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Effects of Surface Roughness on a Unimorph Piezoelectric Micro-Electro-Mechanical Systems Vibrational Energy Harvester Using Finite Element Method Modeling

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Abstract : This paper discusses the effects of surface roughness on a cantilever beam vibrational energy harvester. A silicon sample was fabricated using MEMS fabrication processes. When etching silicon using deep reactive ion etching (DRIE) at large etch depths, rougher surfaces are observed as a result of increased response in process pressure, amount of coil power and increased helium backside cooling readings. To account for the effects of surface roughness on the characteristics of the cantilever beam, finite element method (FEM) modeling was performed using actual roughness data from fabricated samples. It was found that when etching about 550um of silicon, root mean square roughness parameter, Sq, varies by 1 to 3 um (at 100um thick) across a 6-inch wafer. Given this Sq variation, FEM simulations predict an 8 to148 Hz shift in the resonant frequency while having no significant effect on the output power. The significant shift in the resonant frequency implies that careful consideration of surface roughness from fabrication processes must be done when designing energy harvesters.

Keywords : deep reactive ion etching, finite element method, microelectromechanical systems, multiphysics analysis, surface roughness, vibrational energy harvester
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