Vera Popovich

Assistant Professor

Tel: +31 (0) 15 2789568
E-mail: v.popovich@tudelft.nl
Website: http://mse.tudelft.nl

Research interests:

- Fracture mechanical behaviour and fatigue of materials.
- High temperature mechanical properties.
- Microstructure-damage evolution
- Functionally graded, welded, additive manufactured materials

Mechanical behaviour of materials at micro/meso scale

My recent activities have been focused on: providing advance understanding and control of fracture mechanical material behaviour; relating mechanical behaviour to material microstructure; development of advanced functionally graded materials by additive manufacturing.

Functional grading produced by additive manufacturing & multifunctional performance through controlled heterogeneity

Additive manufacturing offers a unique way of anisotropic microstructure control with high design freedom. This study demonstrates that application of a suitable laser scanning strategy and laser source may favour either one sharp single component texture, more uniformly distributed crystal, or a combination of the above in a preferred gradient, which influence the mechanical properties. It is shown that transitions in microstructure, texture, and properties in fabricated Inconel 718 functionally graded components can be obtained at relatively small or large length scales, depending upon the functional gradient desired in a particular application (Figure 1, 2). The developed strategy can be further applied to design functional gradients with selected tailored properties and to account for directional anisotropy of solidified components, and non-equilibrium microstructures.

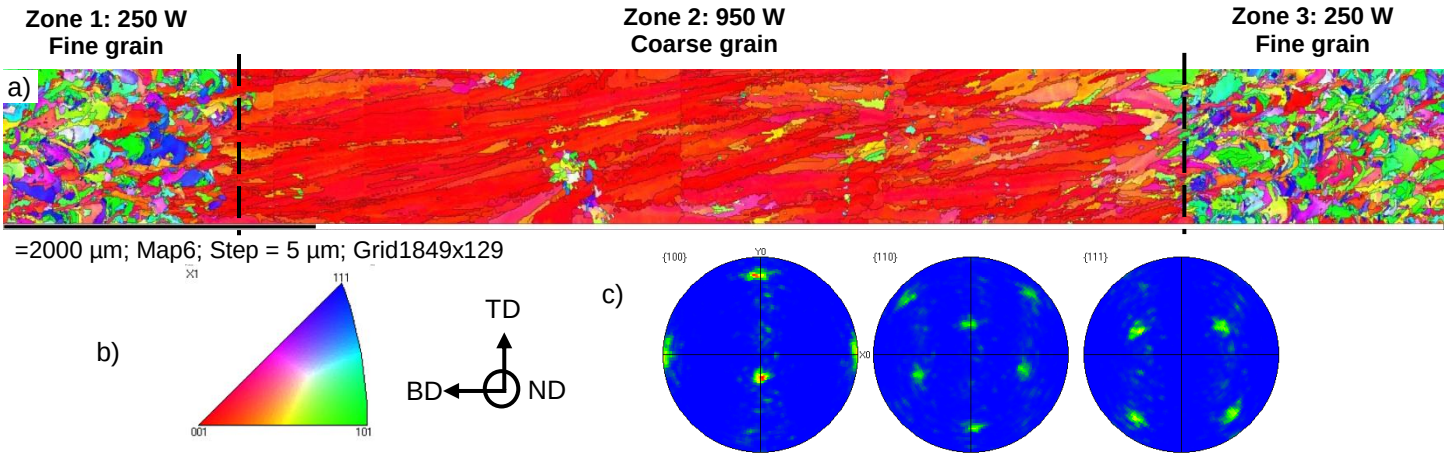

Figure 1. EBSD analysis of a graded Inconel 718 featuring single coarse columnar grain zone embedded in a fine grain matrix a) Inverse Pole Figure (IPF) coloured map of Y-Z section b) The index map of IPF and the reference coordinate c) Pole figures texture for zone 2.

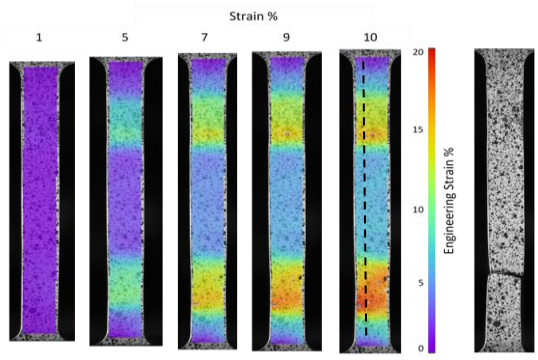

Figure 2. Digital image correlation showing evolution of local strain as a function of cross head displacement (shown for gradient depicted fine grained matrix and two coarse highly oriented grained regions)

The further direction of the research includes the effect of heat treatment and functional grading type (composition, grain size, texture) on mechanical properties and thermomechanical fatigue.

Effect of microstructure on fracture toughness of welded steels

One of the most significant problems associated with the implementation of high strength steels for offshore applications lies with the guarantee of welded joint reliability. An experimental study combining microstructural investigations with a new adjusted sub-sized CTOD test is conducted in order to assess the fracture toughness in the heat affected zone (HAZ) of welds on high strength steels. Emphasis is placed on the coarse grain HAZ and the effects of variations in alloying and inclusion content on the microstructure and toughness properties is studied (Figure 3).

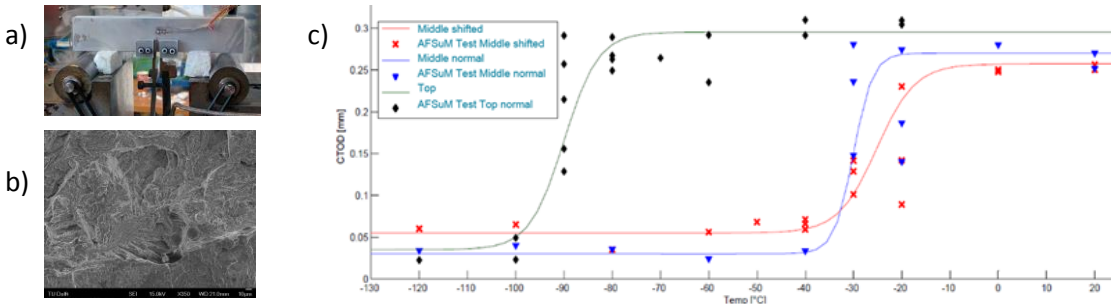

Figure 3. a) sub-sized CTOD test b) cleavage facets and the inclusion, as a crack initiation site c) fracture toughness (CTOD) results of the HAZ of welded plate (red curve refers to top, blue to middle)

The further development of this research direction involves establishing a framework for the cleavage failure probability in structures by providing a physically-based statistical relationship between critical microstructural parameters and fracture toughness.

Key publications:

1. V.A. Popovich, et al, “Functionally graded Inconel 718 processed by additive manufacturing: crystallographic texture, anisotropy of microstructure and mechanical properties”, submitted to Additive Manufacturing Journal, 2016.
2. V.A. Popovich, et al, “Impact of heat treatment on microstructure and mechanical properties of functionally graded Inconel 718”, submitted to Materials & Design, 2016.
3. V.A. Popovich, I.M. Richardson, “Fracture toughness of welded thick section high strength steels and influencing factors”, TMS, 2015.
4. V.A. Popovich, et al, “Characterization of multicrystalline silicon solar wafers fracture strength and influencing factors”, International Journal of Material Science, Vol.3, 2013.
5. V.A. Popovich, et al, “Understanding the properties of silicon solar cell aluminum contact layers and its effect on mechanical stability”, Materials Sciences and Applications, 2013.
6. V.A. Popovich, M. Janssen, I.M. Richardson, T. van Amstel and I.J. Bennett, “Microstructure and mechanical properties of aluminium back contact layers”, Solar Energy Materials and Solar Cells, Volume 95, Issue 1, pp. 93-96, January 2011.