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A STOCHASTIC 3-SCALE METHOD TO PREDICT THE THERMO-ELASTIC BEHAVIORS OF POLYCRYSTALLINE STRUCTURES

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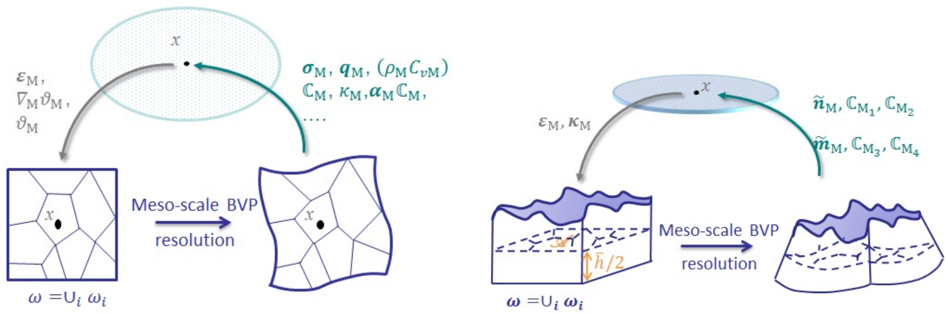
Abstract. The purpose of this work is to upscale material uncertainties in the context of thermo-elastic response of polycrystalline structures.

The probabilistic behavior of micro-resonators made of polycrystalline materials is evaluated using a stochastic multi-scale approach defined using the following methodology.

1. Stochastic volume elements (SVEs) [1] are defined from Voronoï tessellations using experimental measurements of the grain size, orientation, and surface roughness [2];
2. Mesoscopic apparent thermo-elastic properties such as elasticity tensor, thermal conductivity tensor, and thermal dilatation tensor are extracted using a coupled homogenization theory [3, 4] applied on the SVE realizations;
3. A stochastic model of the homogenized properties extracted from Voronoï tessellations using a moving window technique is then constructed in order to be able to generate spatially correlated meso-scale random fields;
4. These meso-scale random fields are then used as input for stochastic finite element simulations.

As a result, the probabilistic distribution of micro-resonator properties can be extracted. The applications are two-fold:



(a) Thermo-elastic homogenization (b) Second-order homogenization

Figure 1: Stochastic homogenization on SVEs

1. A stochastic thermo-elastic homogenization, see Fig. 1(a), is coupled to thermo-elastic 3D models of the micro-resonator in order to extract the probabilistic distribution of the quality factor of micro-resonators [5];

2. A stochastic second-order mechanical homogenization, see Fig. 1(b), is coupled to a plate model of the micro-resonator in order to extract the effect of the uncertainties related to the surface roughness of the polycrystalline structures [2].

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