

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

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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 [1] 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. The constitutive law is however rather complex, so that the experimental identification of the constitutive parameters is a challenge to overcome. 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. Depending on the material, the bending response is expected to display up to 3 sinusoidal components [2].

In order to experimentally validate this prediction, silicon nitride cantilevers of different thicknesses have been functionalized with an azobenzene-containing monolayer. The azobenzene displays a conformational change upon UV illumination, thus changing the surface energy [3]. The resulting deformation has been (partially) 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 informations on the higher-grade elastic parameters, in line with the predictions from [2].

REFERENCES

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