

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

Original

Benefits of Employing Metasurfaces on the Design of a Microwave Brain Imaging Scanner / Razzicchia, E., Ghavami, N., Rodriguez-Duarte, D.O., Tobon Vasquez, J.A., Vipiana, F., Kosmas, P.. - (2021). (ICEAA-IEEE APWC-USNC URSI RSM 2021 Honolulu, HI, USA 9-13 Aug. 2021) [10.1109/ICEAA52647.2021.9539789].

Availability:

This version is available at: 11583/2920760 since: 2021-11-25T12:11:27Z

Publisher:

IEEE

Published

DOI:10.1109/ICEAA52647.2021.9539789

Terms of use:

This article is made available under terms and conditions as specified in the corresponding bibliographic description in the repository

Publisher copyright

IEEE postprint/Author's Accepted Manuscript

©2021 IEEE. Personal use of this material is permitted. Permission from IEEE must be obtained for all other uses, in any current or future media, including reprinting/republishing this material for advertising or promotional purposes, creating new collecting works, for resale or lists, or reuse of any copyrighted component of this work in other works.

(Article begins on next page)

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

E. Razzicchia* ⁽¹⁾, N. Ghavami⁽¹⁾, D. O. Rodriguez-Duarte⁽²⁾, J. A. Tobon Vasquez⁽²⁾,
F. Vipiana⁽²⁾, P. Kosmas⁽¹⁾,

(1) Faculty of Natural and Mathematical Sciences, King's College London, Strand, London, WC2R 2LS, UK;

(2) Dept. Electronics and Telecommunications, Politecnico di Torino, DET-POLITO, Torino, Italy;

email: eleonora.razzicchia@kcl.ac.uk; david.rodriguez@polito.it

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.

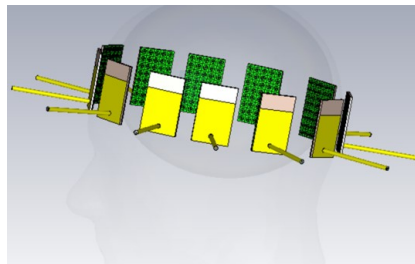


Figure 1. MWI brain scanner consisting of 12 antennas arranged uniformly around a head model. The MTS is placed adjacent to the head and closely fixed to the antennas' substrate.

1. L. Crocco; I. Karanasiou; M. James; R. Conceição, *Emerging Electromagnetic Technologies for Brain Diseases Diagnostics, Monitoring and therapy*, Springer International Publishing AG, Cham, Switzerland, 2018.

2. J. A. Tobon Vasquez, et al., “A Prototype Microwave System for 3D Brain Stroke Imaging”, *Sensors*, Vol. 20, No. 9, 2020.

3. E. Razzicchia, I. Sotiriou, H. Cano-Garcia, E. Kallos, G. Palikaras, and P. Kosmas, “Feasibility Study of Enhancing Microwave Brain Imaging Using Metamaterials”, *Sensors*, vol. 19, no. 24, 2019.

4. D.O. Rodriguez-Duarte, J. A. Tobon Vasquez, R. Scapatucci, 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.

This work was supported by the European Union's Horizon 2020 Research and Innovation Program under the EMERALD project, Marie Skłodowska-Curie grant agreement No. 764479.