Phase Transformations: Solidification

Today's topics:

- **Solidification of superheated liquid against a cooled mold wall**
- **Solidification of supercooled liquid by a nucleation event in the liquid**
- **Shape stability of the solid/liquid interface**
- **Constitutional supercooling of an alloy**
- **Casting microstructures**

Solidification of superheated liquid

- **Heat removed through mold wall at $T < T_m$**

Figure removed due to copyright restrictions.
See Figure 20.10 in Balluffi, Robert W., Samuel M. Allen, and W. Craig Carter. *Kinetics of Materials*. Hoboken, NJ: J. Wiley & Sons, 2005. ISBN: 0471246891.

- **Interface *stable* with respect to shape variations**

Figure removed due to copyright restrictions.
See Figure 20.11 in Balluffi, Robert W., Samuel M. Allen, and W. Craig Carter. *Kinetics of Materials*. Hoboken, NJ: J. Wiley & Sons, 2005. ISBN: 0471246891.

Solidification of supercooled liquid

- **Latent heat removed into liquid at $T < T_m$**

Figure removed due to copyright restrictions.
See Figure 20.12 in Balluffi, Robert W., Samuel M. Allen, and W. Craig Carter. *Kinetics of Materials*. Hoboken, NJ: J. Wiley & Sons, 2005. ISBN: 0471246891.

- **Interface *unstable* with respect to shape variations**

Figure removed due to copyright restrictions.
See Figure 20.11b in Balluffi, Robert W., Samuel M. Allen, and W. Craig Carter. *Kinetics of Materials*. Hoboken, NJ: J. Wiley & Sons, 2005. ISBN: 0471246891.

Constitutional supercooling in alloys

- **Solute enrichment ahead of an advancing solid/liquid interface can effectively supercool the adjacent liquid by forming liquid compositions that are below their melting temperature. This commonly results in dendrite formation in alloys.**

Figure removed due to copyright restrictions.
See Figure 20.13 in Balluffi, Robert W., Samuel M. Allen, and W. Craig Carter. *Kinetics of Materials*. Hoboken, NJ: J. Wiley & Sons, 2005. ISBN: 0471246891.

Cells and dendrites

- **Features resulting from shape instability**

Cells & Dendrites ~10 μm

Figure removed due to copyright restrictions.
See Figure 20.3 in Balluffi, Robert W., Samuel M. Allen, and W. Craig Carter. *Kinetics of Materials*. Hoboken, NJ: J. Wiley & Sons, 2005. ISBN: 0471246891.

Macro grain structure of a casting ~0.1—10 mm grains

Figure removed due to copyright restrictions.
See Figure 20.5 in Balluffi, Robert W., Samuel M. Allen, and W. Craig Carter. *Kinetics of Materials*. Hoboken, NJ: J. Wiley & Sons, 2005. ISBN: 0471246891.

SEM View of Dendrites in Cu–Ni–Mn Alloy

- **These dendrites are very large because the liquid metal was cooled very slowly.**

Figure removed due to copyright restrictions.
See Figure 20.9 in Balluffi, Robert W., Samuel M. Allen, and W. Craig Carter. *Kinetics of Materials.* Hoboken, NJ: J. Wiley & Sons, 2005. ISBN: 0471246891.

- **When a material solidifies dendritically and forms a polycrystal, the grain size is generally *much larger* than the dendrite spacing.**
- **Alloy solidification via dendrite formation leads to compositionally inhomogeneous material.**

Microsegregation

- **Alloy solidification via dendrite formation leads to compositionally inhomogeneous material.**

Figure removed due to copyright restrictions.
See Figure 22.4 in Balluffi, Robert W., Samuel M. Allen, and W. Craig Carter. *Kinetics of Materials*. Hoboken, NJ: J. Wiley & Sons, 2005. ISBN: 0471246891.