# Characterization of Grain Flow Microstructure in Forged Nitronic 50 Stainless Steel

Goddard, R.E.(NHMFL, FSU); Walsh, R.P. (NHMFL, FSU)

## Introduction

Nitronic 50 is an engineered austenitic stainless steel that contains molybdenum giving it excellent anti-corrosive and strength properties [1]. In addition Nitronic 50 does not become magnetic when cold-rolled. After forging, grain morphology is expected to follow the die impression of the sample.

## Experimental

Samples were prepared by standard metallographic practices then analyzed in a Leica M374F metallograph and a Zeiss 1540 XB Field Emission Gun Scanning Electron Microscopy (FEGSEM) to observe microstructure.

## Results and Discussion

Etching revealed both the austenite grain boundaries and twin boundaries (Fig. 1). Discontinuous alternating bands are manifest as light and dark zones that cross grain boundaries. In an SEM-image the morphological bands were observed trending parallel to the indent corner created by the die (Fig. 2). The bands were analyzed by Energy Dispersive X-ray Spectroscopy (EDS) inside the FESEG and found to be of two distinct chemistries (Table 1). The lightly depleted iron bands (zone 1) contain tabular and spherical inclusions that are composed of niobium, chromium, molybdenum, and probably carbon and nitrogen. The tabular nature of some inclusions was confirmed by Focused Ion Beam (FIB) dissection. It is likely that niobium carbon nitrides are formed. The tabular particles of zone 1 are arranged parallel with the long axis plane of zone 1 and normal to the forged direction. Spherical particles are rich in niobium and molybdenum and are not distributed homogeneously.

## Conclusions

Although the austenite grains appear equaxial, the inhomogeneous distribution of the particles and chemistry may result in anisotropy of the material properties, particularly the ductility, fracture toughness and the crack growth rate. The tabular arrangement of some inclusions increases the unidirectional fracture toughness.

## Acknowledgements

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## References

[1] Guo, W., Nemat-Nasser, S., Flow stress of Nitronic-50 stainless steel over a wide range of strain rates and temperatures, **Mechanics and Materials** 38 (2006) 1090-1103

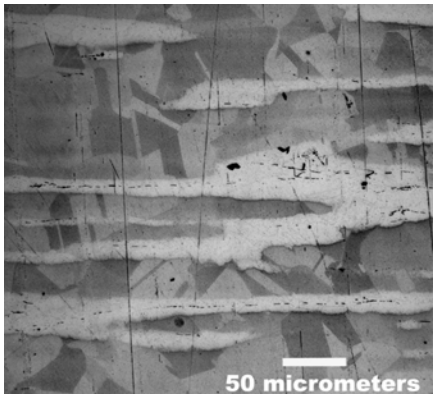


Fig.1 Optical micrograph

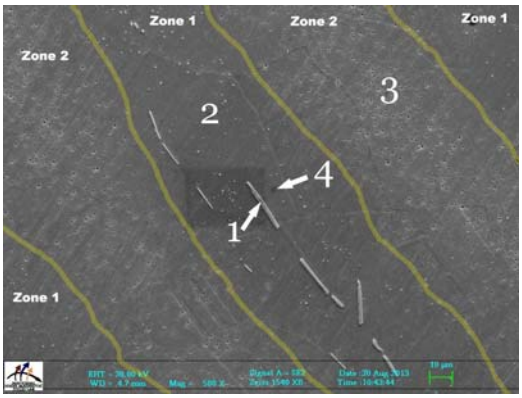


Fig. 2 SEM micrograph

Table 1 Chemical Analysis (wt%)

| Location | Si | Mo | Cr | Mn | Fe | Ni | Nb |
|---|---|---|---|---|---|---|---|
| 1-Tabular inclusion | | 5.5 | 33.2 | 2.2 | 19.5 | 2.5 | 36.0 |
| 2-Matrix-Zone 1 | | 0.4 | 23.2 | 5.7 | 55.5 | 12.1 | 0.8 |
| 3-Matrix-Zone 2 | 1.0 | 2.0 | 21.6 | 5.0 | 59.6 | 10.5 | 0.4 |
| 4-Spherical inclusion | 0.9 | 1.97 | 12.7 | 2.0 | 18.4 | 3.6 | 9.2 |