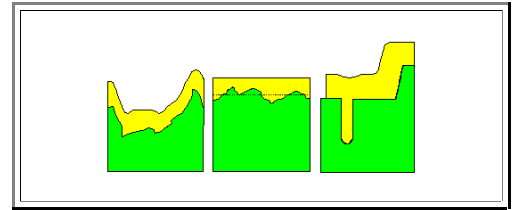


3.2.4 Summary to: 3.2 Mechanical Properties

Thin films have other spatial properties besides their thickness, i.e. roughness

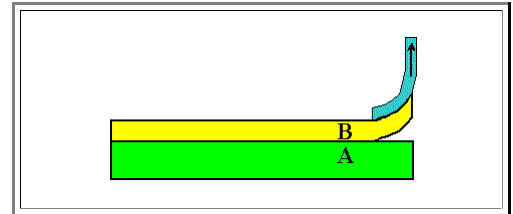
- Interface roughness and surface roughness R defined by their "root mean square".

$$R = \left(\frac{1}{N} \sum_{i=1}^N z_i^2 \right)^{1/2}$$



Useable thin films adhere to their substrate.

- A direct measure of adhesion is the interfacial energy γ_{AB} between film **A** and substrate **B**.
- The phase diagram provides some guideline. Complete miscibility = good adhesion, (eutectic) decomposition = (?) low adhesion. Calculations of γ are difficult.
- Full adhesion can only be obtained for films *grown* on a substrate. Adhesion energies can be measured.



Generally, there will be stress σ and strain ϵ in a thin film and its substrate.

- A major source of strain is the difference of the thermal expansion coefficients α

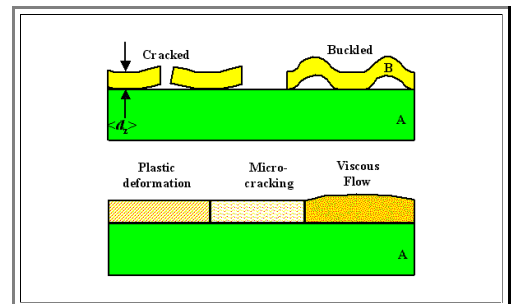
$$\epsilon_{TF} = \Delta T \cdot \Delta \alpha$$

$$\sigma_{TF} = Y \cdot \Delta T \cdot \Delta \alpha$$

Stress and strain in thin films can be large and problematic!

Stress in thin films may relax by many mechanisms; and this might be good or bad:

- Cracking or buckling
 - Plastic deformation
 - Viscous flow
 - Diffusion
 - Bending of the whole system (Warpage)
- Warpage can be a serious problem in semiconductor technology.



Exercise 3.2-1
All Questions to 3.2