GrainBound MATERIAL DIAGNOSIS

Grain Boundary Complexion Time-Temperature-Transformation Diagrams

Grain boundary complexion transformations can instantaneously alter material properties and cause unreliable and inconsistent material performance.

Like bulk phase nucleation, complexion transitions experience an incubation time and can be described with time-temperature-transformation (TTT) diagrams.

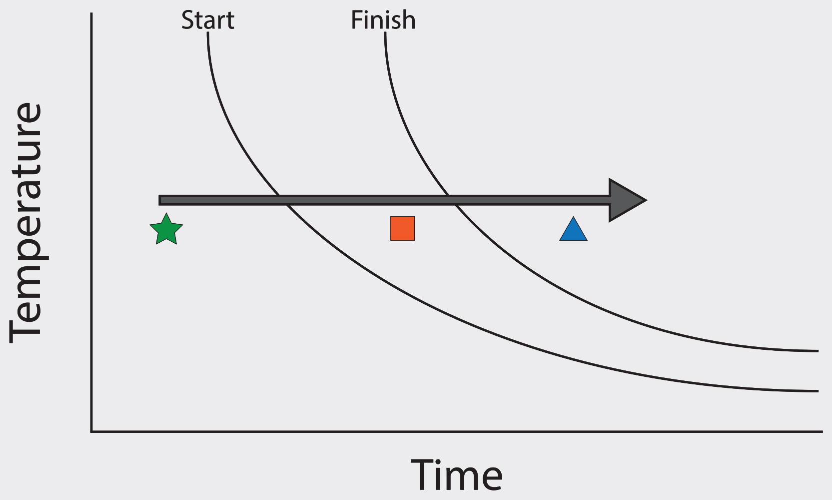
However, complexions transformations can be controlled as they transition between different types depending on misorientation, chemistry, temperature and *time*.

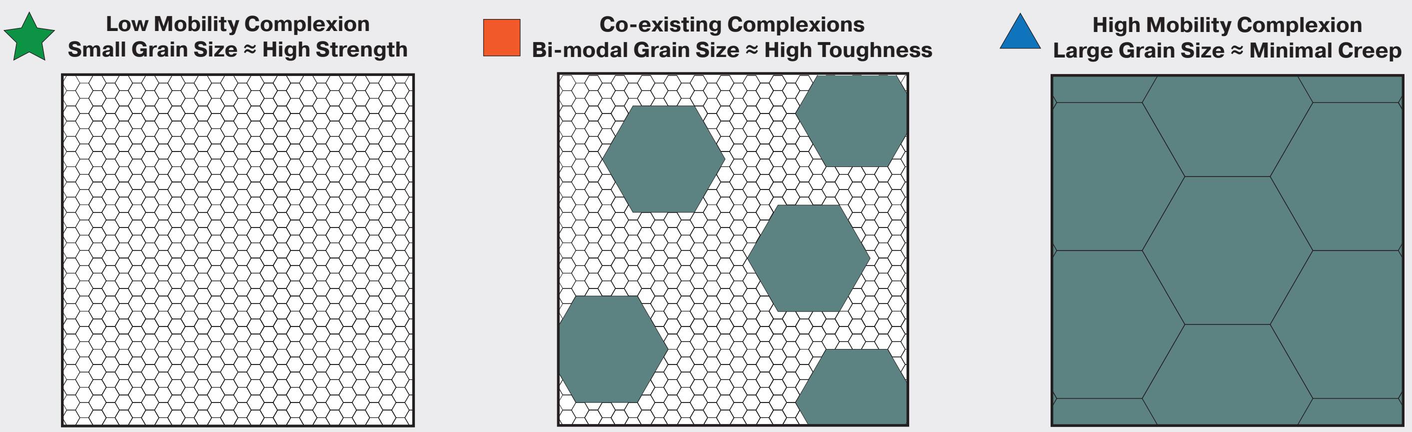
GRAINBOUND CONSTRUCTS TIME-TEMPERATURE-TRANSFORMATION (TTT) DIAGRAMS TO CONTROL BULK PROPERTIES

Complexion transitions can be guided through their TTT curves to engineer intentional grain size distributions and bulk material properties.

The START curve shows when the first grain boundaries transform at a given temperature and time. The FINISH curve represents when all grain boundaries in a microstructure have transformed.

Imagine a small grained material that undergoes a complexion transformation to a fast grain boundary type that causes abnormal grain growth.





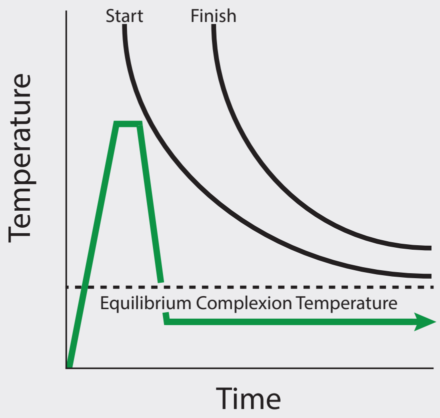
Use-Inspired Applications of Grain Boundary TTT Diagrams

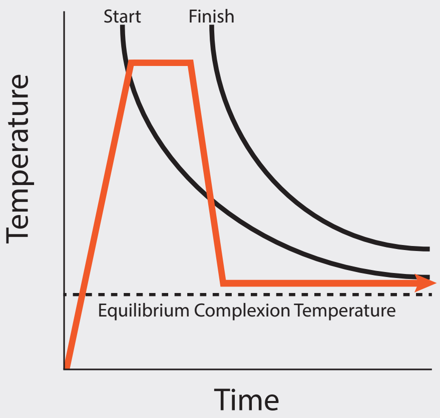
TWO-STEP SINTERING TO LIMIT GRAIN GROWTH

Goal: Create small grain size distributions to achieve high strength and hardness

Method:

- Do not cross the START line to prohibit the complexion transition and retain low mobility grain boundaries
- High temperature for short durations ensures high density and the low temperatures lead to slow grain growth during final densification





DESIGN TOUGHENED BI-MODAL MICROSTRUCTURES

Goal: Create Bi-modal microstructure that exhibits high toughness compared to uni-modal grain size distributions

Method:

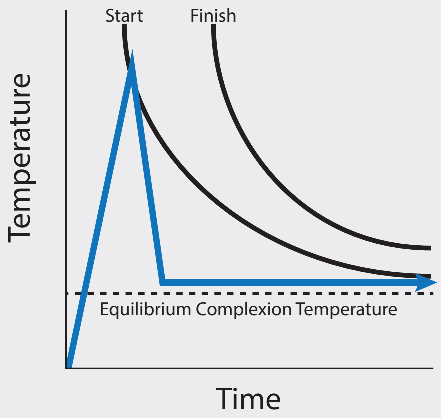
- Cross the START curve but not the FINISH curve to induce a fraction of the grain boundaries to transform to a higher mobility complexion, which creates a two-complexion structure
- Tailor the relative amount of abnormal grains to small grains to reach a desired combination of strength and ductility by controlling the fraction of grain boundaries transformed

CONVERSION TO SINGLE CRYSTAL

Goal: Create single crystals that are creep resistant or for optical and electronic components

Method:

- Cross the START curve and immediately cool to just above the equilibrium complexion transition temperature to induce a single grain boundary to transform to a higher mobility complexion
- Allow this highly mobile grain boundary to grow at a lower temperature, where it can consume all other grains to form one single grain



GrainBound
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