UNIVERSITÄT SIEGEN
FESTKÖRPERPHYSIK

Solid state physics (*winter term 2015/2016*)

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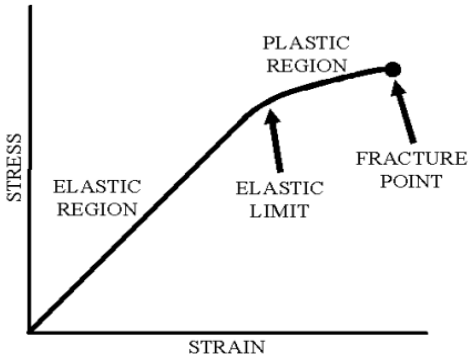
Exercise sheet 4

1. Poisson's Ratio

Hooke's law states that in an elastic solid the strain is directly proportional to the stress (fig1).

Figure 1 Elastic Behavior – A lightly-deformed material will recover its original shape after the stress is removed. Elastic behavior occurs at very low stresses.



1- Using Hooke's law write down the stress components as a linear function of the strain components.

2- Assuming a cubic crystal subjected to uniaxial stress on two opposite faces parallel to the xz-plane, define the Poisson's ratio v and show that it can be written as:

$$v = \frac{c_{12}}{c_{11} + c_{12}}$$

2. Lattice mismatch

A cubic thin layer (epitaxial) is grown along the [010] direction onto an infinitely thick substrate. The lattice parameter of the cubic substrate is 3% smaller than the thin layer

material. During growth, the thin layer adopts the same lattice parameter as the substrate within the plane of growth creating biaxial compressive stress along the x and z axis (fig 2.a). Due to minimization of the stress energy the out of plane lattice of the layer will expand (the normal to the substrate surface is the y axis).

Calculate the strain along the growth axis ε_{yy} for a given in-plane strain $\varepsilon_{xx} = \varepsilon_{zz}$

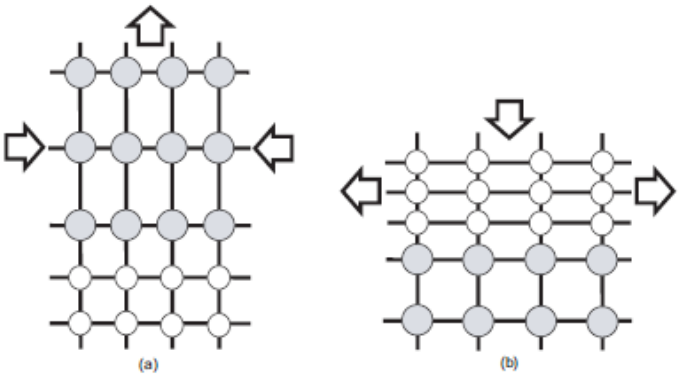


Figure 2Figure 1. Schematic of layers under in-plane (a) compressive and (b) tensile strain. Layers with larger lattice constant are shown in grey.

3. Bulk Modulus and Compressibility

1- Express the elastic energy density of a cubic crystal taking into account all necessary components of the elastic strain tensor after proper reduction due to symmetry.

2- Simplify the energy density obtained in 3.1 assuming uniform dilation. ($\varepsilon_{xx} = \varepsilon_{yy} = \varepsilon_{zz} = \frac{1}{3}\delta$).

3- Deduce the bulk modulus B knowing that the energy density can be written as:

$U = \frac{1}{2} B \delta^2$.

Please return on 18/11/2015