Benefits of Employing Metasurfaces on the Design of a Microwave Brain Imaging Scanner

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Benefits of Employing Metasurfaces on the Design of a Microwave Brain Imaging Scanner

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The demand for personalized and non-invasive technologies for diagnostics of brain-related diseases is a challenge involving multiple research fields. In this context, emerging electromagnetic (EM) techniques are receiving increased attention [1]. Among these techniques, microwave imaging (MWI) has the potential to address specific clinical needs such as intra-cerebral hemorrhage (ICH) detection and monitoring. The success of an MWI brain scanner is strongly dependent on its hardware characteristics. For instance, to achieve a device capable of detecting a hemorrhage inside the brain, array of antennas immersed into a coupling medium are typically used to transmit microwaves in the 0.5–1.5 GHz frequency range into the brain tissue and receive the resulting scattered signal [2]. In addition, our previous studies have shown that metasurface (MTS) structures can be used to enhance transmission and couple the incident power into the region of interest [3].

This paper presents an innovative Jerusalem cross-shaped MTS design to be integrated with a MWI brain scanner, using the monopole antenna reported in [4]. Our study focuses on examining whether this MTS structure can enhance the "weak" signal scattered from a blood-mimicking target. To this end, we have modelled different MWI setups using CST Microwave Studio® and the MTS's interaction with EM waves has been studied. Our results suggest that the proposed MTS film can have a positive impact when placed on the head, closely fixed on the MWI antennas, as shown in Figure 1. In particular, the MTS can greatly enhance transmission, leading to higher signals scattered from the target. Moreover, we present images reconstructed through a Huygens principle-based algorithm, demonstrating that an accurate detection and localization of the target is achieved in the presence of the MTS. In conclusion, this study suggests that MTS technology can be a significant hardware advancement towards the development of functional, portable and ergonomic microwave brain imaging scanners.

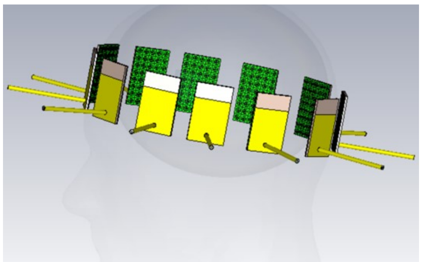

Figure 1. MWI brain scanner consisting of 12 antennas arranged uniformly around a head model. The MTS is placed adjacent to the head and closely fixed to the antennas' substrate.

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4. D.O. Rodriguez-Duarte, J. A. Tobon Vasquez, R. Scapaticci, L. Crocco and F. Vipiana, "Brick-Shaped Antenna Module for Microwave Brain Imaging Systems", *IEEE Antennas and Wireless Propagation Letters,* vol. 19, no. 12, pp. 2057-2061, 2020.

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