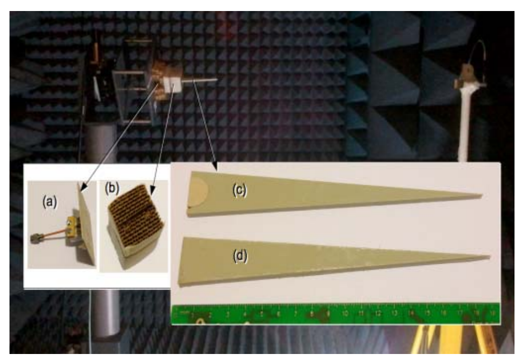


**Fig. 2.** Manufactured proof-of-concept.

## References

[1]. P. H. Siegel, "Terahertz technology," *IEEE Trans. Microwave Theory Tech.*, vol. 50, no. 3, pp. 910–928, Mar. 2002.

[2]. D. Lioubtchenko, S. Dudorov, J. Mallat, J. Tuovinen, and A. V. Räisänen, "Low-loss sapphire waveguide for 75–110 GHz frequency range," *IEEE Microw. Wireless Compon. Lett.*, vol. 11, no. 6, pp. 252–254, 2001.

[3]. J. P. Pousi, D. V. Lioubtchenko, S. N. Dudorov, J. A. Mallat, and A. V. Räisänen, "High permittivity dielectric rod waveguide antenna for 110–150 GHz," presented at the *Proc. 1st Eur. Conf. of Antennas Propag.* (EuCAP06), Nice, France, Nov. 6–10, 2006, CD-ROM SP-262, paper 347786.

[4]. Alejandro Rivera-Lavado, et al. "Dielectric rod waveguide antenna as THz emitter for photomixing devices," *IEEE Transactions on Antennas and Propagation*, vol.63, no.3, pp.882,890, March 2015.