Early Skin Cancer Detection: from Desktop Imaging Setup to Real-time Handheld Device

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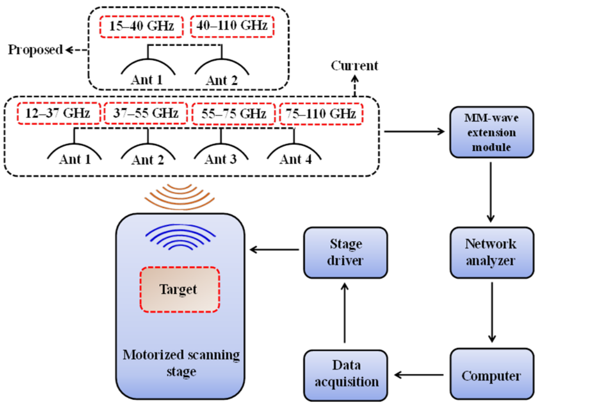

Fig. 1. The concept of ultra-wideband mm-wave imaging system for delineation of skin tissues [1], [2].

Skin cancer is the most common cancer in the United States. Early diagnosis and proper treatment of skin cancer can save lives of the patients since this cancer is highly curable at this stage with less pharmacological treatments. Among all the diagnostic methods, skin biopsy has been commonly used by dermatologists to detect skin cancer since it provides accurate results. This diagnostic procedure is simply inconvenient since it is a painful procedure and has the risk of infection or bleeding. These have motivated researchers to develop an alternative method for skin cancer detection which can provide real-time results and is more convenient and affordable than painful biopsies. Although microwave-imaging systems are cost-effective and can support nonionizing radiation, they are limited by a narrow operating bandwidth and consequently a low spatial resolution which is a critical concern when it comes to tumorous tissues diagnosis for some types of cancer. Mm-wave (30-300 GHz) imaging is proposed as a possible solution to this problem [1]. Given its promising potential for sensing and inspecting, mm-wave technology is a great candidate for biomedical imaging systems due to prime characteristics such as shorter wavelength, obtaining images with high spatial resolution, and high contrast of the dielectric property between the normal and the malignant tissues. Compared to microwave imaging systems, mm waves have shorter penetration depth which is not a key parameter in skin cancer detection. In addition, mm-wave imaging systems allow components with much smaller size which is a key factor for developing portable and handheld imaging systems. Fig. 1 shows the concept of using mm-wave imaging systems for skin cancer detection [2]. However, despite the considerable progress made and being compatible with the Federal Communication Commission safety standards, there are still major challenges that have prevented this technology from advancing into the diagnostic market. The first step towards making the current imaging system real-time to support in-vivo experiments in the clinic, is decreasing the number of the antennas from four (Fig. 1) to two antennas [2]. This will considerably reduce the overall scanning time of the imaging system and make the in-vivo experiments possible in the clinic which is not feasible with the current system. To attain an axial resolution of 200 µm in human skin tissue (with effective dielectric permittivity of 20), an ultra-wide imaging bandwidth of ~100 GHz is required [1]. In the current imaging system, this bandwidth is covered with four antennas. In this work, we have covered the required bandwidth for ultra-high-resolution mm-wave imaging system with two antennas specifically designed for small tissue diagnostic application [2]. Fig. 2 and 3 show the fabricated antennas and their S-parameters and radiation patterns, respectively.

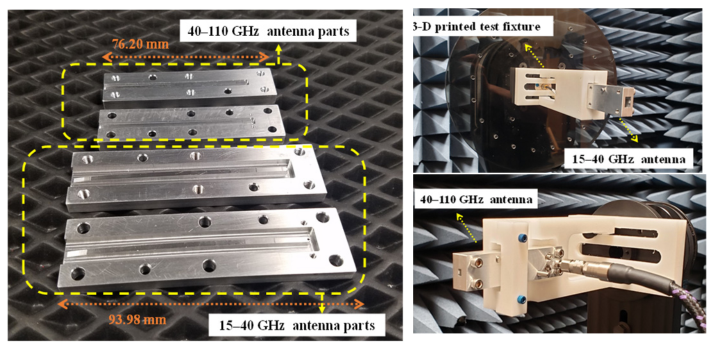

Fig. 2. Fabricated antennas before and after assembly [2].

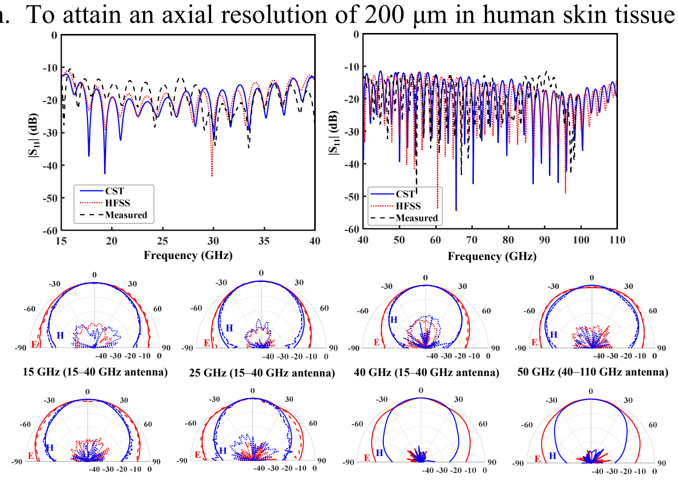

Fig. 3. S-parameters and radiation patterns of the fabricated antennas [2].

References

[1] A. Mirbeik-Sabzevari, E. Oppelaar, R. Ashinoff and N. Tavassolian, “High-contrast, low-cost, 3-D visualization of skin cancer using ultra-high-resolution millimeter-wave imaging,” *IEEE Trans. on Med. Imag.*, vol. 38, no. 9, pp. 2188-2197, Sept. 2019.

[2] M. Mirzaee, A. Mirbeik-Sabzevari and N. Tavassolian, "15-40 GHz and 40-110 GHz Double-Ridge Open-Ended Waveguide Antennas for Ultra-Wideband Medical Imaging Applications," *IEEE Open Journal of Antennas and Propagation* (*Early Acccess*).