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Microanalysis of Precipitation Processes in the Alloy 33 (Fe-Ni-Cr-Mo-N)

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The role of interfaces and the relevance of interfacial energy in controlling the properties of engineering materials have long been recognized. In particular, resulting from the decomposition of a supersaturated solid solution, some alloy systems develop lamellar structures through discontinuous precipitation (DP) processes. Here, the precipitates grow by diffusion of atoms along grain boundaries that, while acting as reaction fronts, migrate consuming the supersaturated matrix living behind the lamellar precipitate structure. In some alloy systems a continuous precipitation (CP), can be observed inside the matrix. While the first reaction, DP, is due to interfacial diffusion at the grain boundaries, the latter, CP, is controlled by diffusion in the matrix[1]. This combined phenomena has been found in the alloy 33, a Fe-based system, containing Cr, Ni, Mo and a high N concentration. Both diffusional transformations generate a microstructure that will incorporate an excess of interfaces in both the lamellar and the homogeneous precipitated products.

The material was received in the form of a 4 mm thick plate with the nominal composition (given in atomic percent) of 30%Fe-33%Ni-35%Cr-1,5%Mo-0,5%N. After homogenization treatment, samples were isothermally aged at 700°C and 900°C. A wide range of microstructure features has being revealed. We focus our attention to the precipitation processes developed upon aging at the above-mentioned temperatures, which are typical of the alloy operational conditions.

A typical SEM overall view of a microstructure resulting from aging at 700ºC is shown in Fig.1a, where some grain boundaries exhibit well-developed DP products, while others are precipitate-free. A DP colony can be observed with detail in Fig.1b. The identification of homogeneous and discontinuous precipitates required transmission electron microscopy (TEM). Sample preparation followed conventional procedure and electrolytic thinning. TEM studies were conducted using a Jeol 2010 instrument operating at 200 kV under diffraction mode.

A characteristic simultaneous reaction of DP and CP is shown at Fig.2. The first TEM bright field (BF)/centered dark field (CDF) pair (a/b), shows DP lamellae in non uniform size and spacing, which is evidence that the driving force for DP reaction is not constant. A more detailed view of the DP colony (c/d - BF/CDF pair) reveals two lamellae embracing a homogeneous precipitate. A qualitative EDS microanalysis on the image in Fig.2a has shown a Fe, Ni rich matrix with a DP lamellae containing mostly Cr and a grate part of the Mo content segregated. The residual Mo seams to be allocated at the homogeneous precipitate, rich in Cr and Ni.. In Fig.3, BF / CDF pair of a diamond shape precipitate, with apparent coherent interfaces. Fig.4, on the other hand, shows another BF / CDF pair of a larger precipitate where the interfaces are semi-coherent. An even larger incoherent itermetalic precipitate in zone axis orientation is also presented in Fig.5. Current investigation is directed towards the identification of the above-described precipitates [2].

References:
[1] I.G. Solórzano, M.R. Andrade and J.A. Cohn, Interfacial Engineering for Optimized Properties II - MRS Symposium Proceeding, 586, 139-150, 2000.
[2] The authors are grateful to Dr. P. Dolabella, BAM , Berlin, Germany, for providing the alloy. to Capes and Brown University for the financial support.

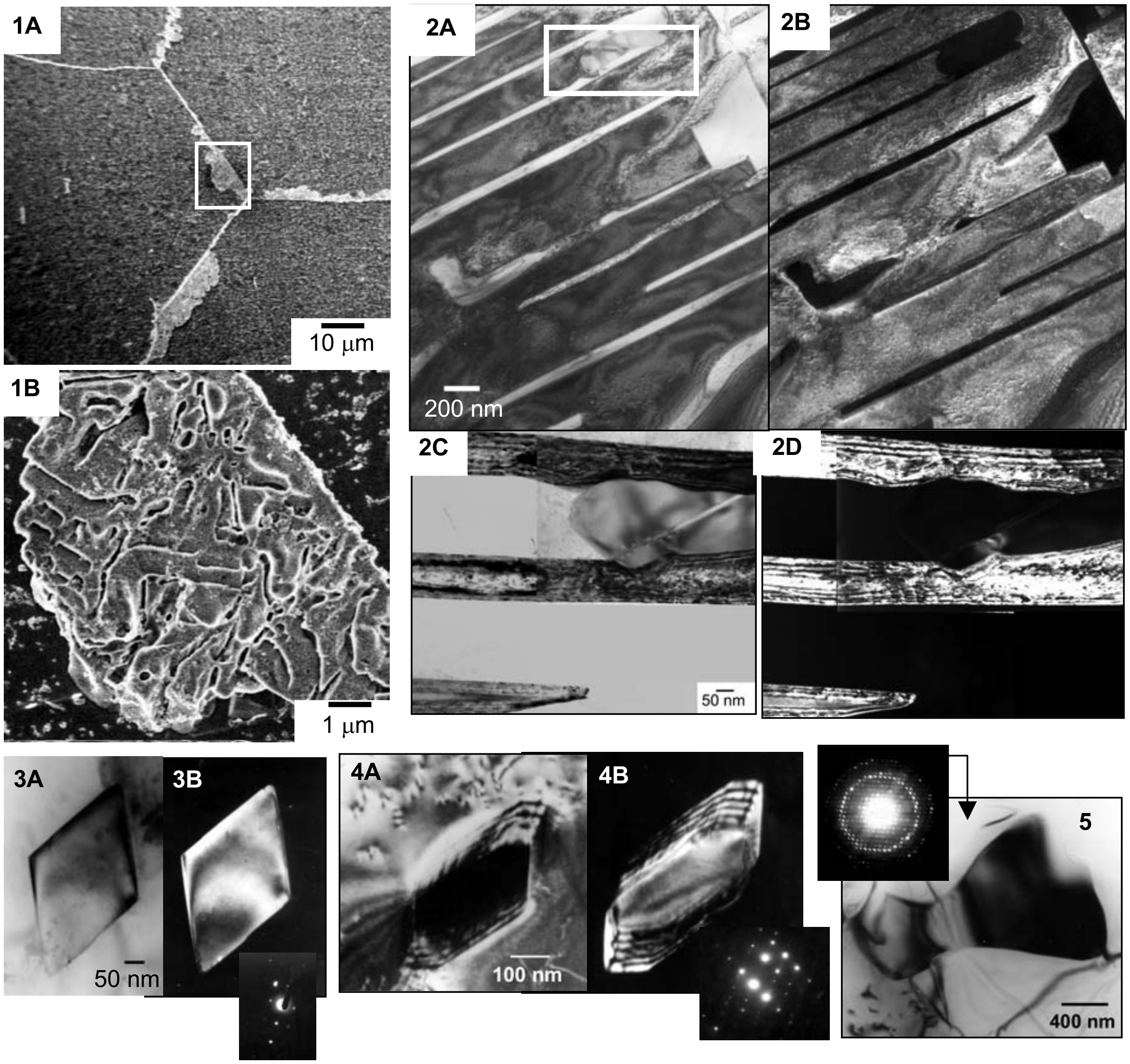

Fig.1 – FEG SEM micrograph of the polycrystalline microstructure, containing continuous and discontinuous precipitation in alloy 33 (a). Below (b) an image of a DP lamellae colony.
Fig.2 – Characteristic simultaneous reaction of DP and CP. BF/CDF pair (a/b), of DP lamellae with non uniform size and spacing. Below, another BF/CDF pair (c/d) shows a detailed view of the previous image, where two lamellae embrace a large homogeneous precipitate.
Fig.3 –BF / CDF pair of a diamond shape homogeneous precipitate with coherent interfaces.
Fig.4 – BF / CDF pair of a semi-coherent precipitate. Notice misfit dislocations at the interface.
Fig.5 – BF micrograph of a large incoherent precipitate in zone axis orientation. Inserted, corresponding SADP showing the zero, first and second Laue zones.

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