3D isotropic metamaterial design using smart transformation optics

D. Shin¹, I. Seo², and K. Kim¹*

¹Department of Mechanical Engineering, Yonsei University, Republic of Korea
²Agency for Defense Development, Republic of Korea
*corresponding author: kks@yonsei.ac.kr

Abstract - We introduce new design method for 3D isotropic transformation optics device using smart transformation optics. In 2 dimension smart transformation optics, elastic deformation satisfied quasi-conformal transformation with negative Poisson’s ratio -1. We extended smart transformation optics to 3 dimension and demonstrated 3D isotropic metamaterials waveguide. This 3D waveguide is arbitrary bendable and maintain phase in wave propagation.

Transformation optics (TO) is theory for controlling electromagnetic waves based on invariance of Maxwell’s equations in transformed coordinate [1]. TO designs TO device such as electromagnetic cloak using artificial metamaterials with gradient material properties not observed in nature. Especially quasi-conformal mapping (QCM) design 2 dimensional TO device with only isotropic electric permittivity which can be practical demonstration [2]. This lossless and broadband metamaterials also make possible to fabricate easier than anisotropic resonant metamaterials which have lossy component and narrow operation band.

3D isotropic TO device is hard to design and demonstrate. Some approaches for cloak and Luneberg lens using axial symmetry have limitation that operating well just in optical plane including symmetric axis [3, 4]. Recently, full 3d isotropic transformation media and its design method using Green coordinate transformation are reported [5].

Figure 1. 3D bended wave guide using 3D isotropic smart transformation optics

We report more intuitive design method for 3D isotropic TO using smart transformation optics. In this scheme, the transformation medium defines as elastic solid and mechanical deformation regards as coordinate transformation. With Poisson’s ratio close to -1, 2D elastic deformation satisfies QCM [6]. In the 3 dimensional
deformation, more boundary condition should be added for isotropic 3D transformed medium. We demonstrated arbitrary bendable waveguide as 3D TO device with isotropic refractive index. As shown in figure 1, wave propagation in deformed waveguide maintains phase and not shows internal reflection or interference patterns.

Today’s 3D printer technology and computer aided design system make easier fabrication of isotropic metamaterials with complex geometry not feasible in the past. 3D smart TO provides simple design method for 3D isotropic TO devices using isotropic metamaterials which have broad operational band and low loss factor.

REFERENCES