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Nanoindentation mapping to probe local mechanical properties of oxidation-affected region in Inconel 718

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Mechanical and oxidative/corrosive performance at intermediate temperature is what makes Inconel 718 so valuable. However, long-term exposition in air above 700°C has been shown to be harmful to mechanical properties [1]–[3]. The present experimental work investigates the local mechanical properties of Inconel 718 exposed under air at 850°C during 450h using continuous stiffness measurement mapping with a Berkovich nanoindentation tip.

Internal and external oxidation products were characterized along with microstructural evolution of the metallic alloy using EDS analyses on cross-sectional and shallow wedge sections. The latter allows us to spread the micrometer deep oxidation-affected material over millimeters using a small-angle wedge. Internal (Nb,Ti)-rich internal oxides were found in addition to the known external chromia and internal alumina. Transmission electron microscopy observations were conducted to identify the chemical and crystallographic nature of the precipitates and internal oxides within the oxidation-affected material.

Nanoindentation tests on the controlled-wedge section aimed to identify the gradient of mechanical properties along the material depth, i.e. hardness and reduced modulus. High resolution maps at different scales were performed to identify both the large-scale gradient of properties (Fig. 1) and sub-grain gradient inherent to the local metallurgical state.

Keywords: Nanoindentation, Superalloy, Oxidation, Continuous stiffness measurements mapping

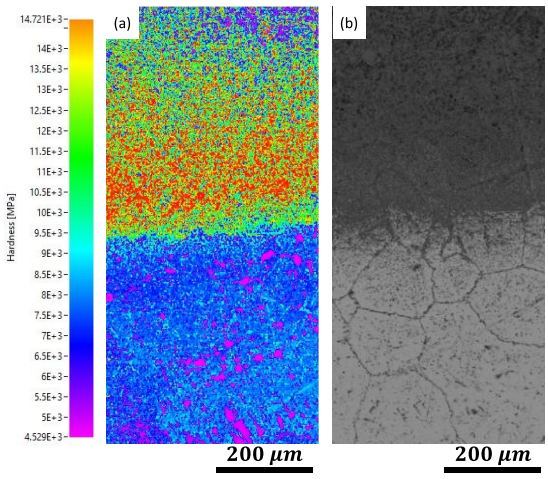

Fig.1: (a) Hardness map obtained by nanoindentation of an oxidized Inconel 718 sample. The wedge cut exposes a gradient of composition from chromia (top) to core Inconel 718 (bottom). (b) Micrographs of the corresponding aera obtained with a laser scanning confocal microscope.

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