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All thin film magnetoelectric magnetic field sensors.[1]

PENG ZHAO, University of Maryland, College Park

We have fabricated prototype ac magnetic field sensors operating at room temperature based on all thin film ME devices showing strong magnetoelectric (ME) coupling. The ME layers consist of a sol-gel derived $Pb(Zr_{0.52}Ti_{0.48})TiO_3$ (PZT) film and a dc magnetron sputter deposited magnetostrictive $Fe_{70}Ga_{30}$ (FeGa) film. The bilayer structures are prepared on micromachined Si wafers, and the laser cutting technique is used to release and isolate the cantilevers for optimization of the sensor performance. The PZT layer and the FeGa layer couple via the piezoelectric d_{31} mode and the corresponding ME coupling coefficient is as high as $\approx$ 2 V/(Oe cm) for a lateral dimension of 1 mm^2 device at the mechanical resonant frequency of 333 Hz of a Si cantilever. The soft magnetic FeGa film requires dc bias magnetic field of around 90 Oe to operate the thin film ME device. The coupling between the PZT and the FeGa films is remarkably improved by depositing a 40 nm thick Pt intermediate layer. The clamping effect on the ME coupling is dramatically reduced by back-etching the Si cantilever down to 35 μm thick. The present work indicates presence of robust ME coupling in microfabricated multilayer thin film ME devices.

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