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Probabilistic model for MEMS micro-beam resonance frequency made of polycrystalline linear anisotropic material

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In order to ensure the accuracy of MEMS vibrometers, the first resonance frequency should be predicted at the design phase. However, this prediction cannot be deterministic: there is a scatter in the reached value resulting from the uncertainties involved in the manufacturing process.

The purpose of this work is to take into account these uncertainties of the microstructure and to propagate them up to the micro-beam resonance frequency. The objective is a non-deterministic model that can be used since the design stage. Towards this end a 3-scales stochastic model predicting the resonance frequency of a micro-beam made of a polycrystalline linear anisotropic material is described. Uncertainties are related to the sizes and orientations of the grains.

The first part of the problem is a homogenization procedure performed on a volume which is not representative, due to the small scale of the problem inherent in MEMS. The method is thus non-deterministic and a meso-scale probabilistic elasticity tensor is predicted. This stage is followed by a perturbation stochastic finite element procedure to propagate the meso-scale uncertainties to the macro-scale, leading to a probabilistic model of the resonance frequency of the MEMS.

Keywords: MEMS, stochastic multiscale, perturbation stochastic finite element method, micro-beam resonance frequency