

## Exercise 3.2-1

### Quick Questions to

#### 3.2 Thin Films - Mechanical Properties

Here are some quick questions:

- 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 your expectation.
- The "surface" energy of glass is around  $\gamma(\text{Glas})$  **300 mJ/m<sup>2</sup>**, for a metal we might have  $\gamma(\text{Metal}) \approx$  **2100 mJ/m<sup>2</sup>**. 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.
- A thin layer on some substrate is either under strong tensile or strong compressive stress. Discuss and sketch what might happen if
  1. The interface energy is small, i.e. the adherence is weak.
  2. The interface energy is large.

In the second case something must "give" Discuss possible mechanisms of strain relaxation

- Consider a thin **SiO<sub>2</sub>** film on a thick **Si (10 × 10) mm<sup>2</sup>** substrate that was made at **1.100 °K**. The thermal expansion coefficients are
  - $\alpha_{\text{Si}} = 3 \cdot 10^{-6} \text{ K}^{-1}$
  - $\alpha_{\text{quartz}} = 0.6 \cdot 10^{-6} \text{ K}^{-1}$

What will be the stress and strain in the film at **300 °K**? How does the elastic energy stored in the film scale with its thickness **d<sub>z</sub>**?

- Besides a mismatch in the coefficient of thermal expansion, other mechanisms can produce stress in thin films, too. Do you know any or can you think of any?
- The red thin layer (thickness **d<sub>B</sub>**) on the blue circular **Si** wafer substrate (thickness **d<sub>A</sub> >> d<sub>B</sub>**) is under compressive stress  $\sigma$ ; the wafer thus is warped with a radius of curvature = **R**. What would **R** be proportional to?  
*Hint:* It is a two-dimensional problem.
- Imagine, that in the picture on the right you deposited the red film also on the backside. What would the radius of curvature be now? The stress in the two layers? Now imagine that you keep processing this system until, for example, you get a transistor. This involves structuring the top layer, i.e. etching part of the layer off. When would you take the layer on one side off, if you don't need it for whatever you try to produce?

