Preface

Terahertz spectroscopy is gaining momentum as a tool for imaging in the field of biomedical engineering. This increase in popularity is due to the non-invasive, non-ionizing nature of terahertz radiation coupled with its propagation characteristics in water, which allows the operator to obtain high-contrast images of skin cancers, burns, etc., without detrimental effects. In order to tap this huge potential, researchers are aiming to build highly efficient biomedical imaging systems by introducing radiation (THz) absorbers into biomedical detectors. The biggest challenge faced in the fulfilment of this objective is the lack of naturally occurring dielectrics, which is combated with the use of artificially engineered resonant materials called metamaterials.

Due to sharp resonance, metamaterial absorbers show narrow band absorption. Therefore, in order to use the same detector for imaging and characterization of a variety of samples at different frequencies, a technique to tune the resonant frequency of the metamaterial absorber is introduced. In this technical brief, the design of an active, metamaterial absorber for biomedical imaging in the terahertz range of frequencies is explored. The design is optimized for near unity absorption using a particle swarm optimization (PSO)-based computational engine.

The design of a terahertz absorber is a three-step process involving integration of metamaterial unit cell into the design and simulation, extraction of absorption characteristics, and optimization towards performance enhancement. In this work, circular split ring resonator (SRR) is chosen as the metamaterial unit cell. The terahertz split ring resonator is designed using established techniques such as scaling and S-parameter retrieval. This SRR is then used as the basic element of a multi-layer structure, which together acts as an absorber. Then, a frequency tuning mechanism using MEMS switches is proposed. A PSO computational engine has been developed to integrate optimization algorithms with commercial EM solver. Further an adaptive tuning concept is introduced for multi-functional biomedical applications.

It is seen that conventional design techniques can be used to realize metamaterial absorbers with absorption greater than 95 %. Using the developed computational engine, the performance can be enhanced to near unity absorption with an optimized thickness. Further, this near unity absorption can be maintained for a tuning range of 0.5 THz using the MEMS-switches based technique presented in this work. A sensitivity analysis for taking into account fabrication and material tolerances is also presented.

In conclusion, a circular SRR-based active absorber has been designed and reported in this technical brief. The absorber shows near-unity absorption for a tuning range of 0.5 THz. The design of the absorber has been optimized for enhanced performance using particle swarm optimization, thereby validating the effectiveness of the methodologies presented in this document for the design of high performance, ultra-thin, metamaterial-based active terahertz devices.

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