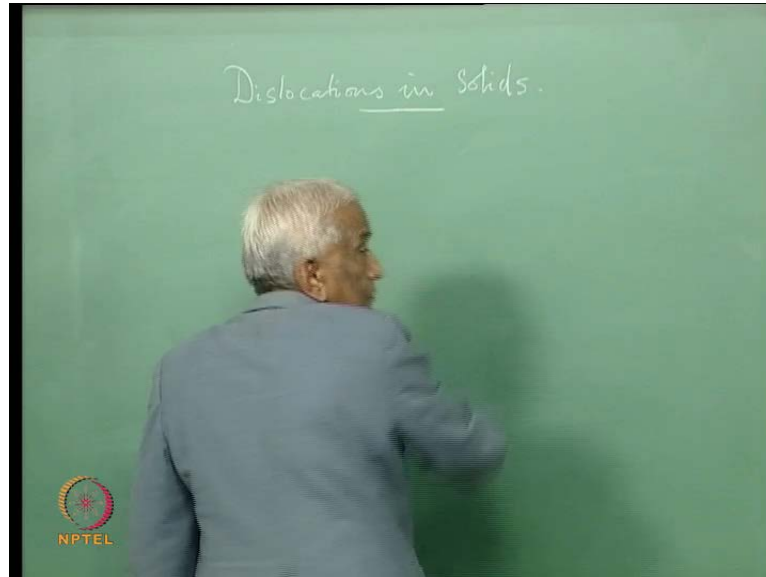


Condensed Matter Physics  
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Lecture - 39  
Dislocation in Solids – Worked Examples

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Today, we will work out some examples on dislocations in solids.

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Worked example 100

Problem

In a cubic system find if it is possible for two dislocations

$\frac{a}{2} [111]$  and  $\frac{a}{2} [\bar{1}\bar{1}\bar{1}]$  to combine to give a single

dislocation  $a[110]$ .



The first example tells us that we have a cubic crystal and we are asked to check if it is possible for two dislocations represented by a by 2 111 each whether it is possible for these two dislocations to combine to form a single dislocation at 110 that is the question, a 110.


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**Solution**

Energy of formation  
of dislocation  $\frac{a}{2} [111] \propto b^2 = \frac{a^2}{4} (1+1+1) = \frac{3a^2}{4}$

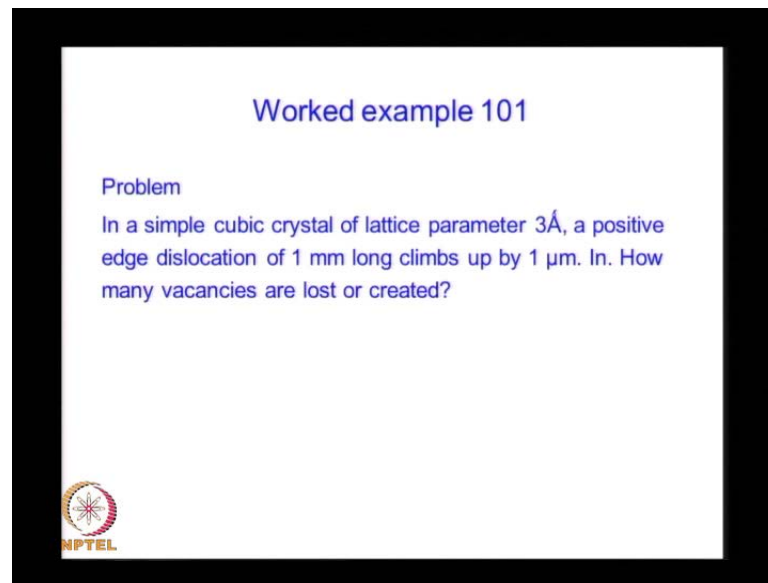
Energy of formation  
of dislocation  $\frac{a}{2} [\bar{1}\bar{1}\bar{1}] \propto b^2 = \frac{a^2}{4} (1+1+1) = \frac{3a^2}{4}$

Total energy of formation of the two dislocations  $\propto \frac{3a^2}{2}$



In order to find this is basically a question of energy of the formation of dislocation a by 2 111, this is equal to a square plus k square 1 square plus 1 square plus 1 square by 2 a square which is 3 by 2 a square, so that is the energy of the single dislocation. So, energy of two dislocations is 3 half's a square, whereas the energy of a dislocation 1 110 is 1 square 1 plus square into a square which is 2 a square. So, since this energy, so this is e 1 this is e 2, it is clear that e 1 is less than e 2. So, the combination, the two dislocations combining to form a single dislocation is not energetically possible that is the answer.


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**Worked example 101**

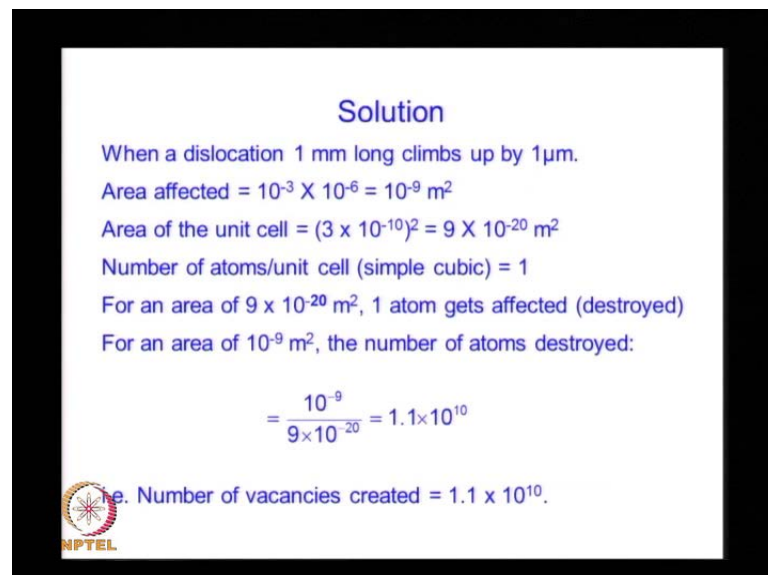
**Problem**

In a simple cubic crystal of lattice parameter  $3\text{\AA}$ , a positive edge dislocation of 1 mm long climbs up by  $1\ \mu\text{m}$ . In. How many vacancies are lost or created?



Next we are again told that we have a simple cubic crystal whose lattice parameter is a 3 angstrom. So, a positive edge dislocation whose length is one millimetre, we are told that it climbs up by 1 micro meter. We are asked find how many vacancies are lost or created that is the question.

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**Solution**

When a dislocation 1 mm long climbs up by  $1\ \mu\text{m}$ .

Area affected =  $10^{-3} \times 10^{-6} = 10^{-9}\ \text{m}^2$

Area of the unit cell =  $(3 \times 10^{-10})^2 = 9 \times 10^{-20}\ \text{m}^2$


Number of atoms/unit cell (simple cubic) = 1

For an area of  $9 \times 10^{-20}\ \text{m}^2$ , 1 atom gets affected (destroyed)

For an area of  $10^{-9}\ \text{m}^2$ , the number of atoms destroyed:

$$= \frac{10^{-9}}{9 \times 10^{-20}} = 1.1 \times 10^{10}$$

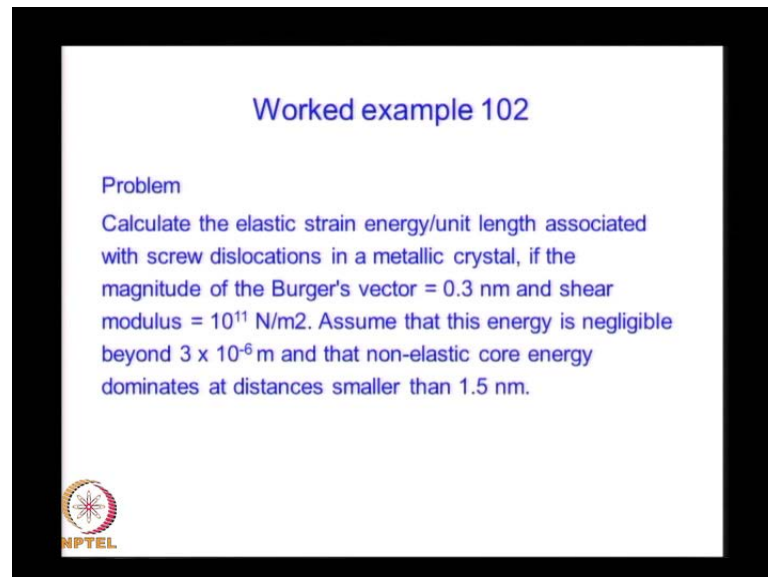
∴ Number of vacancies created =  $1.1 \times 10^{10}$ .



So, we are told that you have an the area is 1 millimetre 10 to the power minus 3 meters into one micron metre, which is 10 to the power minus 6 which is 10 to power minus 9 meters that is the area affected. It is 3 into 10 to the power minus 10 square which is 9

into  $10$  to the power minus  $20$  meter square. So, in this area how many unit cells are there for an area of  $10$  to the power minus  $9$ . We have  $10$  to the power minus  $9$  by  $9$  into  $10$  to the power minus  $20$ , which is  $1$  by  $9$  into  $10$  to the power  $11$  which is  $1.1$  into  $10$  to the power  $10$ . This is the number of vacancies created.


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**Worked example 102**

**Problem**


Calculate the elastic strain energy/unit length associated with screw dislocations in a metallic crystal, if the magnitude of the Burger's vector =  $0.3$  nm and shear modulus =  $10^{11}$  N/m<sup>2</sup>. Assume that this energy is negligible beyond  $3 \times 10^{-6}$  m and that non-elastic core energy dominates at distances smaller than  $1.5$  nm.



The next problem concerns the elastic strain, we are asked to calculate the elastic strain per unit length associated with screw dislocations in a metallic crystal. We are told that the burgers vector is  $0.3$  nanometres. The shear modulus is  $10$  to the power  $11$  newton per metre square. You are also given as to assume that this strain energy is negligible beyond  $3$  into  $10$  to the minus  $6$  meters, and the non elastic core energy, dominates at a distance less than  $1.5$  nano meters.

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**Solution**

$$\text{Energy/unit length (Equation 2.9)} = \frac{Gb^2}{4\pi} \ln \frac{R}{r_0}$$
$$G = 10^{11} \text{ N/m}^2, b = 0.3 \text{ nm}, R = 3 \times 10^{-6} \text{ m}$$
$$r_0 = 1.5 \times 10^{-9} \text{ m}$$
$$\text{Energy / unitlength} = \frac{10^{11} \times (0.3 \times 10^{-9})^2}{4\pi} \ln \left( \frac{3 \times 10^{-6}}{1.5 \times 10^{-9}} \right)$$
$$= 5.4 \times 10^{-9} \text{ N (or J/m)}$$



This is the substitutional problem in which we know the expression for the strain energy which was discussed in the lecture it is strain elastic strain per unit length is  $G b^2$  square by  $4 \pi \log R$  by  $r_0$ . So, in this, this is  $b$ , this is  $G$  this is  $r_0$  and this is  $R$ . So, substituting these values  $10$  to the power  $11$  into  $0.3$  into  $10$  to the minus  $9$  square by  $\ln R$  is  $3$  into  $10$  to the power minus  $6$  by  $r_0$  is  $1.5$  into  $10$  to the power minus  $9$ . So, calculation gives per metre.

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**Worked example 103**

**Problem**

Iron is BCC with a lattice constant of  $2.8 \text{ \AA}$ . If slip occurs causing edge dislocation what would be the length of the Burgers vector?



In the last question, we are told that iron has a body centered cubic structure with a lattice constant. If slip occurs causing edge dislocation what would be the length of the Burgers vector? You know that the slip direction in a bcc structure is  $111$ . And it is a by  $2$   $111$ . So, this will be in the case of  $111$ , since lattice constant is  $2.8$  angstroms, this  $2.8$  into root of  $1$  square plus  $1$  square plus  $1$  square by  $2$ . So, this will be which is...