Excellent Photonic-assisted Measurement System for High Order Mode Pattern Scan in Reactive Near Field

Ingeun Lee[1], Mun Seok Choe[2], Dong-Joon Lee[3], and EunMi Choi[1, 2]
[1]Department of Electrical Engineering, Ulsan National Institute of Science and Technology (UNIST)
Ulsan 689-798, Republic of Korea
[2]Department of Physics, Ulsan National Institute of Science and Technology (UNIST)
Ulsan 689-798, Republic of Korea
[3]Division of Physical Metrology, Korea Research Institute of Standards and Science (KRISS)
Daejeon 305-340, Republic of Korea

***Abstract*—We present experimental results of $TE_{6,2}$ mode electric field pattern results utilizing a photonic-assisted W-band measurement system and a vector network analyzer (VNA) system in the reactive near field region. We introduce the photonic -assisted W-band measurement system and demonstrate that it provides extremely precise probing capability compared to the VNA system, especially when a higher order mode pattern is scanned in the extreme near field region.**

I. INTRODUCTION

TO identify the specific modes from higher order mode generators or antennas, scanning the field patterns in the extreme near field region is necessary since fields diverge rapidly in free space. Therefore, we strongly need a probe that can measure field pattern in vicinity of the aperture of a device under test (DUT) with high resolution and less perturbation without any field distortion. An electro-optic (EO) probe, which is used in a photonic assisted measurement system, demonstrates a remarkable performance for a near field measurement, even an endoscopic measurement [1]. In this experiment, we use a femtosecond laser with a conventional double-pass EO probe [2], and a $TE_{6,2}$ mode generator operating at 95 GHz which generates pure counter clockwise rotate mode, clockwise rotate mode, and mixed rotate mode. Our experimental schematic of the photonic-assisted measurement system is illustrated in Fig. 1. A pulse repetition rate (RR) for a mode-lock laser should be accurately set since the harmonics of the pulse repetition frequency (PRF) play a role as a local oscillator. For the final setting parameters, the RR is set to be 80.0338 MHz with the 1187^{th} harmonic component of the PRF of 95.0001206 GHz, and the intermediate frequency (IF) is 0.1206 MHz [3].

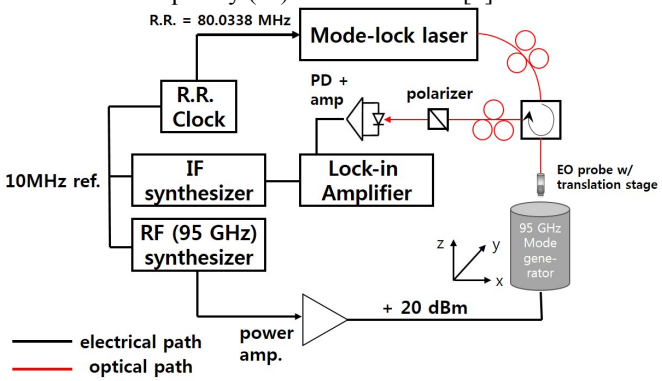

Fig. 1. The experimental schematic of the photonic-assisted W-band measurement system.

In parallel, the typical experimental setup utilizing the metal based open ended waveguide WR08 probe is performed with the vector network analyzer system. The field pattern measurement is done at 1mm ($\approx 1/3\,\lambda$) away from a 14 mm diameter aperture with 0.1mm scan resolution.

II. RESULTS

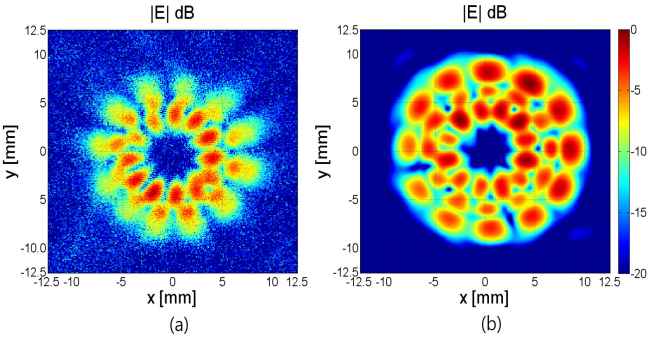

Fig. 2. $TE_{6,2}$ mode patterns at 1mm distance from the 95 GHz mode generator's aperture. (a): EO probe measured data; (b): VNA measured data.

At first, we measured mixed rotate $TE_{6,2}$ mode by two methods. In Figure 2, the field patterns measured at the same location from the aperture are plotted. We superimpose E_x and E_y data to obtain radial and azimuthal patterns. Each data set consists of 251 × 251 pixels. Although EO probe data have comparatively lower signal to noise ratio, we can clearly confirm that Fig. 2(a) indicates more accurate field pattern of the $TE_{6,2}$ mode in the reactive near field region. However, as shown in Fig. 2(b), the field pattern is significantly distorted to be a $TE_{6,3}$ mode when the open waveguide probe was used. As a result, the entire field pattern of fig. 2(b) appears larger than that of fig. 2(a), and very likely, this may result in a wrong determination of an output mode. Also, fig. 2(a) shows first radial electric field intensity is stronger than second radial electric field intensity. However, comparatively high electric field is appeared at first and third radial components in fig 2(b). Further detailed investigation of the near field scan is underway.

III. SUMMARY

We present the field pattern measurement system done by two different methods. The photonic-assisted W-band measurement system shows an outstanding performance in reactive near field region with less invasiveness and deformation. This system gives a very promising way for scanning higher order mode even in higher frequency.

REFERENCES

[1]. I. G. Lee, D. J. Lee, and E. M. Choi, "In situ endoscopic observation of higher-order mode conversion in a microwave mode converter based on an electro-optic probe system," *Opt. Express*, vol. 22, pp. 27542-27552, Oct., 2014.

[2]. D. J. Lee, N. W. Kang, J. H. Choi, J. Y. Kim, and J. F. Whitaker, "Recent advances in the design of electro-optic sensors for minimally destructive microwave field probing," *Sensors (Basel),* vol. 11, pp.806-824, 2011.

[3]. D. J. Lee, J. Y. Kwon, Y. P. Hong, and Jeffery Jargon, "Photonic-assisted Endoscopic Analysis of W-band waveguide," *IEEE Photonics Society Annual Meeting*, pp. 216-217, San Diego, USA, Oct. 12-16, 2014.