SURFACE ELASTICITY WITH APPLICATIONS TO MATERIAL MODELLING AT THE NANO- AND MICRO-SCALES

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The aim of the lecture is to discuss the applications of the surface elasticity to material modelling such as determination of effective properties of materials and some related phenomena as surface wave propagation. Within the surface elasticity in addition to the constitutive equations in the bulk the surface stain energy or another constitutive relations at the surface are introduced. Nowadays the most popular models of surface elasticity relates to the models by Gurtin and Murdoch and by Steigmann and Ogden. Some other models are also known in the literature, which can describe surface/interface related phenomena. The presence of the surface strain energy and surface stresses may significantly change the properties of solutions of the corresponding boundary-value problems.

The first part of the lecture is devoted to the introduction of the useful surface elasticity models. From the physical point of view these models corresponds to an elastic solid with attached to its boundary an elastic membrane or shell. The corresponding boundary dynamic boundary conditions are derived at the smooth parts of the boundary as well as at edges and corner points. Let us underline that these conditions include also dynamic terms. As a result, we have here a dynamic generalization of the Laplace-Young equation known from the theory of capillarity.

Second, we discuss the influence of the surface stresses at the effective stiffness parameters of layered plates and shallow shells. For small deformations we derived the exact formulae for modified tangent and bending stiffness parameters of the plates and shells. The influence of residual surface stresses are also discussed.

Unlike to previous case where surface stresses are slightly changing the material properties, there is another example of essential influence of surface properties. This example relates to the propagation of anti-plane surface waves. We discuss some peculiarities of these waves propagation as well as some similarities with the strain gradient elasticity.

Finally, we discuss the microstructured coatings. These coatings constitute a new class of surface metamaterials called metasurfaces. Among applications of such coatings we consider superhydrophobic and superoleophobic surfaces used for manufacturing of self-cleaning and bactericide coatings. For coatings with complex inner microstructure we propose two steps of homogenization for derivation of the effective surface properties. The main idea consists of replacing thin coating of small but finite thickness by material surface with some effective properties. Then these properties can be applied to previous results on the modification of material properties considering surface elasticity.