

## Tutorial problems and questions

1. Most of the materials that we encounter in our daily lives are polycrystalline. If the grain boundary energy does increase the free energy of the system, why do they not disappear leaving behind a single crystal?

### Answer

Polycrystalline materials are one of the best examples of systems in metastable equilibrium. The true equilibrium in a material can be reached only when all the grain boundaries disappear and the system becomes a single crystal. However, unless extreme care is taken, that never happens. In most materials, the grain boundaries reach configurations in which the interfacial energies balance each other; in such scenarios, there is a barrier which must be overcome for the boundaries to move; the system is stable with respect to small changes in boundary shape and surface area. Hence, such metastable structures tend to stay.

2. What happens if a grain boundary intersects a free surface as shown in Fig. 7?

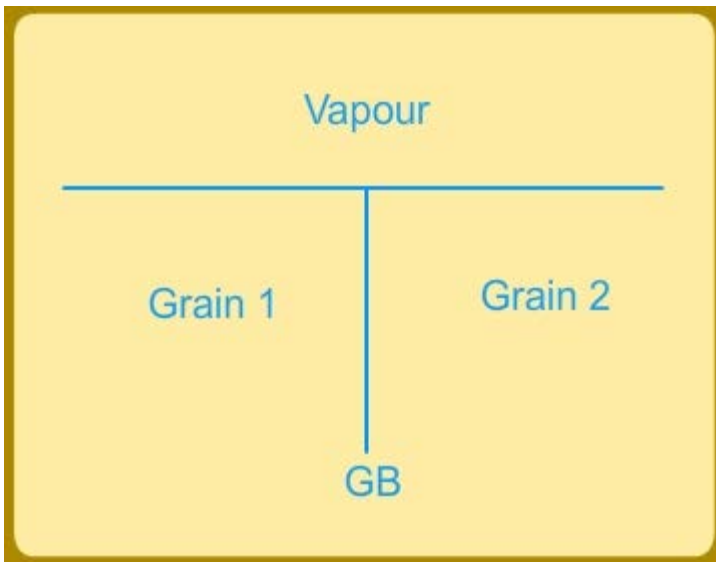


Figure 7: Grain boundary intersecting a free surface.

### Answer

We show in Fig. 8 what happens when a grain boundary intersects a free surface. The grain boundary region grooves; it grooves in such a way that the net surface-vapour surface tensions balance the grain boundary energy as shown in the figure. Grain boundary grooving is sometimes used to prepare microscopy samples because a grooved grain boundary gives rise to contrast which makes it clearly visible under a microscope.

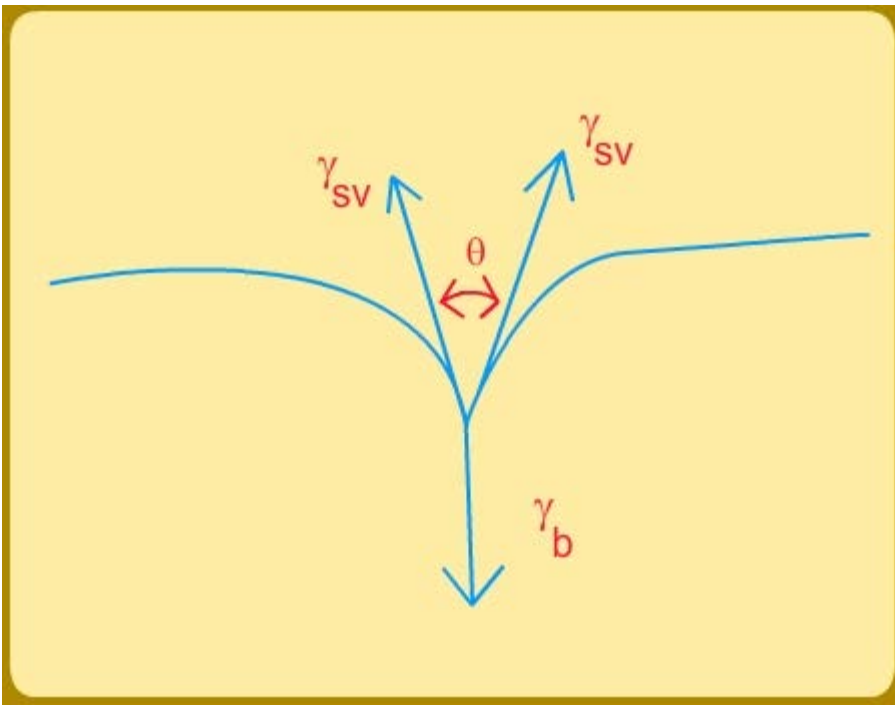


Figure 8: Grain boundary intersecting a free surface grooves to balance the forces.