The 8th European Congress on Computational Methods in Applied Sciences and Engineering
ECCOMAS Congress 2022
5 – 9 June 2022, Oslo, Norway

ARCHITECTURED AND ADDITIVELY MANUFACTURED DOUBLE-NEGATIVE INDEX METAMATERIALS

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Key Words: *Thermomechanical Metamaterials, Topology Optimization, Additive Manufacturing, NPR, NTE.*

Metamaterials are artificially engineered materials with periodic microstructures that exhibit properties that are unattainable in traditionally manufactured materials. Most contributions in literature focus on metamaterials that exhibit negative *Poisson*'s ratio (NPR) or negative thermal expansion (NTE) separately. However, a recent interest has raised in metamaterials coupling both negative indexes, the so-called *anepectic* metamaterials [1]. Nonetheless, obtaining metamaterials with target properties by the systematic design of their microstructure remains a major challenge to this day. Here, the authors perform Finite Element Analysis (FEA), Topology Optimization (TO), fabrication, testing and characterization of such metamaterials aiming to contribute to the development of a new generation of metamaterials going through an engineering-cycle. The first experimental development of an *anepectic* metamaterial reported in the literature presents a bi-material polymeric re-entrant truss-like microstructure [1]. To simulate *in-silico* the experimental results presented in that pioneer work, a microstructural Finite Element Model (FEM) is presented here. In the framework of elastic continua, an auxetic microstructure is designed by homogenization-based topology optimization [2]. The optimal microstructure is then post-processed such that it can be 3D printed and tested using Digital Image Correlation (DIC) techniques. The FEA is performed on optimal microstructure lay-outs and enriched to be effective in predicting the behaviour of the experiments carried out. To that purpose, scale-size effects are studied implying the evaluation of the metamaterial thermomechanical properties which are sensitive to the number of repetitions of a Representative Volume Element (RVE). The design of *anepectic* microstructures by topology optimization is envisaged as well as the respective experimental validation. The present work emphasizes thus the importance of the engineering-cycle completion, i.e., starting with the systematic and optimal design of metamaterials and ending up in prototype fabrication and its verification.

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