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Numerical and experimental study on temperature energy harvesting in barium titanate/copper laminated composites

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This paper presents the numerical and experimental study on the energy harvesting characteristics of piezoelectric laminated composite consisting of barium titanate ($BaTiO_3$) and copper (Cu) due to temperature changes. First, the output voltages of the piezoelectric $BaTiO_3$/Cu laminated composite were evaluated from room temperature to a liquid nitrogen temperature (77 K). The output power was also obtained for various values of load resistance. The output voltages of the $BaTiO_3$/Cu laminated composite were then measured from room temperature to a higher temperature (333 K). Next, linking phase field and finite element simulations were performed to discuss the output voltages of the $BaTiO_3$/Cu laminated composite due to temperature changes. A phase field model for grain growth was employing to generate grain structures and the phase field model was employed for $BaTiO_3$ polycrystals, coupled with the time-dependent Ginzburg-Landau theory and the oxygen vacancies diffusion, to calculate the temperature-dependent piezoelectric coefficient and permittivity. The output voltages of the $BaTiO_3$/Cu laminated composite from room temperature to both 77 K and 333 K were predicted by three-dimensional finite element methods, using these properties and the results are presented for several grain sizes and oxygen vacancy densities. The effects of grain sizes and oxygen vacancy densities on the relationship between the output voltage and the thermally induced bending stress were examined in detail.

Biography

Fumio Narita is currently a Professor in the Department of Materials Processing at Tohoku University in Japan. From 1998 until 1999 he has worked as an Engineer at Tokin Corporation. He is engaged in research to design and develop piezoelectric/magnetostrictive materials and structures for energy harvesting for the IoT, wearable devices and smart sensors. He is making extensive use of state-of-the-art electro-magneto-mechanical characterization techniques in combination with computational multi-scale modeling to gain insights into fundamental structure-property relationships of complex multifunctional composite materials.

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