EKSAMEN I FAG FY3114 Funksjonelle Materialer
Wednesday 19 December 2013
Time: 15.00 – 19.00
SOLUTIONS (English)

Task 1:
Aim: Verify that the students learned the essentials from mini-project presentations given by others and placing their own work in perspective. In addition, some questions related to details in book. Lot of text to read, but limited amount of points awarded. Quick to mark. Expect average score of 8-9, but weak souls tend to score poor already here.

Marking: 1 point per correct answer. Wrong answer with argumentation that deflects insight can be rewarded points.

1(a): A
1(b): D
1(c): D
1(d):
1(e): C
1(f): A
1(g): C
1(h): C
1(i): B
1(j): B

Task 2:
Aim: Verify students know basics of crystal structures for functional materials and have insight in crystal symmetry operations and relate structure to functional properties.

Question 2(a):

Question 2(b):

-Unity(1), 4-fold rotation axis with mirror plane perpendicular, 3-fold rotation-inversion axis, and 2-fold rotation with mirror plane perpendicular. Cubic crystal system.

Question 2(c):

Task 3:
Aim: Verify that student can work with tensors related to functional properties

Question 3(a):

$$a_{ij} = \begin{bmatrix} \cos\theta & -\sin\theta & 0 \\ \sin\theta & \cos\theta & 0 \\ 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} \frac{1}{2} & -\frac{1}{2}\sqrt{3} & 0 \\ \frac{1}{2}\sqrt{3} & \frac{1}{2} & 0 \\ 0 & 0 & 1 \end{bmatrix}.$$

This gives:

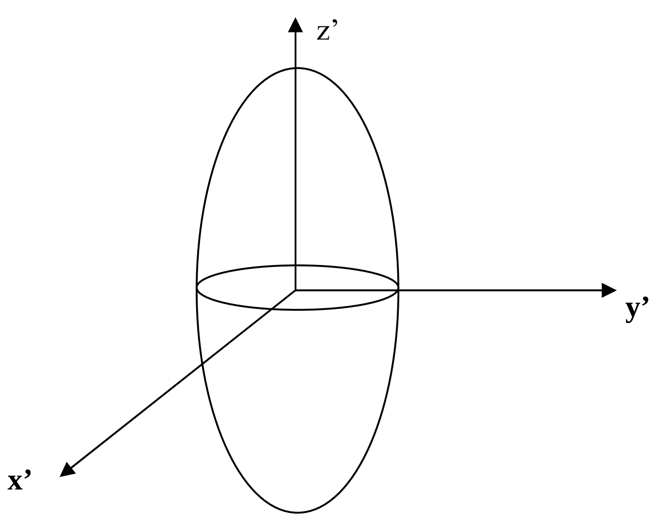
$$\sigma'_{11} = a_{11}a_{11}\,\sigma_{11} + a_{11}a_{12}\,\sigma_{12} + a_{12}a_{11}\,\sigma_{21} + a_{12}a_{12}\,\sigma_{22}$$
$$\sigma'_{22} = a_{21}a_{21}\,\sigma_{11} + a_{21}a_{22}\,\sigma_{12} + a_{22}a_{21}\,\sigma_{21} + a_{22}a_{22}\,\sigma_{22}$$
$$\sigma'_{33} = \sigma_{33}$$

All other σ'_{ij} are zero, nice if at least one is calculated as example and control.

$$\sigma'_{ij} = \begin{bmatrix} 25 & 0 & 0 \\ 0 & 16 & 0 \\ 0 & 0 & 9 \end{bmatrix}$$

Question 3(b):

***J* = σ*E* and *E* = ρ*J*,** *which means that $\rho = inv(\sigma)$.*
$\rho_{xx} = 1/25$, $\rho_{yy} = 1/16$, $\rho_{zz} = 1/9$ are the principal components of the resistivity tensor in the rotated coordinate system.



Question 3(c):

$J_i = \sum \sigma_{ij} E_j$ (summation over j).
$J_x = \sigma_{xx} E_x = \sigma_{xx} E \cos\phi$
$J_y = \sigma_{yy} E_y = \sigma_{yy} E \sin\phi$

Angle α between current J and the x'-axis is given by:

$\tan\alpha = J_y/J_x = \tan\phi\ \sigma_{yy}/\sigma_{xx} = \tan(60^o)\ 16/25 = 1.11$ which gives $\alpha = 47.9^o$.
The angle between J and E is then $\phi - \alpha = 60^o - 47.9^o = 12.1^o$.

Question 4(a):
For description of a Schottky junction see book or lecture notes.

Question 4(b):
For carrier statistics in a doped semiconductor see book or lecture notes.

Question 5(a):
See book/notes

Question 5(b):
See book/notes