Solution problem 6 , FYS4310

tgf

PROBLEM 6

Imagine that we force the unit cell of Ge to occupy the same volume as

the unit cell of Si. The Ge is thus deformed elastically and we need to apply a stress

(pressure) to maintain this.

a) Calculate the value of the deformation.

Hint: assume elastic deformation, characterize it by by the strain In scalar form

$\sigma = \frac{F}{A}$, $E = \frac{\sigma}{\varepsilon}$, $\varepsilon = \frac{\Delta l}{l}$, where σ: stress, ε: strain, E:Youngs modulus

b) Calculate the value of the stress.

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> restart;
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We need to look up some values. First the lattice parameters for Si and Ge

The lattice constant for Si is 5.43 A, and the lattice constant for Ge is 5.66 A

d_Si=0.543 nm d_Ge=0.566 nm

E_Ge=102.7 GPa

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> lookups:={d_Si=0.543*1e-9*m,d_Ge=0.566*1e-9*m,E_Ge=102.7e9*N/m^2};
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$$\text{lookups} := \left\{ \text{d\_Ge} = 5.66\ 10^{-10}\ \text{m},\ \text{E\_Ge} = \frac{1.027\ 10^{11}\ \text{N}}{\text{m}^2},\ \text{d\_Si} = 5.43\ 10^{-10}\ \text{m} \right\}$$

a)

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> "The deformation is";
  subs(lookups,(d_Ge-d_Si));'OR';subs(lookups,(d_Ge-d_Si)/d_Ge);
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"The deformation is"

$$2.3\ 10^{-11}\ \text{m}$$

OR

0.04063604240

There is no strict definition of 'deformation', a measure for it is the elongation or the relative elongation. The latter is the strain

b)

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> sigma=E*epsilon;
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$$\sigma = E\,\varepsilon$$

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> sigma=E_Ge*((d_Ge-d_Si)/d_Ge);
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$$\sigma = \frac{E\_Ge\,(d\_Ge - d\_Si)}{d\_Ge}$$

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> subs(lookups,%);
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$$\sigma = \frac{4.173321555\ 10^{9}\ N}{m^{2}}$$

The stress is 4.2 GP.

Compare that to the yield stress of Ge. "Apparent Elastic Limit = 89.6 MPa"

The numbers for this may vary in tables, It is of course dependant on temperature.

But the important thing is that the stress required is very large. So large that it is unlikely to force a pure Ge crystal inside a Si latice and then take over its lattice parameters- there would be a tendency for this beeing favourable by direct bonding arguments at the interfaces, but the elastic energy would have been very big. This iis of relevance for epitaxial growth of Ge or GeSi on Si.