Modeled Electroformed MEMS Variable Capacitors for Cobalt Iron Alloy Magnetostriction Measurements

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Abstract

Electroplated CoFe alloys demonstrating Joule magnetostriction (i.e., a large change in material shape induced by an applied magnetic field) have been recently developed for the creation of microfabricated magnetoelastic resonators for tagging applications. This development requires a measurement technique for evaluating film magnetostriction performance to provide feedback for optimization of the electrodeposition process. This technique must be suitable for electrodeposited films in terms of thickness and ease of processing, have the required sensitivity and dynamic range for accurate microstrain measurements in low magnetic fields up to saturation, and be cost competitive with commercial instruments. A new MEMS variable capacitor has been developed for this purpose that incorporates electroformed mechanical and electrical features as well as the electrodeposited film under test. A 3D model exploiting bilateral symmetry of this variable capacitor is built in COMSOL Multiphysics® software. The capacitor is comprised of copper electrical connections, an actuation electrode, a bottom capacitor plate, an anchor post, and a top capacitor plate attached to the end of a suspended bimorph cantilever. The capacitor is set up to be actuated both magnetically and electrostatically via a magnetostrictive CoFe alloy/copper cantilever under an applied DC magnetic field as well as a voltage biased actuation electrode on the substrate surface. This allows for pre and post magnetic electrical testing of the capacitors to avoid testing of nonfunctional capacitors saving on testing time and to troubleshoot capacitors that fail magnetic testing. Both AC/DC and Structural Mechanics modules were employed for this modeling effort using Magnetic Fields (mf) and Magnetostriction interfaces (magnetic actuation) and Electrostatics (es) and Electromechanics (emi) interfaces (electrostatic actuation). This capacitor has a modeled 3 pF variable range covering microstrains up to 200 ppm. This presentation will cover the modeling and design of these capacitors for magnetostriction measurements of CoFe alloy electrodeposited films. This will also include a discussion of a custom printed circuit board for extracting capacitance signals during the magnetic field ramp inside of a superconducting quantum interference device (SQUID) magnetometer.