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Effects of porosity distribution on the properties of multifunctional foam structures

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Three-dimensional unit-cell based finite element models are developed to completely characterize the effect of porosity distribution and porosity volume fraction on the elastic, dielectric and piezoelectric properties as well as relevant figures of merit of 3-3 type multifunctional foam structures. Eight classes of foam structures which represent structures with different types and degrees of uniformity of porosity distribution are identified; a Base structure (Class I), two H-type foam structures (Classes II and III), a Cross-type foam structure (Class IV) and four Line-type foam structures (Classes V, VI, VII and VIII). Three geometric factors that influence the electromechanical properties are identified: (i) the number of pores per face, pore size and the distance between the pores; (ii) pore orientation with respect to poling direction; (iii) the overall symmetry of the pore distribution with respect to the centre of the face of the unit cell. To assess the suitability of these structures for such applications as hydrophones, bone implants, medical imaging and diagnostic devices, five figures of merit are determined via the developed finite element model; the piezoelectric coupling constant (K_t), the acoustic impedance (Z), the piezoelectric charge coefficient (d_h), the hydrostatic voltage coefficient (g_h) and the hydrostatic figure of merit ($d_h g_h$). At high material volume fractions, foams with non-uniform Line-type porosity (Classes V and VII) where the pores are preferentially distributed perpendicular to poling direction, are found to exhibit the best combination of desirable piezoelectric figures of merit.

Biography

K.S. Challagulla completed his PhD in 2006 from the Department of Mechanical Engineering, Dalhousie University (Canada). Following his PhD program, he worked as a Research Associate at Tulane University (USA) and as a Postdoctoral Research Associate at Composite Materials and Structures Laboratory, McGill University (Canada). He joined Laurentian University in 2009. His areas of research include characterization of multifunctional cellular solids and composite structures using unit cell-based finite element modeling; development of analytical and numerical micromechanical models for the design of composite and smart structures; fabrication, analysis, testing and assessment of advanced composites with integrated sensors; numerical simulation of static and dynamic behaviour of rockbolts for underground mine support systems; and design of novel multiple blade wind turbine rotor. He has published 20 articles in high impact journals, 1 book chapter and a patent. He served as an organizing committee member and session chairs for highly attended conferences.

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