Approaching second-strain gradient elasticity with soft X-rays diffraction

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Abstract

It is well established that downsizing mechanical structures make their surface-over-volume ratio much larger than for usual objects, so that their ability to interact with their environment is significantly augmented. This has been particularly used in the development of cantilever sensors, where a surface energy change on one side induces the cantilever's bending. Even though this phenomenon has been implemented for a wide range of molecules, the modeling the mechanical response of a micromechanical structure to a surface energy change has been scarcely investigated. Second-strain gradient elasticity has been shown to naturally involve the equivalent of surface tension for solids, and thus seems particularly suited to model the deformation of solids subjected to a surface energy change.

A toy model is first used to demonstrate the key role of the material in the chemo-mechanical transduction, thereby stressing the need for an adequate experimental identification procedure.

First results from an original approach are reported herein. Beams made of a material driven by second-strain gradient elasticity are expected to display short-wavelength sinusoidal components in their displacement field. In order to experimentally validate this prediction, silicon nitride cantilevers of different thicknesses have been functionalized so that the surface energy is controlled by UV illumination. The resulting deformation has been probed using a simultaneous illumination in the soft X-rays range in transmission. The sinusoidal components of the displacement are shown to act as a diffraction grating and the observed diffraction peaks yield key information on the higher-grade elastic parameters, in line with theoretical predictions.

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