The emergence of auxetic material as a result of optimal isotropic design

S. Czarnecki, P. Wawruch

Phys. Status Solidi B, 1–11 (2015) / DOI 10.1002/pssb.201451733

Read online>>

Abstract:
Using both mathematical and numerical methods, the optimal distributions of material characterized by the Young modulus and Poisson ratio (as well as other moduli of isotropy) maximizing the overall stiffness of an inhomogeneous isotropic elastic 3D body transmitting a given surface loading to a given support are constructed. The overall stiffness of the body is defined as the inverse of the work of external forces on displacements, called here the compliance of the structure. The isoperimetric condition bounds the integral of the trace of the Hooke tensor. It is proved that isotropic composite materials forming the bodies of extremely high stiffness exhibit negative Poisson ratio in large subdomains, which points at the significance of the auxetic material in modern structural design. The obtained results show that the whole range of possible variation of the Poisson ratio is used, from −1 to 1/2, which proves usefulness of the auxetic materials.