



IIT ROORKEE



NPTEL ONLINE
CERTIFICATION COURSE

Failure Analysis and Prevention

General Procedure of Failure Analysis: Microscopy of fracture surfaces

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Purpose of micro-fractography

- Micro-fracture mechanisms
- Better understanding and classification of fracture modes
- Estimating service conditions i.e. type of load, overloading, cyclic loading and specific service environment
- Improver manufacturing procedures leading to metallurgical issues

Methods of micro-fractography

- Electron microscopy
 - As high as 3,00,000 magnification but common used up to 10,000
 - Resolution up to 10^{-8} A
 - High depth of field
- Optical microscopy:
 - limited resolution 0.5 micron
 - Limited up to 500 X
 - Limited depth of field



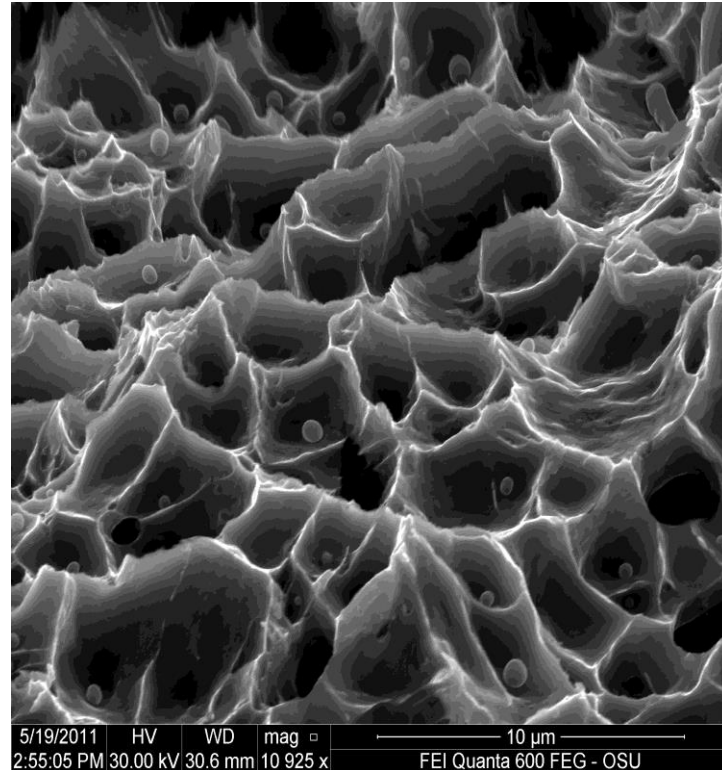
Surface preparation

- Metal surface: no preparation
- Oxide powders and non-metals: thin gold coating of about 50 $\text{\AA}$ thickness by PVD



Basic features of micro-fractography

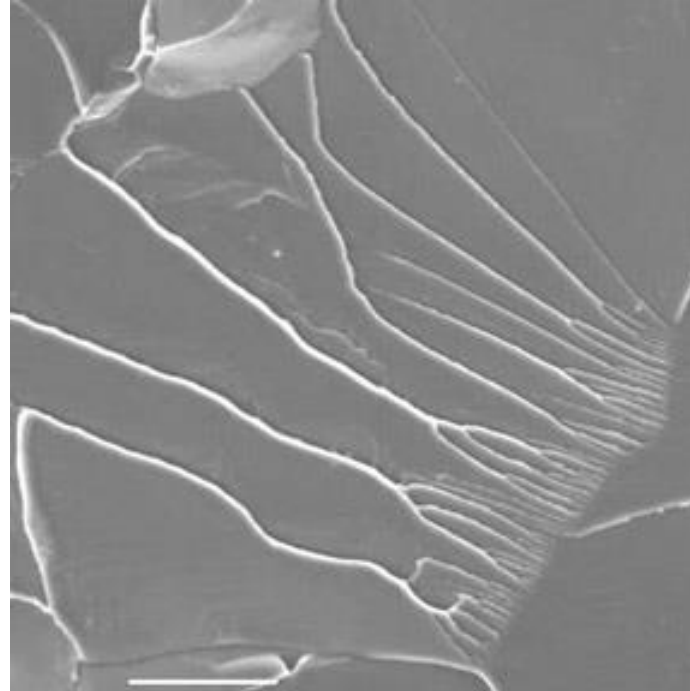
- Dimple fracture:
overstress
failure of ductile
metals and
alloys



Basic features of micro-fractography

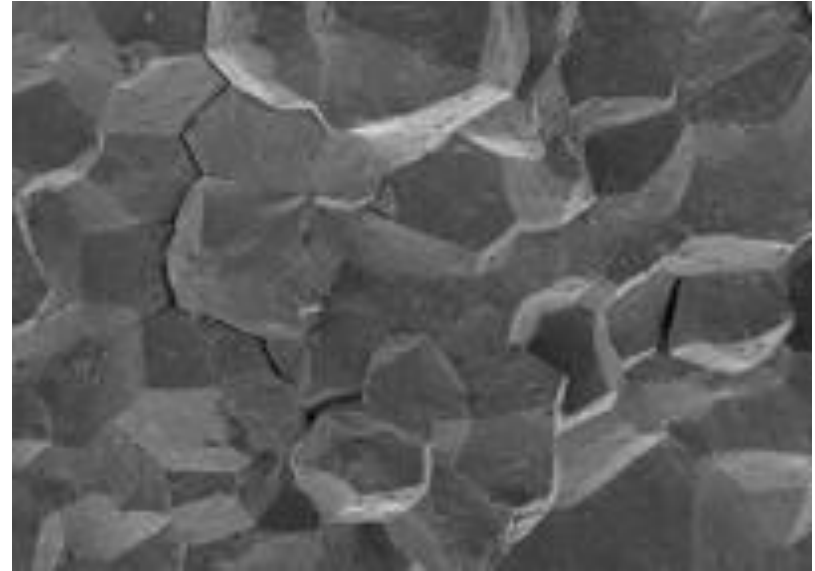
Cleavage facets

- Trans granular brittle fracture
- BCC and HCP metals



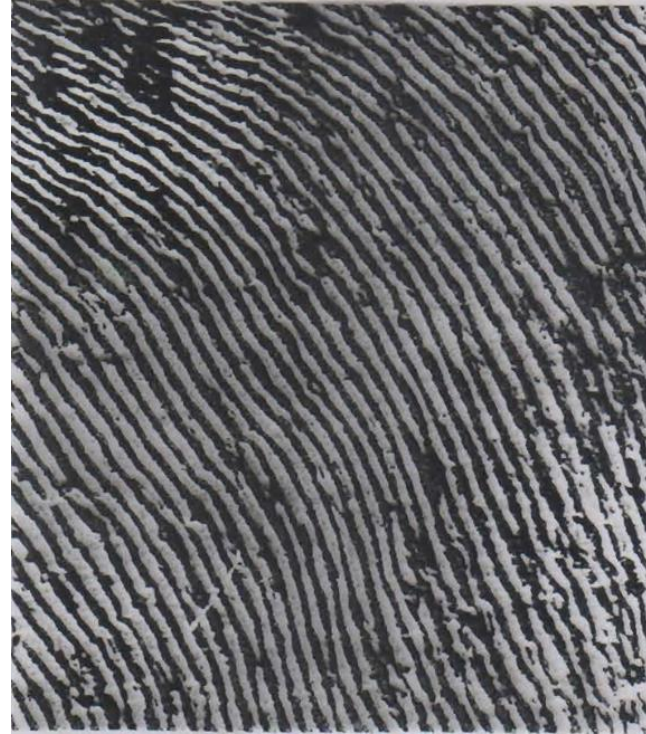
Basic features of micro-fractography

- Brittle inter-granular fracture
 - Temper brittle steel due segregation of embrittling species at GBs
 - SCC
 - HIC



Basic features of micro-fractography

- Stage II striations
 - Cyclic loading
 - Fatigue fracture

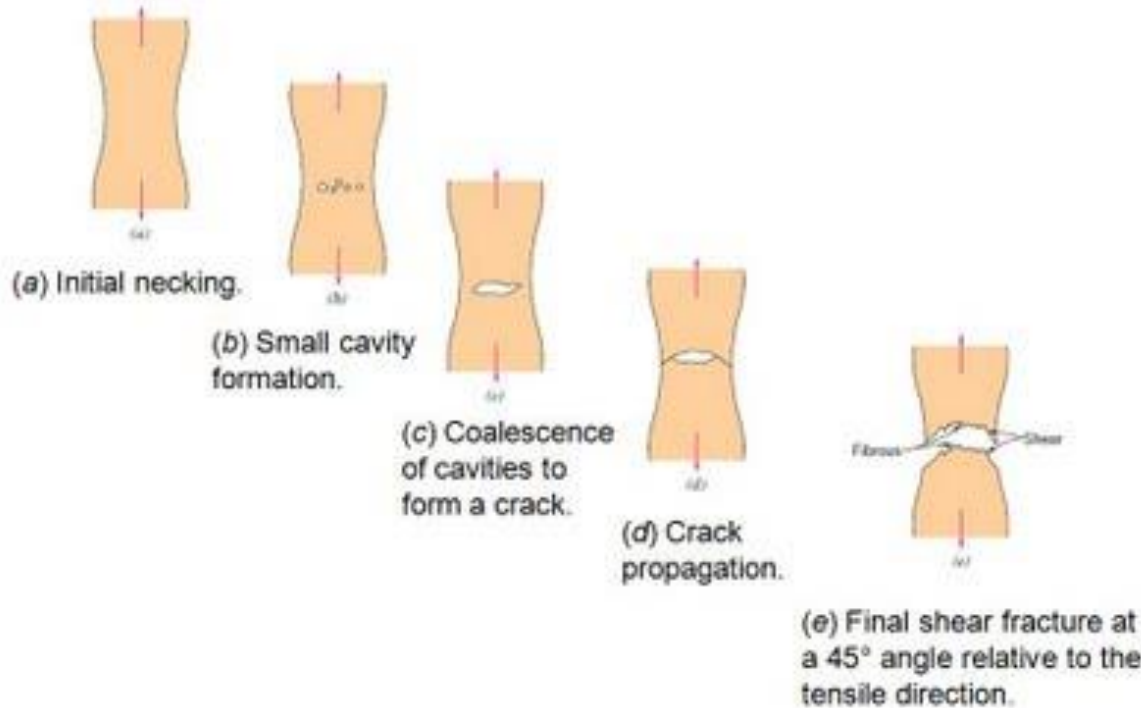


Micro-mechanisms

- Ductile fracture: dimple fracture: high energy and fracture tough system
- Brittle fracture: cleavage facets, inter-granular and fatigue: low energy and brittle systems
- Based on crack propagation
 - Trans-granular: cleavage, dimple
 - Inter-granular
- Inter-granular: Creep, SCC, HIC, Poor MFG, Chemical heterogeneity



Macro-mechanism of ductile fracture



Micro-mechanism

