Ferromagnetic MEMS Arrays for Reconfigurable Frequency Selective Surfaces
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The expanding needs of RF and mm-wave system designers are pushing the limits of MEMS development. Tunable RF and mm-wave systems are of great interest because they offer the potential to expand the functionality and capability of high-frequency communication systems. Frequency-selective surfaces (FSSs) are periodic structures in two dimensions that can provide frequency filtering to incoming electromagnetic waves (Figure 1). A common FSS example is the mesh screen on the door of a microwave oven. Although FSSs have long been studied, they have experienced tremendous growth in the last ten years with new applications emerging (e.g., frequency filters or diplexers in high performance reflector antenna systems, advanced radome designs, and smart surfaces for stealth applications). Although prior work on FSSs has only been on arrangements of static in-plane elements [1-2], in many applications it would be highly advantageous to adaptively reconfigure the frequency and bandwidth response of an FSS. Simulations have shown that the frequency response of an FSS is a strong function of dipole element tilt [3] (Figure 2). Advances and developments in micromachining and MEMS technology can be used to fabricate an FSS array with elements capable of rotation, thereby enabling the tuning of the frequency response. Particularly well suited for this application is a ferromagnetic microactuator consisting of an electroplated ferromagnetic plate and non-magnetic torsional flexures (Figure 3). The device is actuated by an off-chip source for the magnetic field. The microactuation principle is essentially that of a compass needle – the integrated magnetic microelements rotate with the applied magnetic field. The ability of microactuators made with this technology to rotate through large out-of-plane deflections (>90°) has been previously demonstrated [4-5]. The microactuators used in this work consist of a 896×168×30 µm³ ferromagnetic plate made of 40Co-60Ni attached to a pair of 400×30×1 µm³ polysilicon torsion bars (Figure 3). The remanent magnetization in the hard ferromagnetic material allows relatively small magnetic fields (~1750 A/m or 22 Oe) to induce significant angular deflections (~45°). The frequency response of this FSS has been measured using an HP8510 network analyzer with a millimeter-wave source setup (Figure 4) [6]. These experimental results reveal the trend predicted by simulations (Figure 3). Namely that as the elements are tilted, the blocked frequency band shifts higher.