Interfacial oxidation in processing of nanocrystallised metallic materials using duplex technique - experimental and modelling aspects

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Abstract

Duplex techniques are attempted to be developed combining nanocrystallisation processes with a subsequent thermomechanical processing in order to produce multilayered bulk structures with improved yield and ultimate tensile strengths, while conserving an acceptable elongation to failure Fig. 1a and b [1 - 4]. However, bonding imperfections at the interfaces due to interfacial oxidation among other reasons during the duplex process can significantly influence the final properties. Moreover, the interface oxidation occurring during duplex processes influences microstructure development around the interfaces depending on whether the oxide scale is a continuous layer or a layer of discontinuous oxide clusters with heterogeneous thicknesses. Effectively the oxide scale becomes a part of microstructure development in such nano-crystallised multilayered structures. This paper deals with understanding of the underlying events around the highly reactive interfaces explaining the microstructure evolution applying advanced experimental and numerical modelling techniques. The research encompassed surface mechanical attrition treatment followed by constrained compression testing and hot rolling of the assembly of steel strips supported by multilevel numerical analysis using combined finite element (FE) and cellular automata (CA) methods. Shear banding has been observed near metal-metal contact between the oxide clusters at the interfaces (Fig. 1c). The shear banding can be considered as bonding enhancement creating channels for the base metal of the different laminates to come into contact through the oxidised interface. Temperature, texture and grain refining are among the factors influencing the shear banding. In the simulations, the meso-level of the developed multi-level FE-based model is combined with the advanced 3D frontal CA numerical model allowing for both appearance of the new boundaries and rotation of dislocation cells (sub-grains and grains) simultaneously (Fig. 1d).

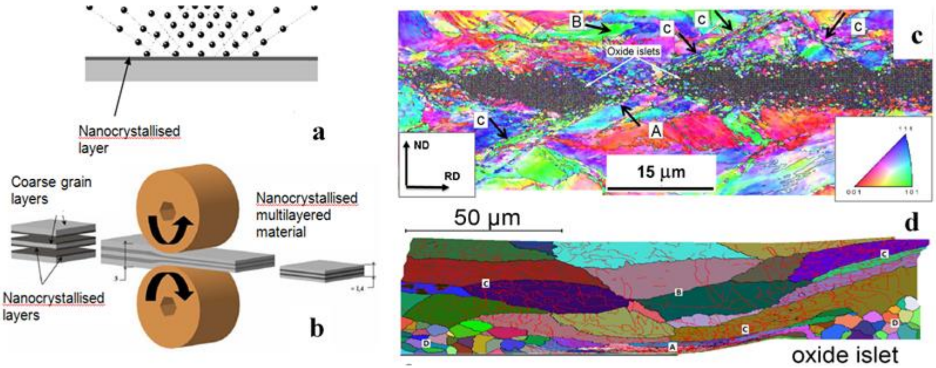

Fig. 1 Duplex technique components (a, b), EBSD orientation map of the cross section (c) and microstructure of 316L predicted near the oxidised interface (c).

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