Lecture

Prediction of charge, voltage, and work-conversion performance of magnetoelectric composites

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Wednesday, November 11th, 2015, 14:30

Johannes Kepler University Linz, Lecture Tract, Lecture Hall HS5

IKL Institut für Konstruktiven Leichtbau

JKU JOHANNES KEPLER UNIVERSITÄT LINZ

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Abstract

Interest in magnetoelectic (ME) composites is motivated by potential applications such as sensors, energy harvesters, and solid state memory. Although ME materials exist in nature, their ME charge coefficient β is too small and/or their Neel temperature is too low for practical applications. On the other hand, composite materials can be built to exploit the product property between a strongly magnetostrictive s/H material and a strongly piezoelectric E/s material; that is, obtaining the product ME property E/H, where s, H, E, are the strain, magnetic field, and electric field, respectively. Notable is the difference between additive composites (the ones we know) and the new product composites.

Unlike naturally occurring ME materials, ME composites can achieve strong ME voltage coefficient α and charge coefficient β, both at room temperature. In this sense, ME composites are considered to be metamaterials. Also, magnetoelectric materials are multifunctional because they can sense and harvest energy simultaneously from deformation, electric, and magnetic fields.

ovel closed form formulas are derived for the calculation of the magnetoelectic charge coefficient, voltage coefficient, and coupling factor as a function of material properties of both phases, the piezomagnetic volume fraction, and device geometry. The predicted voltage coefficient is in agreement with previous work and experimental data. A new approach is proposed to take into account the conductivity of the piezomagnetic phase, thus correcting the approaches available in the literature. A novel derivation and closed form solution is presented for correctly predicting the coupling factor, which is used to assess the efficiency of the conversion of magnetic work into electric work. Using actual material properties, conclusions are drawn regarding the optimal configuration and volume fraction necessary to achieve maximum charge, maximum voltage, and maximum work conversion, respectively. The newly proposed analytical method [1,2,3] is shown to apply to all four laminated configurations.

Bibliography

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Ever J. Barbero received a BSME/BSEE degree from UNRC (Argentina) in 1983, and a Ph.D. in Engineering Mechanics from Virginia Tech (USA) in 1986. He is a Fellow of ASME and SAMPE, Professor of Mechanical and Aerospace Engineering at West Virginia University, and honorary Professor at Universidad Carlos III de Madrid (Spain), University of Puerto Rico (PR), and Universidad Nacional de Trujillo. His research interests are broad, including materials modelling and characterization, structural design, and so on. He is the author of several books, book chapters, over 100 journal publications, numerous conference papers, and mentor of over 30 MS and 15 Ph.D. graduates currently serving leadership positions in academia and industry worldwide. He holds two US Patents, #6,455,131 (2002) and #6,544,624 (2003), received the AE Alumni Academy Award for Outstanding Teaching and numerous research awards. He is Associate Editor for *Annals of Solid and Structural Mechanics* (Springer) and *Revista Internacional de Desastres Naturales, Accidentes e Infraestructura Civil* (University of Puerto Rico).

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