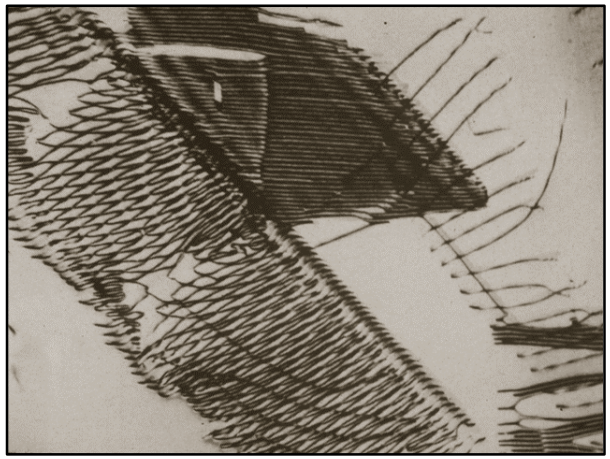
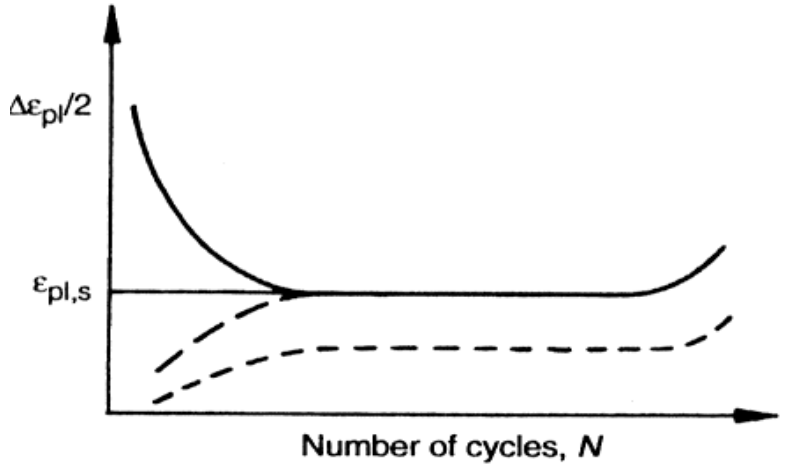
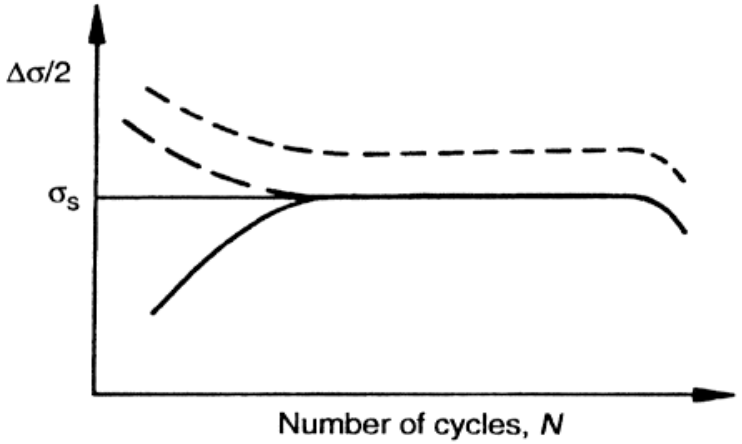
Materials Issues in Fatigue and Fracture



- 5.1 Fundamental Concepts
- 5.2 Ensuring Infinite Life
- 5.3 Finite Life
- **5.4 Summary**

Stress or strain controlled?



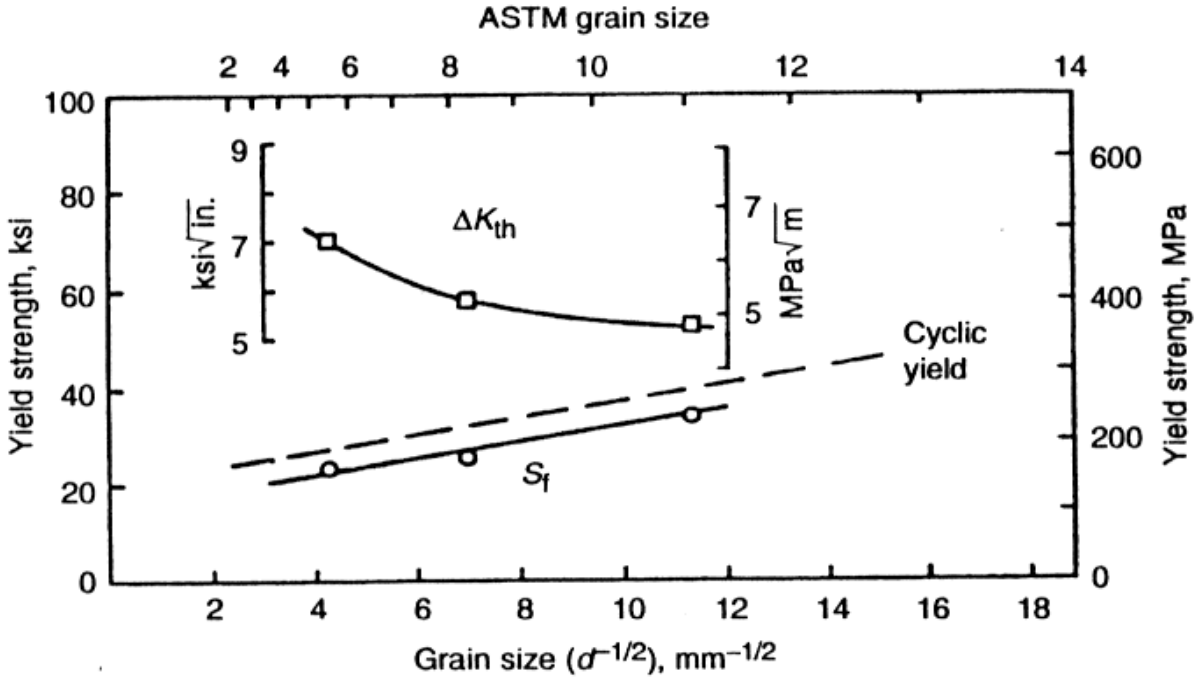


stress controlled

strain controlled

There is a fundamental difference between stress and strain controlled fatigue situations. Recall the phenomenon of "coaxing".....!

Opposing effect of grain size



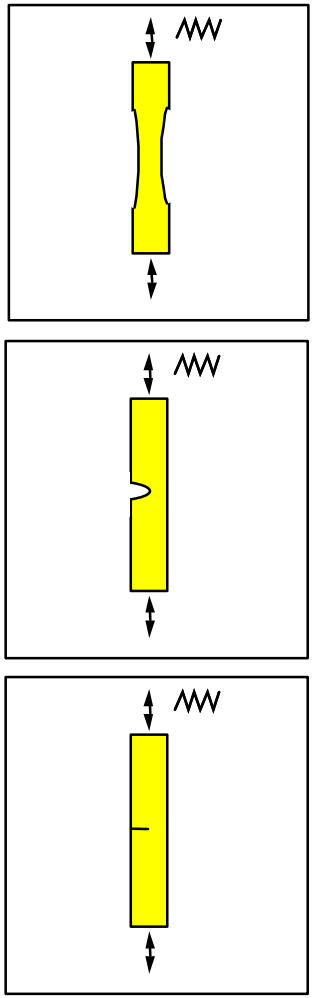
Crack initiation controlled by strength

$$\sigma_{y\ polycrystal} = \sigma_T + \sigma_{ST} + k\ D^{-1/2}$$

Short crack growth controlled partly by grain size

$$\Delta K_{th} = 6.14\ \sigma_{ys}\ (D)^{1/2}$$

Optimum microstructure?



Smooth specimen (K_t ~ 1) - at long lives life dominated by initiation so pick small, high-strength microstructures

Notched Specimen (K_t ~ 2) - at long lives initiation and crack growth equally important. Avoid high tensile residuals therefore use lower strength materials

Cracked specimen ($K_t > 5$) - in the absence of tensile residuals and for near conditions, large grain size preferred

Summary

- Avoid stress and strain concentrations both at the component and microstructural level.
- Monotonic and cyclic response can be quite different.
- Role of microstructure differs in the high-stress short-life and in the low-stress long-life regime.

Summary

- Optimizing microstructure for fatigue resistance is usually less important than optimizing it for other reasons: e.g. fracture resistance.
- Small scale microstructures favor the resistance to crack initiation.
- Large scale microstructures promote crack closure and hence retard crack growth particularly for near-threshold conditions.