Title: Multi-scale Creep Characterisation of CuCrZr Alloy as Heat Sink Used in the Divertor of Nuclear Fusion Tokamaks

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Abstract. The research conducted attempts to create an understanding about the creep response of copper alloys selected as candidate heat sink materials for nuclear fusion reactors. An understanding about the material's creep response at macro and micro-structural length scales has been presented by employment of multi-scale characterisation techniques. The preliminary tensile and creep rupture test results have also been analysed and presented to establish the material's response under tensile loading at required temperatures before advancing into the ex-situ tests also involving high resolution strain mapping. In conclusion the research attempts to understand the material behaviour by analysing data on surface deformation, grain boundaries, orientation distribution and dislocations.

Possible Sessions

Nuclear Applications: Fusion, Metals and Microstructure, Optical and DIC Techniques

Key Words and Abbreviations: Macro-DIC, Digital Image Correlation (DIC), High (Hi), Resolution (Res), Scanning Electron Microscopy (SEM), Electron Back Scatter Diffraction (EBSD), Ultimate Tensile Strength (UTS), Yield Strength (YS).

Introduction

In the heart of fusion reactors lies the Divertor, with the task of extracting heat and Helium ash. It is also a primary plasma facing component, thus subjected to extreme temperatures for prolonged periods of time. Such a component thus needs to effectively be cooled throughout its operational and post operational cycles [1]. The material is expected to operate between 250˚C to 350˚C and at sustained stresses. The material used in this research [2], [3] is therefore solution annealed peak aged CuCrZr alloy which has been selected for the production of the divertor heat sinks. To enhance our understanding of these materials, advanced techniques of HR-DIC, SEM with EBSD are employed [4].

The research presents findings on the creep mechanisms at macro and micro mechanistic length scales by incorporating Macro-DIC test to map multiple stress states in the bulk material along the gauge length using an hourglass sample in conjunction with EBSD analysis on the same sample [4]. The Hi-Res DIC (Micro-DIC) uses Backscatter imaging and EBSD, enabling for precise monitoring and analysis of deformation patterns at micro-structural levels. Some preliminary characterisation and sample preparation techniques were developed from Poole *et al* [5] for this alloy, with characterisation being done using EBSD analysis to create an understanding about the grain size, precipitates, and the orientations across the bulk material. The image for the same is shown in Figure 1.

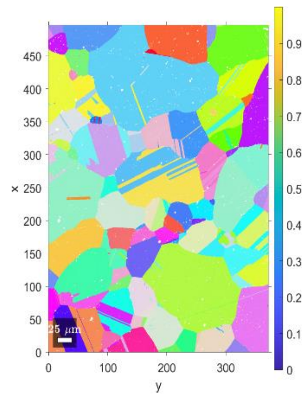

Figure 1 - Post heat treatment EBSD Map for characterisation

Experimental findings have also been investigated from the tensile and creep rupture tests to develop an understanding on the UTS, YS and creep strength of the material at 300˚C before proceeding to the ex-situ creep tests. Larger hourglass samples have been investigated under the required temperature and loading conditions using white light Macro-DIC. These samples are analysed using Micro-DIC by employing EBSD analysis, thus providing valuable insights into the material's behaviour at the macro and micro -structural level. The utilisation of an imaging vacuum furnace facilitates an addition of an enhanced perspective on material response to the required conditions at macro and micro structural length scales. Ex-situ EBSD in combination with Macro-DIC provides a macro and micro-structural perspective by offering surface deformation and crystallographic information of grain boundaries, orientation, and texture changes at the microscopic level.

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