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Abstract

A Deep Learning-Based Approach to Uncertainty Quantification for Polysilicon MEMS †

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Abstract: The path towards miniaturization for micro-electro-mechanical systems (MEMS) has recently increased the effects of stochastic variability at the (sub)micron scale on the overall performance of the devices. We recently proposed and designed an on-chip testing device to characterize two sources of variability that majorly affect the scattering in response to the external actions of inertial (statically determinate) micromachines: the morphology of the polysilicon film constituting the movable parts of the device, and the environment-affected over-etch linked to the microfabrication process. A fully stochastic model of the entire device has been set to account for these two sources on the measurable response of the devices, e.g., in terms of the relevant C-V curves up to pull-in. A complexity in the mentioned model is represented by the need to assess the stochastic (local) stiffness of polysilicon, depending on its unknown (local) microstructure. In this work, we discuss a deep learning approach to the micromechanical characterization of polysilicon films, based on densely connected neural networks (NNs). Such NNs extract relevant features of the polysilicon morphology from SEM-like Voronoi tessellation-based digital microstructures. The NN-based model or surrogate is shown to correctly catch size effects at a varying ratio between the characteristic size of the structural components of the device, and the morphology-induced length scale of the aggregate of silicon grains. This property of the model looks to indeed be necessary to prove the generalization capability of the learning process, and to next feed Monte Carlo simulations resting on the model of the entire device.

Keywords: deep learning; uncertainty quantification; polysilicon; polysilicon film; densely connected neural networks; Voronoi tessellation; Monte Carlo simulations

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