

### 3.4.2 Thin Film Structure

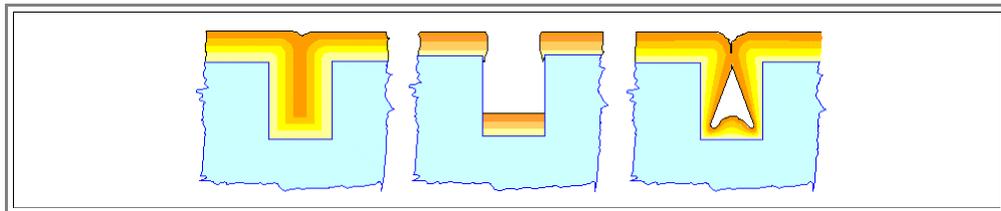
▶ This will be short, because we will discuss this topic mostly when we come to deposition methods.

▶ Let's distinguish to separate points

1. Geometry and morphology.
2. Internal structure.

▶ The first topic has been [mentioned before](#), but now we go beyond the points made there.

- Let's consider to grow a thin film on a substrate that has a small hole in it - say half a  $\mu\text{m}$  in lateral size and  $1 \mu\text{m}$  deep. We deposit a thin film (atomic) layer by layer (symbolized by various shade of yellow). What we might get could have one of the topologies shown below or anything in between



- The only difference between these quite different topologies is the deposition method; we will cover that in more detail in [chapter 6](#).

▶ There is much more along this line, but we cover it when we get to it.

▶ As far as the internal structure goes, the situation is similar. Everything known from bulk materials goes:

- *Poly-crystalline* thin films with grain sizes ranging from a few nanometers to **cm** (Are the **Zn**-covered steel lamp posts, letter boxes, etc. with huge grains products of the thin film industry?)
- *Single crystalline* thin films, but full of defects like dislocations, precipitates, point defects.
- *Nearly perfect* single crystalline thin films - what we often would like to have, but not always get.

▶ If we just look at polycrystalline thin films, we may have just regular grains, or all kinds of textures. Again, we deal with it when we run across it.

▶ Then we have some **thin film specialities**:

- **Amorphous thin films**, like amorphous **Si** (**a-Si**) or many other materials. You just can't have amorphous **bulk Si** or most everything else that usually likes to form a crystal.
- Mixtures of amorphous and crystalline phases; truly nanocrystalline structures (i.e. grain size around **10 nm**) - practically never found in bulk.

▶ A case in point is **Silicon** (what else?). We have:

- **Amorphous Silicon**, used, e.g., in microelectronics. If it is heavily mixed (= "doped" with Hydrogen (> 15 %)), we have the crucial thin film for **a-Si:H solar cells** or for the transistor matrix of **liquid crystal displays (LCD)**. Another example is amorphous **SiO<sub>2</sub>**, the work-horse of microelectronics.
- *Amorphous-crystalline* mixes, like **a-Si:H** containing nanometer-sized embedded islands of crystalline silicon (**c-Si** and then called **μc-Si:H**). This is the base of the so-called "microcrystalline **Si** thin-film solar cell", one of the hottest contender for the solar cell market of the future.