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Abstract

Piezoelectric Ultrasonic Micromotor †

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Abstract: Ultrasonic motors are characterized by low speed and high-torque operation, without the need for gear trains. They can be compact and lightweight, and they can also work in the absence of applied loads, due to the frictional coupling between the rotor and the stator induced by the traveling wave. In this work, we discuss a concept design based on thin piezoelectric films, sol-gel directly deposited onto a silicon substrate to provide high-torque motors compatible with wafer integration technologies. Due to the large dielectric constants and the enhanced breakdown strengths of thin piezoelectric films, such ultrasonic micromotors can lead to meaningful improvements over electrostatic ones in terms of energy density. As far as the fabrication of the micromotor at the mm-scale is concerned, an integrated approach is proposed with significant improvements regarding: the comb-tooth structure, to maximize/optimize the motor torque; a back and front etch lithographic process; and the design of the electrodes, which provide the electric signal at the central anchor of the stator, taking advantage of low-temperature soldering. The proposed design has been assessed through multiphysics simulations, carried out to evaluate the resonant behavior of the stator and the motor performance in terms of angular velocity, torque, and output power, and it is shown to lead to promising results.

Keywords: micro electro-mechanical systems; ultrasonic micromotor; piezoelectric micromotor; multiphysics; finite element simulations

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