Frictionless Electrostatic Rotary Stepper Micromotor for Microrobotic Applications

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We present the modeling and experimental characterization of a monolithic 3-phase rotary stepper micromotor which employs a flexure suspension to guide the rotor (see Figure 1). The monolithic structure avoids any frictional contact during operation, providing a precise, repeatable and reliable bidirectional stepping motion without feedback control.

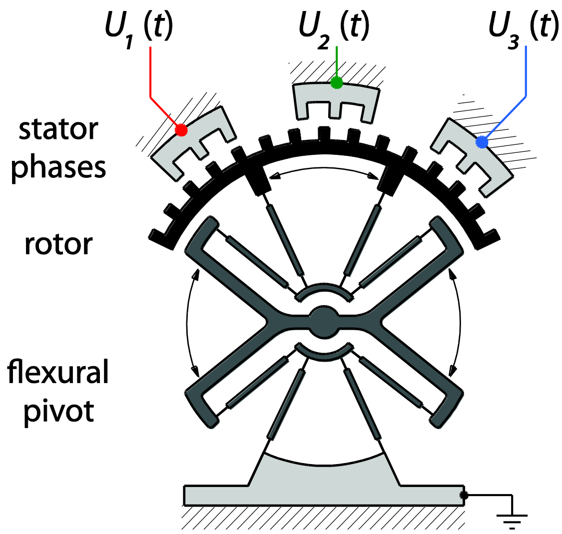

Figure 1: Working principle of the 3-phase electrostatic rotary stepper micromotor with a flexure pivot mechanism.

We have performed finite element analysis (FEA) simulations of the mechanical static and dynamic properties. These studies are consistent with the extensive experimental characterization performed in the quasi-static, transient, and dynamic regimes. Dynamic nonlinearities have been observed and compared to a complete mathematical model including the electrostatic actuation and the mechanical properties of the system. The analytic model is consistent with the simulations and the experiments.

The monolithic 3-phase rotary stepper micromotor has been modified to increase its torque and we have included a differential capacitive angular sensor. The implementation of this micromotor in a microgripper has also been studied and designed (see Figure 2).

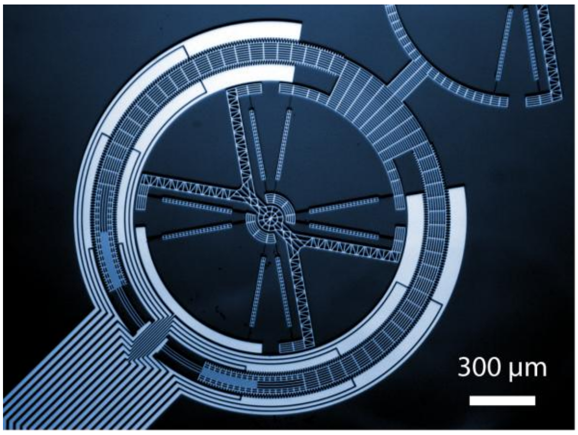

Figure 2: Micrograph of a micromotor fabricated in a single-crystal silicon, using a simple single-mask process, based on standard Silicon-On-Insulator technology.

The fabrication was performed in the cleanroom of the EPFL Center of MicroNanoTechnology (CMi) and has conducted to the preliminary experimental characterization of prototypes which validated the single-mask process.

Part of the results presented in this Master Project have been published in *Proc. 24th IEEE Int. Conf. on Micro Electro Mechanical Systems (MEMS):* M. Stranczl *et al.*, "Modal Analysis and Modeling of a Frictionless Electrostatic Rotary Stepper Micromotor", pp. 1257-1260, Cancun, Mexico, January 23-27, 2011.