Isotropy and fatigue

Patrik Ölund

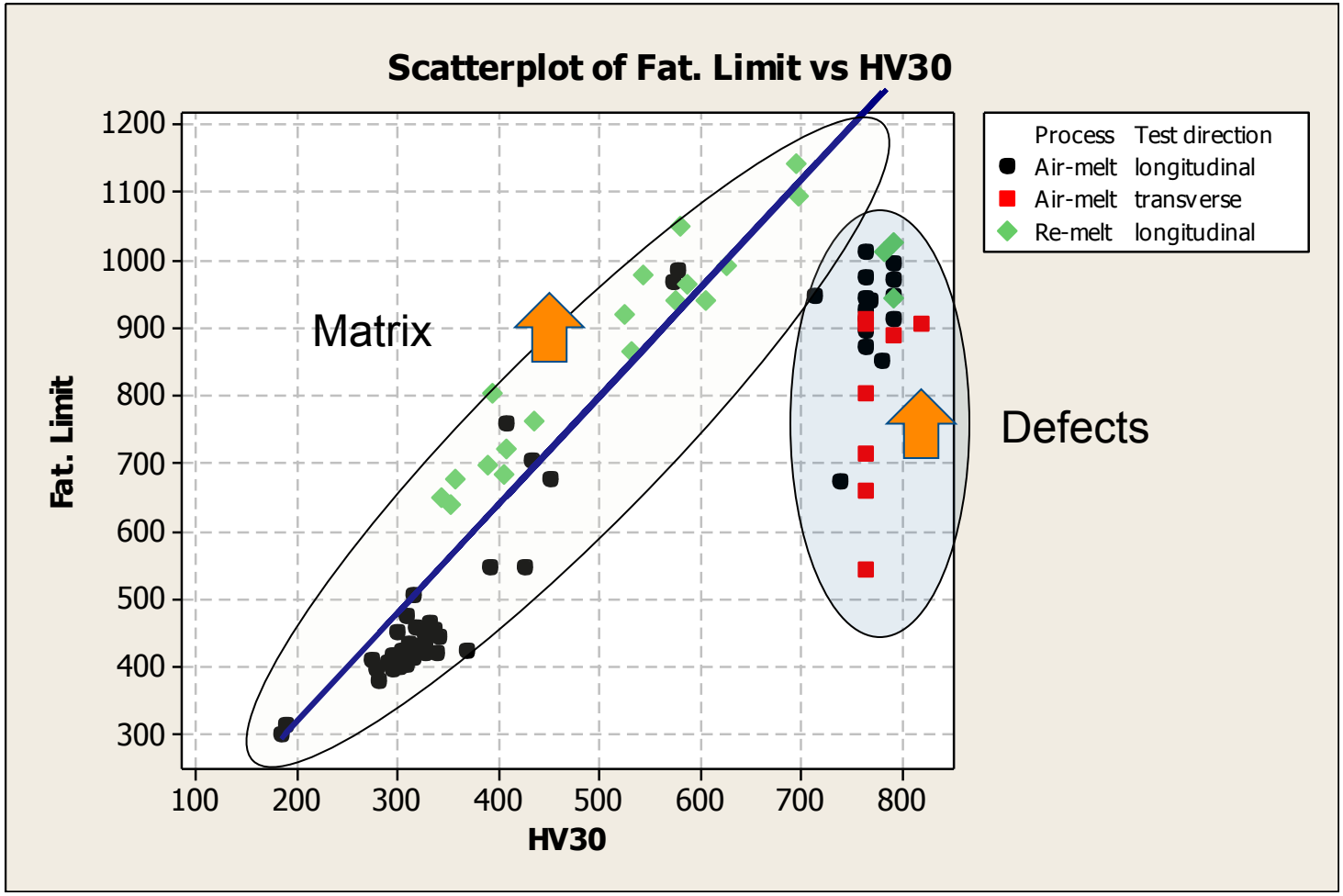
Ovako Group R&D

patrik.olund@ovako.com

Content

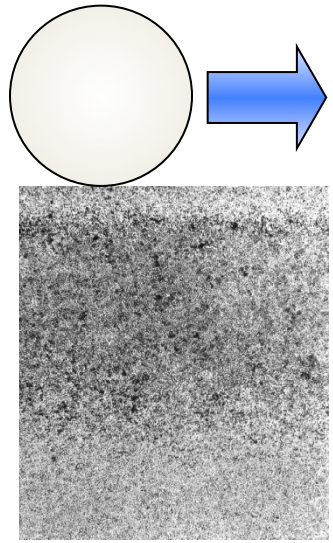
- Fatigue – the influence of matrix/defects
- Influence of loading direction – isotropy
- Influence of loaded volume
- Influence of temperature
- Summery and conclusions

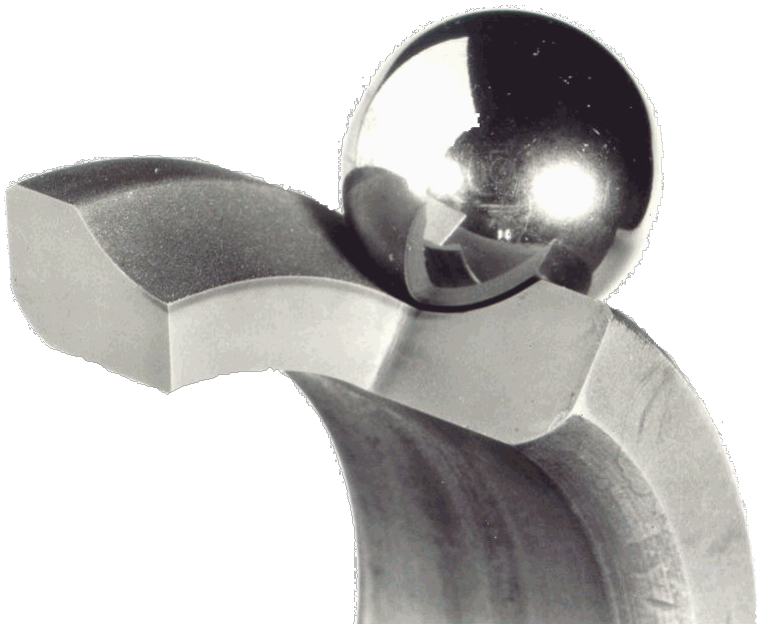

Matrix
Defects


Scatterplot of Fat. Limit vs HV30
Fat. Limit
HV30
1200
1100
1000
900
800
700
600
500
400
300
100
200
300
400
500
600
700
800
Process
Test direction
Air-melt
longitudinal
Air-melt
transverse
Re-melt
longitudinal
Matrix
Defects

Contact fatigue

- Occurs in application subjected to contact stresses
  - Bearings
  - Gears
  - Cam rollers
  - Cam shafts

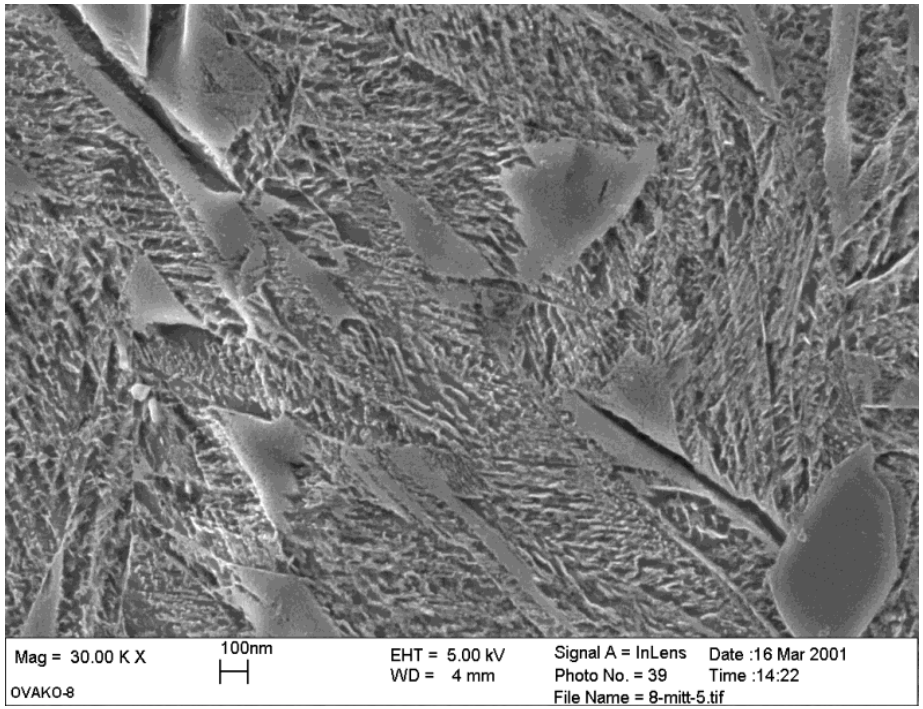




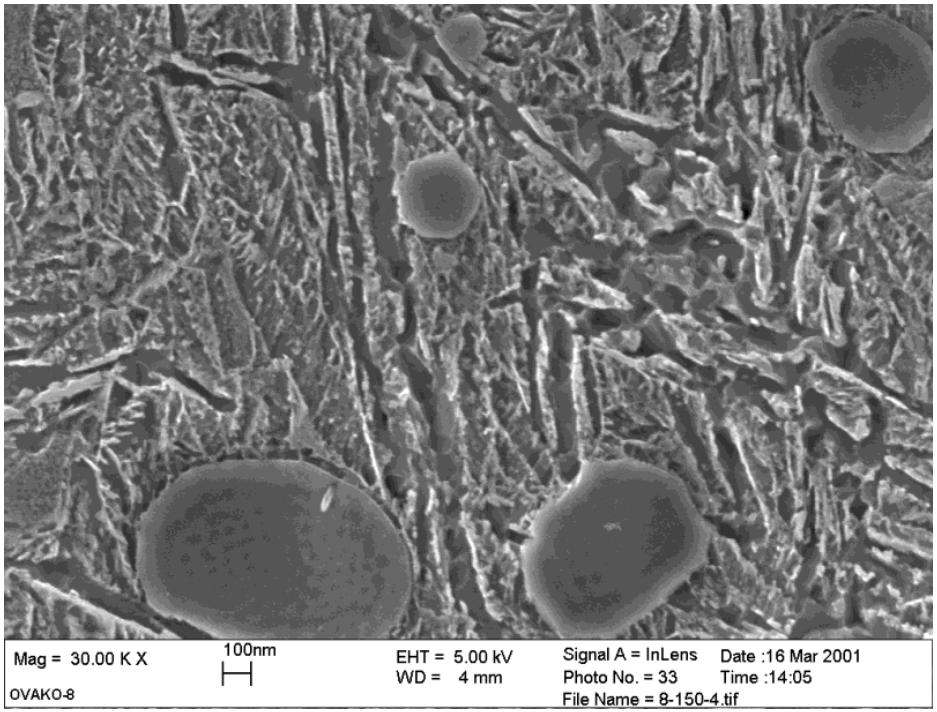
[1]Dark Etching Region

RCF Tested Martensitic 100Cr6
Testing conditions: 3.2 GPa; 100°C; 130 million cycles

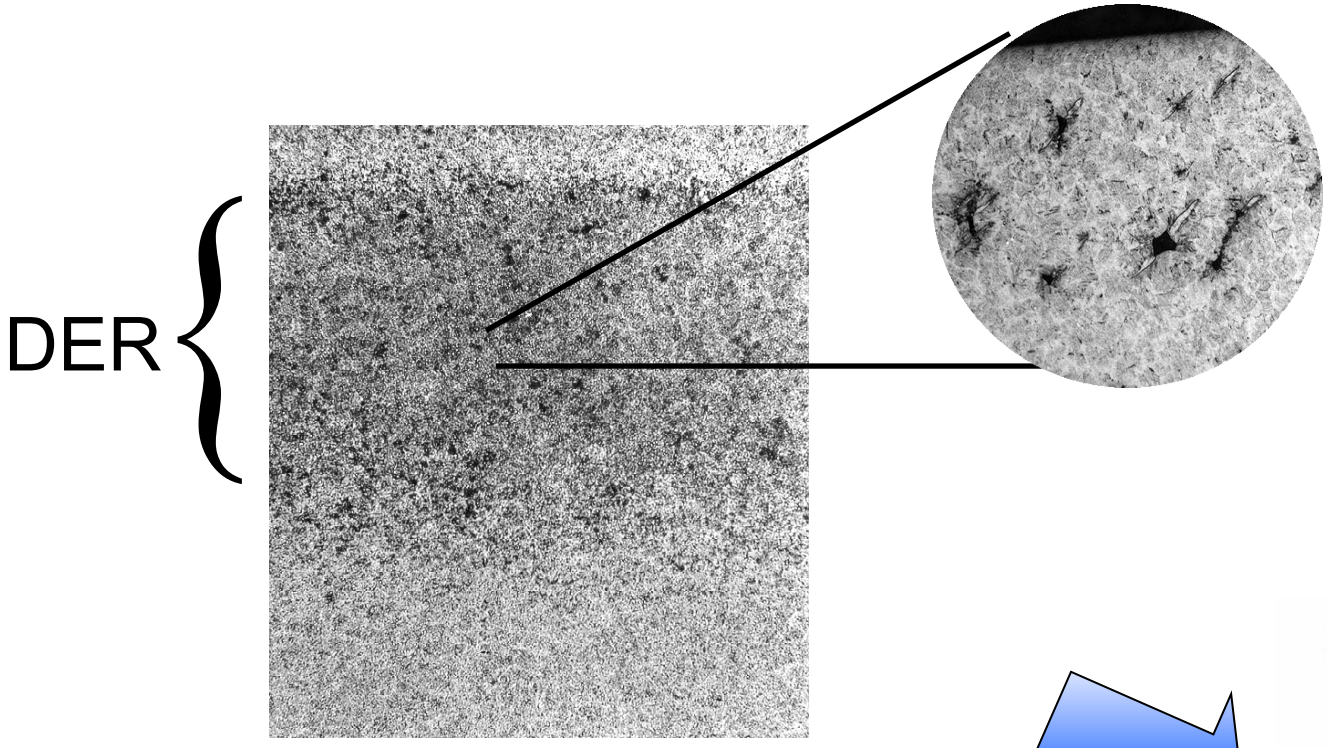
Outside DER

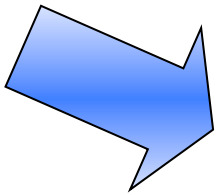


Inside DER



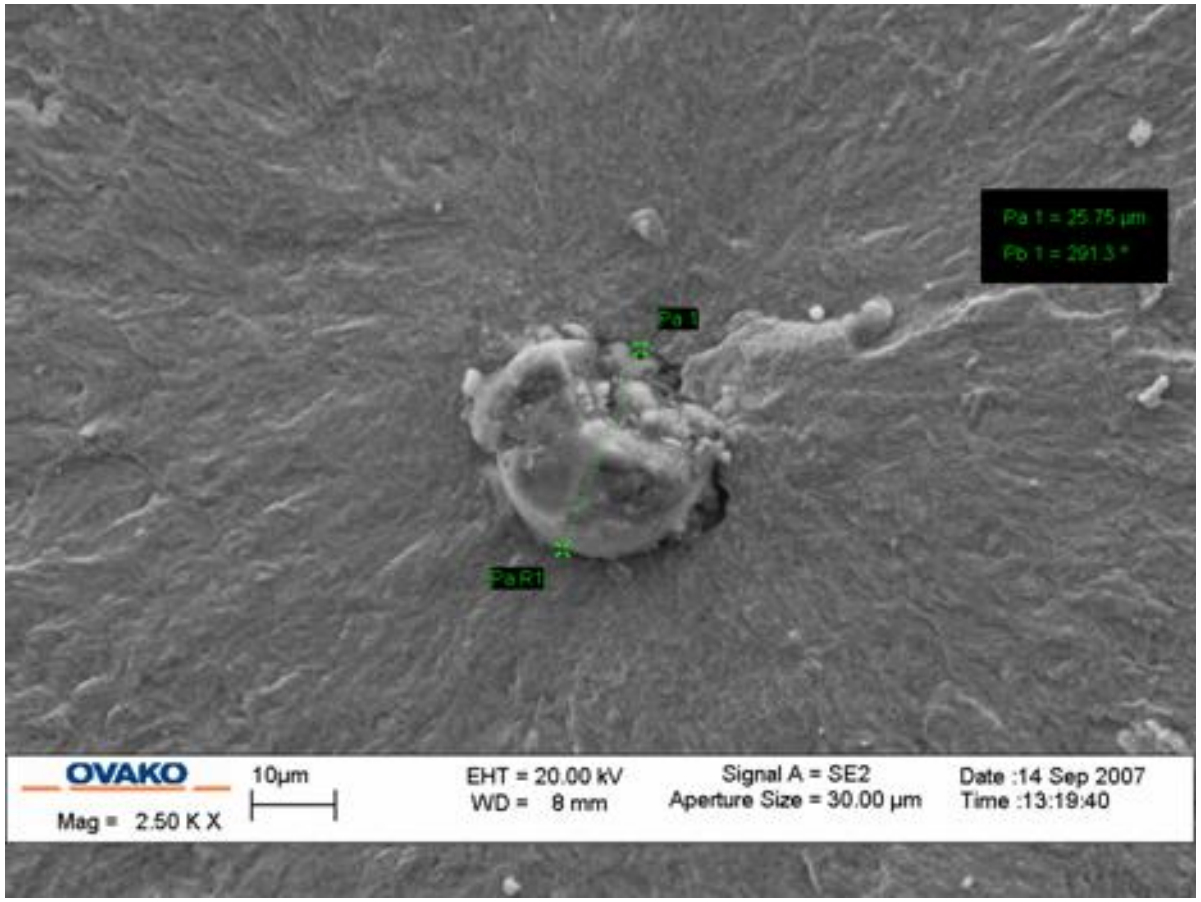
A material decay process occur due to applied thermomechanical energy!



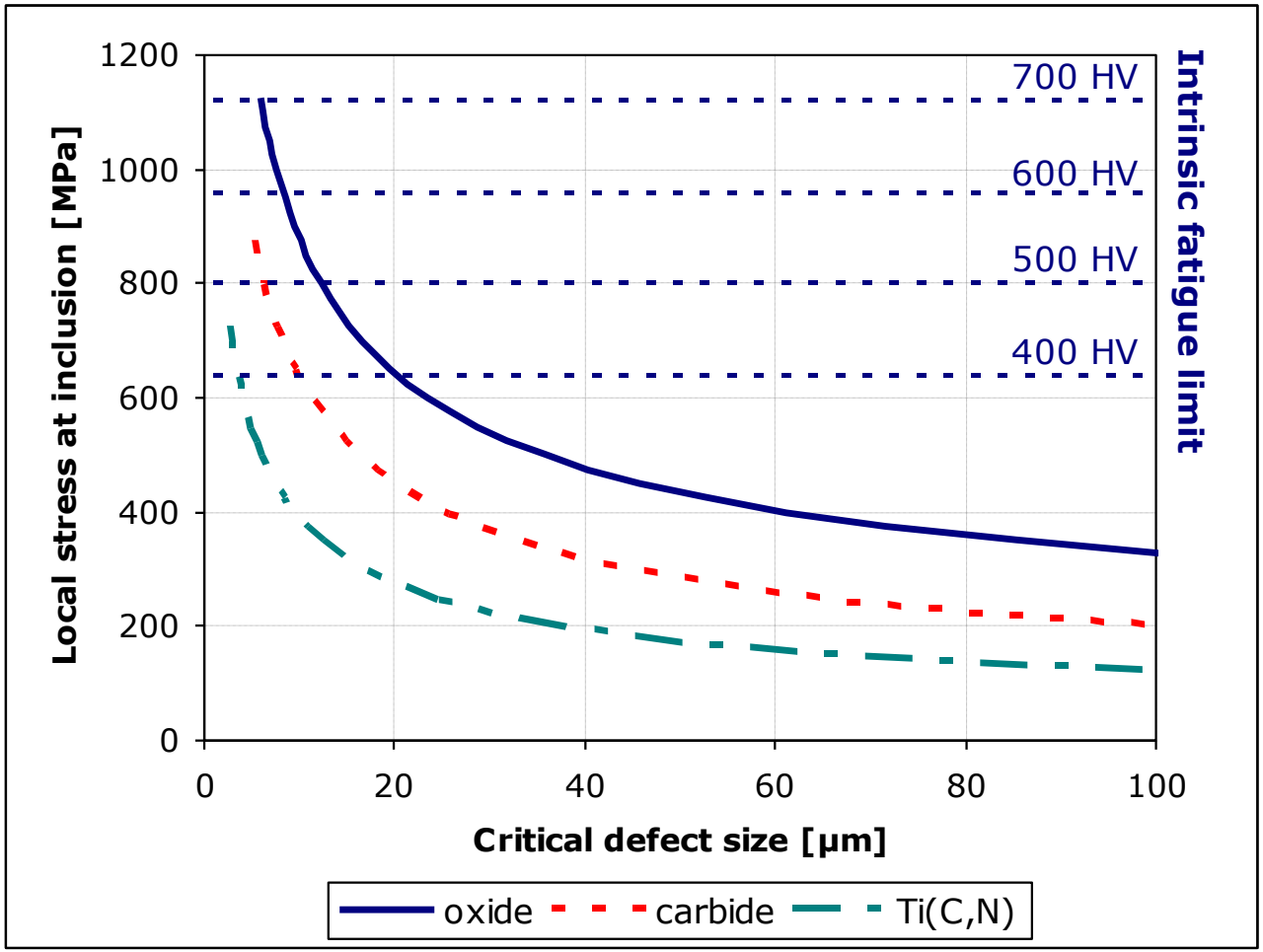


The decay process is enhanced by the precence of defects acting like stress (strain) raisers.

Initator in structural fatigue



Influence of defect size



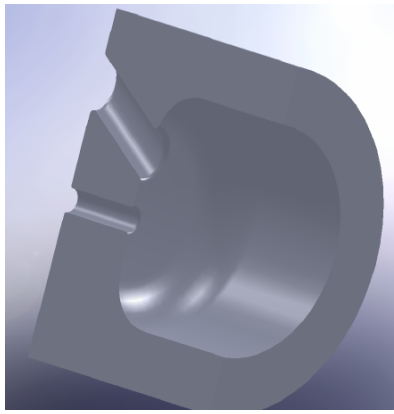
Fatigue message

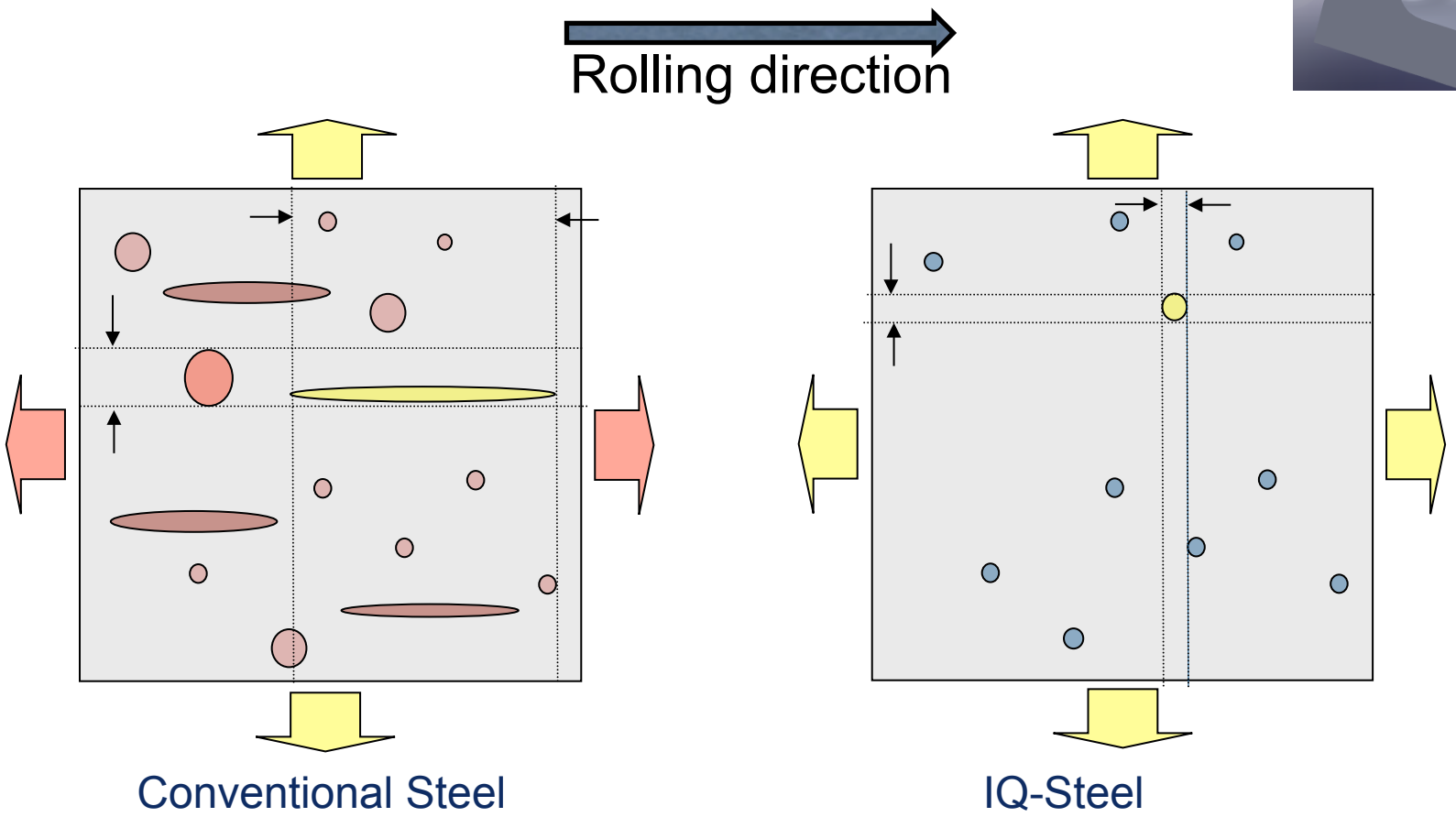
- Stop treating high strength steel as a continium!
  - It is transforming over time due to stress and temperature. If we could describe/model this we could ”design properties”

- Do not forget the defects!
  - Local strain at defects will accelerate the decay of the structure (initiation).

Complex loading mode

Steel performance limited in transversal direction

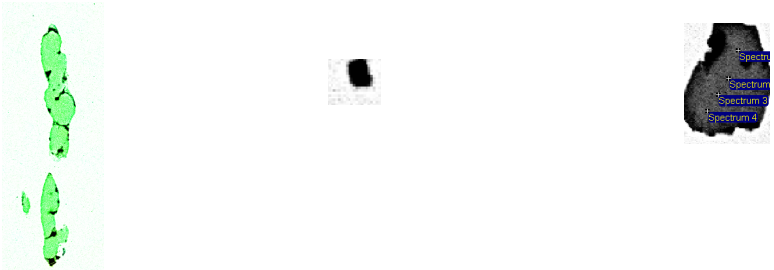




Overview of Micro Inclusions

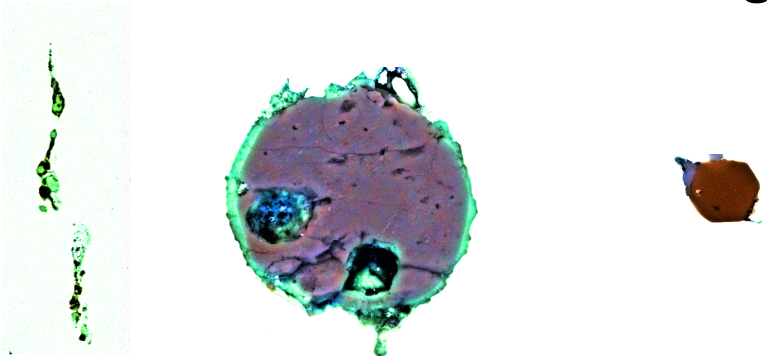
- Sulphides

Influenced by Sulphur Manganese Calcium and Magnesium content



- Oxides

Influenced by Oxygen Aluminium Calcium and Magnesium content

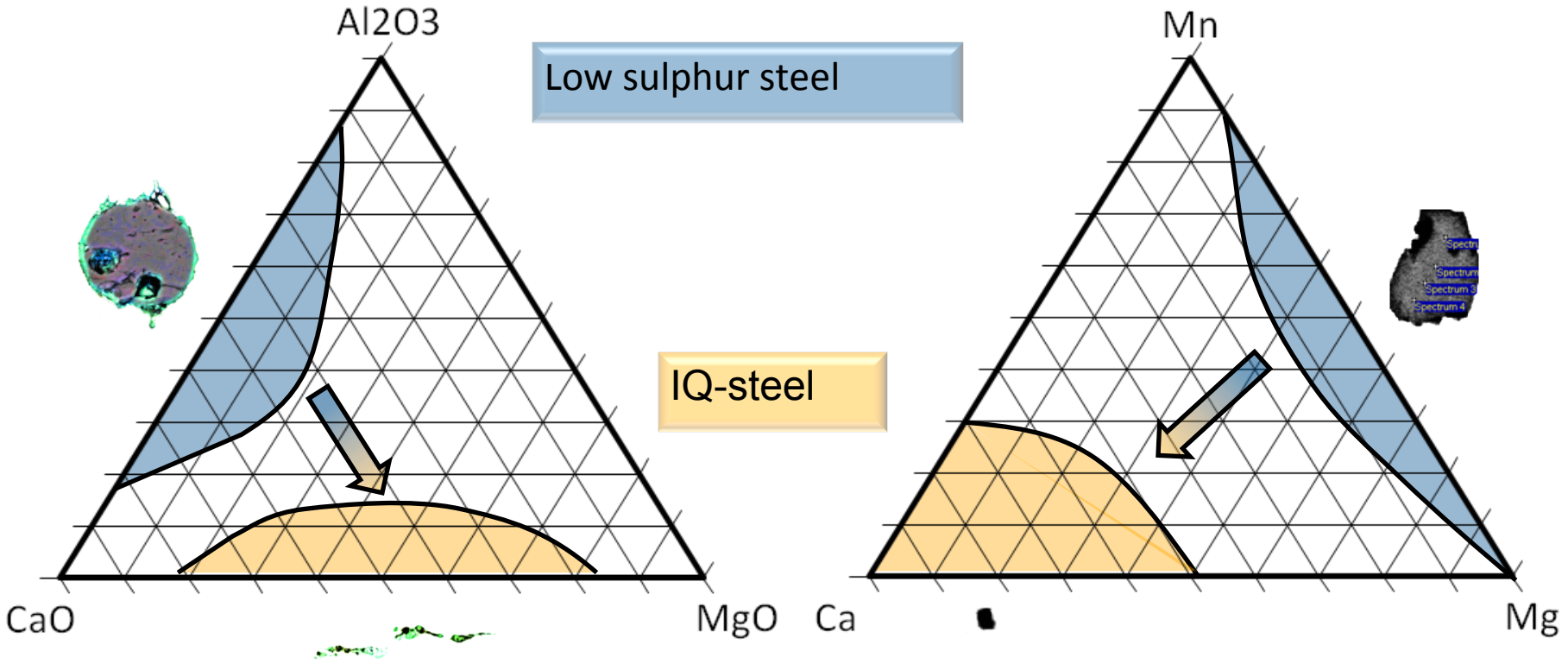


- Nitrides

Influenced by Nitrogen and Titanium content (sizes normally < 15um)

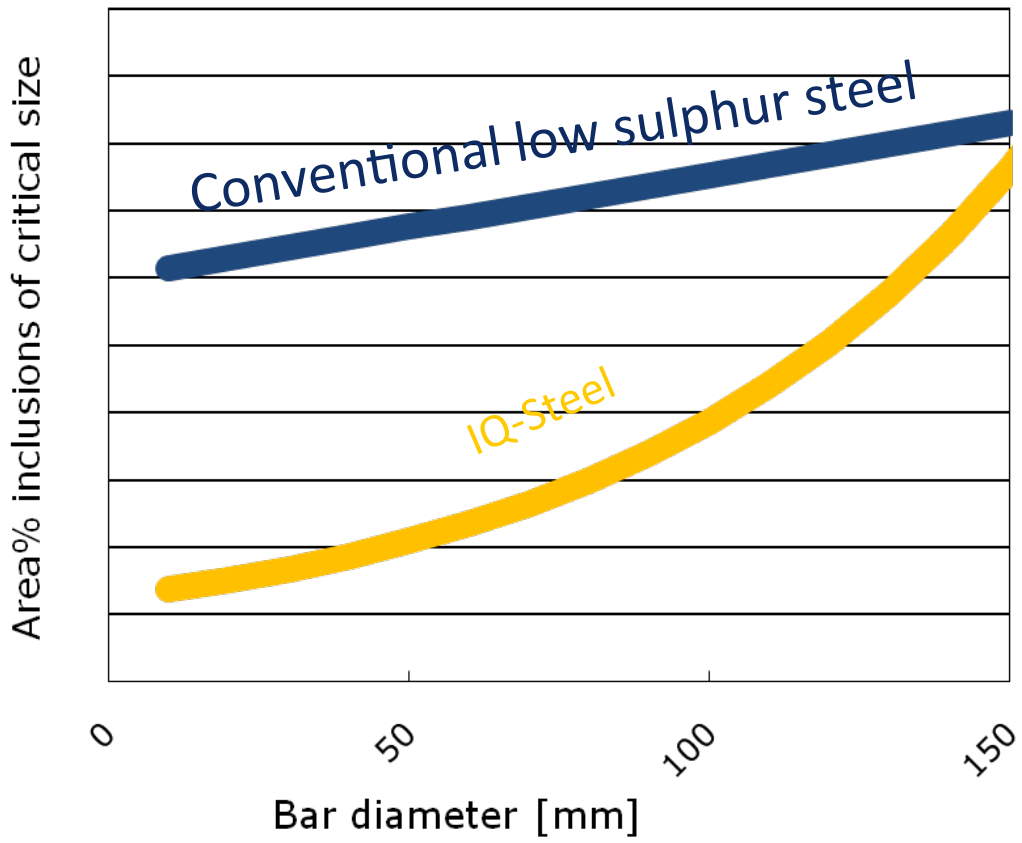
Inclusion engineering

Ensuring an optimized performance



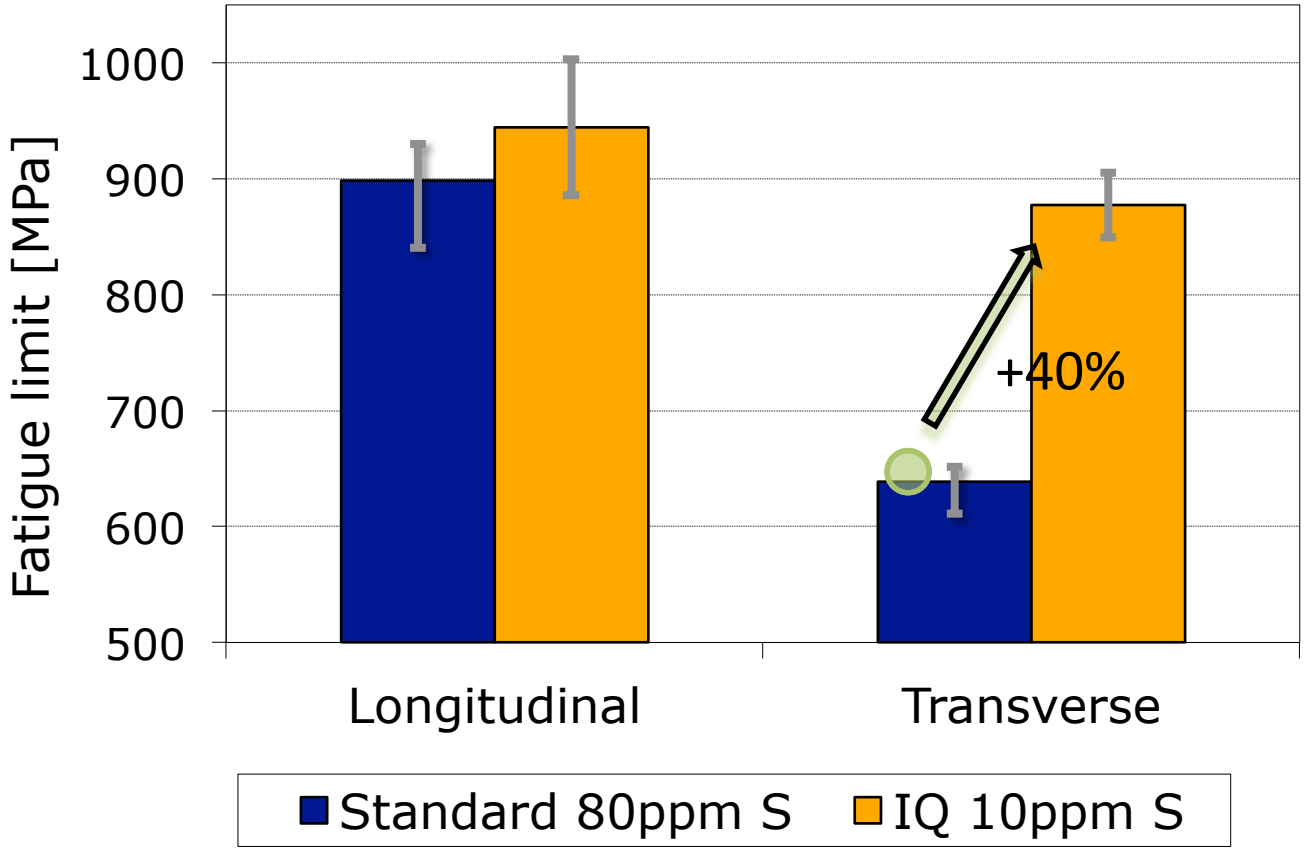
Metal working

Degree of deformation improves IQ-Steel properties



Rotating bending fatigue

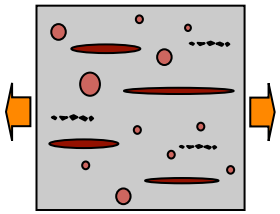
40% improvement in transversal direction

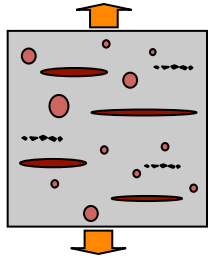


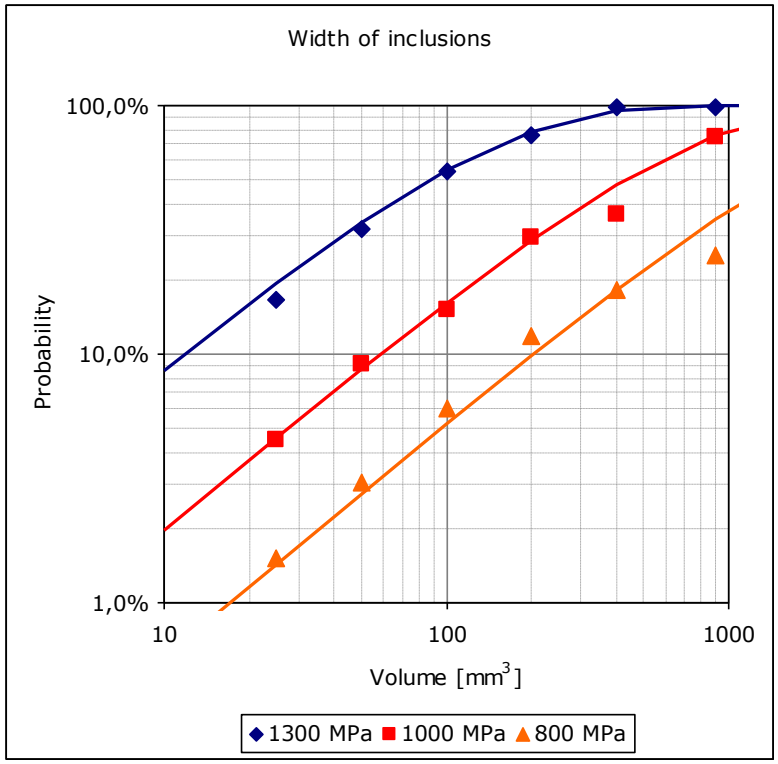
Influence of specimen geometry on fatigue life

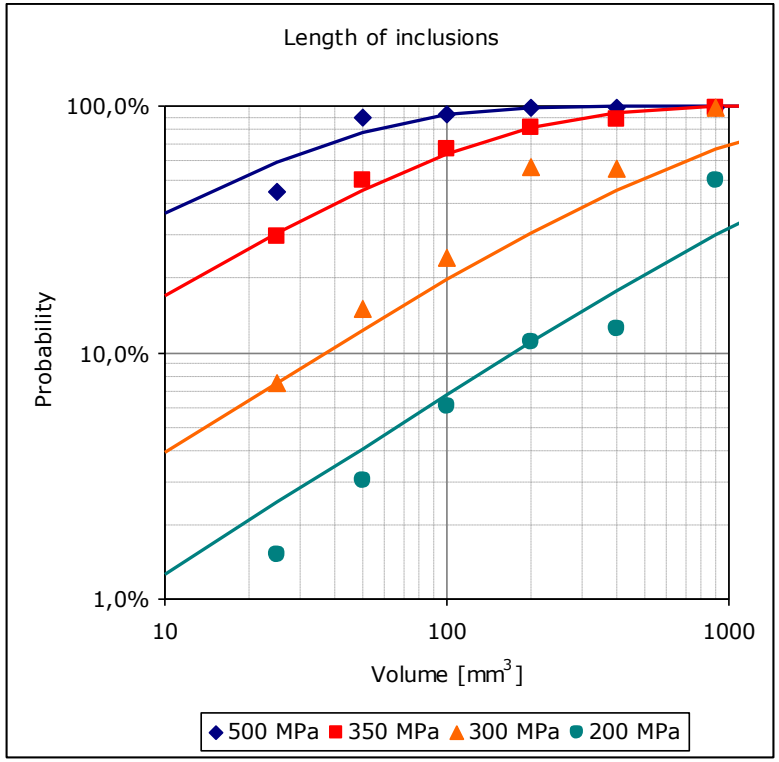
Minimum diameter [mm]	Fatigue limit* [MPa]
3,00	≈1250
5,00	≈ 1100
9,50	≈ 870
25,0	≈ 680

Fatigue strength vs loading direction and volume



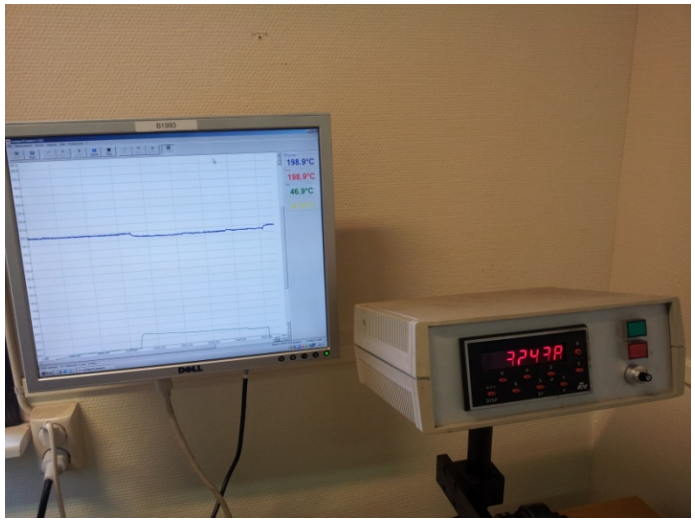






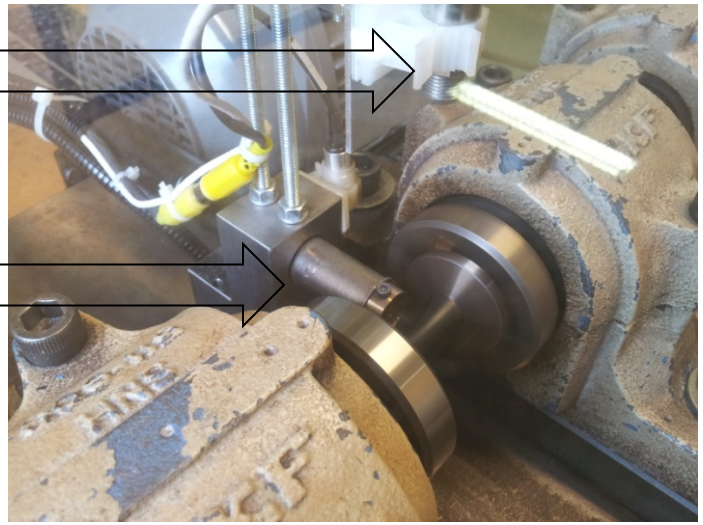
Influence of temperature

Temperature graph

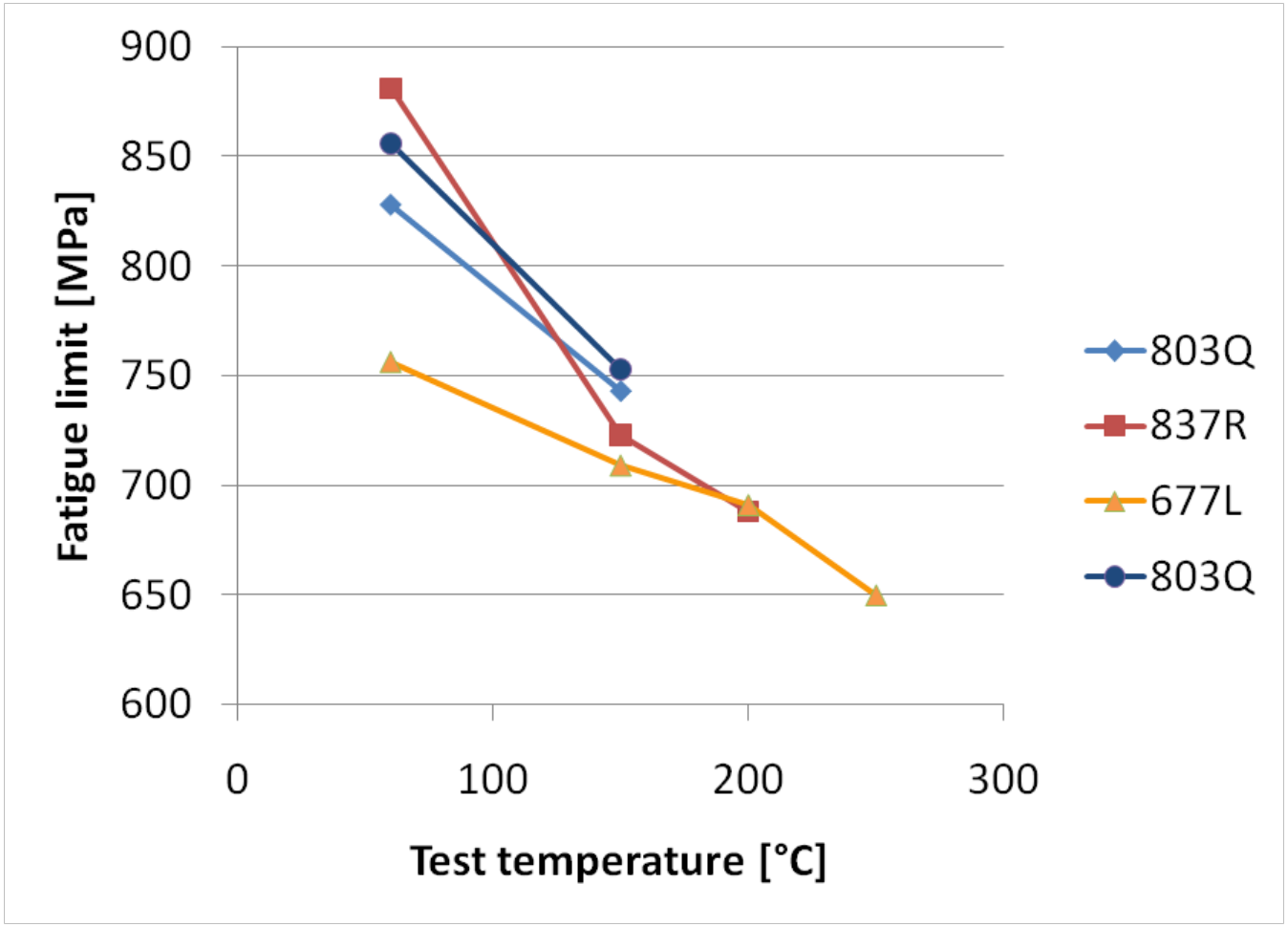


IR sensor for
temp measuring

Heat generator



Fatigue data



Summary and Conclusions

- The structure and matrix composition influences the thermomechanical response
- Loading direction can drastically influence the fatigue life of a component
- Loaded volume can drastically influence the fatigue life of a component
- It is possible to influence the material elevated temperature fatigue properties by alloying