

Structural design in electromagnetic fields through topology optimization schemes on metamaterials

†J. Yoo¹, H. Lim², and H. Shin²

¹ School of Mechanical Engineering, Yonsei University, Seoul 120-749, Korea

²Graduate School of Mechanical Engineering, Yonsei University, Seoul 120-749, Korea

†Presenting and corresponding author: yoojh@yonsei.ac.kr

Abstract

Metamaterials have been a widely spread concept to overcome the limit of traditional material properties in nature. Metamaterials may get their exceptional properties not only from the composition of the base materials but also from their exquisite structural design. In spite of their explosive request, systematic design approaches for metamaterials especially focused on their structural design are hard to be found.

Topology optimization schemes are prospective way to offer an effective process for metamaterial design [Bendsøe and Sigmund (2003)]. This study suggests a systematic design approach of the structures in electromagnetic fields focused on device design in radio frequency (RF) ranges. We combined the metamaterial design concept in elastic fields with its application in electromagnetic fields. The unit-structure having negative Poisson's ratio close to -1 was obtained from a pre-exist unit-structure using the structural optimization scheme based on the phase field method [Yamada et al. (2011)]. The patterned unit-structures were applied to a band-gap structure to realize the approximately linear band-gap shift using its linear shape variation [Lim et al. (2014)]. The relation between the variations of the band-gap range according to the auxetic unit-structure deformation was investigated through numerical simulations. We also evaluated the design concept experimentally in the X-band RF range.

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Keywords: Topology optimization, Phase field method, Auxetic unit-structure, Radio frequency range, Band-gap tunability.

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