Accepted Manuscript

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PII: S0925-8388(18)31819-X

DOI: 10.1016/j.jallcom.2018.05.122

Reference: JALCOM 46098

To appear in: *Journal of Alloys and Compounds*

Received Date: 14 March 2018

Revised Date: 8 May 2018

Accepted Date: 9 May 2018

Please cite this article as: H. Palneedi, S.-M. Na, G.-T. Hwang, M. Peddigari, K.W. Shin, K.H. Kim, J. Ryu, Highly tunable magnetoelectric response in dimensional gradient laminate composites of Fe-Ga alloy and $Pb(Mg_{1/3}Nb_{2/3})O_3$-$Pb(Zr,Ti)O_3$ single crystal, *Journal of Alloys and Compounds* (2018), doi: 10.1016/j.jallcom.2018.05.122.

Highly tunable magnetoelectric response in dimensional gradient laminate composites of Fe-Ga alloy and $Pb(Mg_{1/3}Nb_{2/3})O_3$-$Pb(Zr,Ti)O_3$ single crystal

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Abstract

In this study, it is proposed and demonstrated that highly tunable magnetoelectric (ME) response can be achieved from magnetostrictive/piezoelectric laminate composites by integrating the effects of size variation and piezoelectric anisotropy. Tri-layered, rectangular ME composites with different aspect ratios were prepared using a magnetostrictive Fe-Ga alloy and a (011) oriented $Pb(Mg_{1/3}Nb_{2/3})O_3$-$Pb(Zr,Ti)O_3$ (PMN-PZT) piezoelectric single crystal. ME coefficients in the range of 0.25-2.2 V/cm·Oe and 2-75 V/cm·Oe in the off-resonance and resonance mode, respectively, were obtained from the composites. Magnetic sensitivity of the ME composites followed a similar trend in variation as that of their ME response with respect to the laminate size and applied magnetic field direction. The tunability of the ME response of the composites was correlated with the size dependent demagnetization and magnetic flux density distribution in the Fe-Ga alloy and direction dependent piezoelectric properties of the (011) PMN-PZT single crystal. In both the off-resonance and resonance modes, an order of magnitude large tunability could be attained in the ME coefficient of the composites. Such a highly tunable ME response will facilitate the development of ME based devices with controllable functionality.

Keywords: Fe-Ga; PMN-PZT; magnetoelectric; composite; tunable.

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