Exercise 3.6-1

All Class Exercises and Quick Questions to

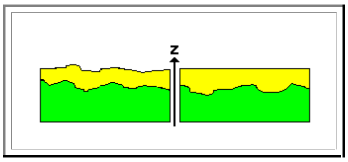
3. Thin Films

Subchapter 3.1: Thin Films - General

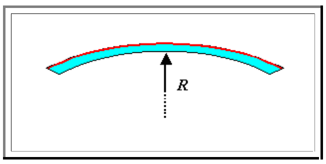
- Interference causes the color of a thin film and betrays its thickness? *Explain!*
- Give examples of what "thin" could mean in relation to *intrinsic* length scales. Provide (and discuss briefly) some intrinsic lengths, in particular with respect to semiconductors
- Give a few number for the meaning of "thin":
    - Thickness of a human hair ≈≈ **????**
    - Thickness of a gate oxide in an integrated transistor ≈≈ **????**
    - Thickness of antireflection layers of optical lenses ≈≈ **????**
    - Thickness of a thin film solar cell ≈≈ **????**
    - Other examples you can come up with **???**
- Give somer examples of thin film applications outside of semiconductor technology.
- Give the equation for the capacity ***C*** of a parallel plate capacitor with plate area ***A*** for a maximum voltage of **10 V**. How can you achieve maximum capacity and what are the limits? Hint: Consider field strength and relvant intrinsic length scales.

Subchapter 3.2: Mechanical Properties

- How would you define the roughness of the two thin films shown? Give an equation if possible and differentiate between the two cases.

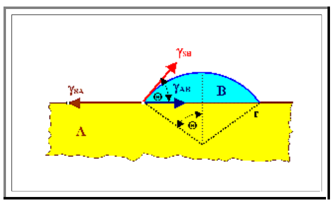


- Give examples for a thin layer of material **B** on substrate **A** for which you would expect good or bad adhesion, respectively: Give reasons for you expectation.
- The "surface" energy of glass is around **γ(Glas) 300 mJ/m^2**, for a metal we might have **γ(Metal)** ≈ **2100 mJ/m^2**. You deposit a noble metal. On which substrate would you expect better adhesion?
- Give an example of how one could measure the adhesion strength of a thin film.
- The red thin layer (thickness d_B) on the blue circular **Si** wafer substrate (thickness $d_A \gg d_B$) is under compressive stress σ; the wafer thus is warped with a radius of curvature = ***R***.
  What would ***R*** be proportional to?
  Hint: It is a two-dimensional problem.



Subchapter 3.3: Nucleation and Growth

- What happens when first incoming atoms hits the surface of the substrate? Give at least 4 different possibilities.
- Where would you expect the first imcoming atoms to be solidly bound? Use the proper terminology.
- Define "sticking coefficient". Discuss the dependenc of the sticking coefficient for a given system on the precise substrate condition for a given substrate.
- Explain briefly the major methods for investigations of the nucleation of thin films on substrates.
- Explain how you get from interface energies to forces, and from forces to the wetting angle Θ
- Discuss and name the two major growth mode following from extreme values of Θ
- Discuss and name a third major growth mode



Subchapter 3.4: Structure, Interface and Some Properties

- What is epitaxial growth? Consider the possibility of epitaxial growth; giving possible conditions (e.g. with respect to structures, lattice constants, ...) and use simple pictures:
  - **A** on **A**.
  - **A** (**fcc**) on **B** (**fcc**).
  - **A** (**fcc**) on **C** (**hex**).
  - **A** (**fcc**) on **B** (**fcc**) with intermediate layer.
  - ....
- **B (fcc; (100))** with lattice constant a_A is deposited on **A (fcc; (100)** with $a_B = 0.95\, a_A$. Sketch the structure for
  - Thickness of **B** only a few atomic layers.
  - Thickness of **B > 50 nm**
- *Difficult!* Sketch a pure edge misfit dislocation network on a **{100}** interface plane for a misfit of **10 %** for the case of
  - Burgers vector of the dislocations is ***b*** **=** ***a*****<100>**.
  - Burgers vector of the dislocations is ***b*** **=** ***a*****/2<110>**.
- *Difficult!* What would happen if the (square) network of misfit dislocations on a **{100}** type interface would be changed from edge dislocations to screw dislocations?
- What are the energetic reasons for introducing misfit dislocations into epitaxial interface it the layer thickness is larger than a critical thickness? What determines the critical thickness?
- Sketch the curve for the critical thickness d_{crit} in a d_{crit} - misfit diagram, Try to give approximate numbers.
- Enumerate and discuss *structures* obtainable with thin films but not (easily) with bulk materials. Give examples for applications.
- Give reasons why thin film properties can be quite different from bulk properties; give examples.
- Name some technologically extremely important special thin film properties; discuss with actual numbers.