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Quantitative Description of the Interface between γ and γ´particles in a Ni-Al Alloy by HREM.

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Ni Base superalloys are important materials for high temperature structural applications. They owe their excellent mechanical properties to the presence of particles of γ' phase (NiAl with an $L1_2$ structure) in a γ matrix (Ni–Al solid solution with an fcc structure). Besides Al, other elements are used to impart either a higher strengthening or improved corrosion properties at high temperature. However the system Ni-Al retains all the basic characteristics necessary for simulation of the evolution of the particle dispersion with time under the effect of temperature. Diffusion driven coarsening of the particle distribution can lead to a reduction of mechanical strength. This process is promoted by a reduction of the total energy of the system which includes the interfacial and the elastic energies as its main contributors in the solid state. Simulation of the evolution must include these two parameters and the nature of the γ-γ' interface becomes important. Additionally, Ni-base superalloys can exhibit rafting after creep deformation, the γ' precipitates, cuboidal before deformation, change to a flat shape. In such a case, the force on γ/γ' interfaces due to plastic deformation becomes important and so is the nature of the interface itself. There are different interface models ranging from a sharp to a diffuse interface (e.g., using either physical or artificial order parameters) [1]. High resolution electron microscopy is an excellent tool to determine the characteristics of the interface both structurally and compositionally in the Ni-Al system and some results are given in this paper.

Figure 1 shows two cases of γ–γ' interfaces in a Ni -12 at.% Al alloy i.e., a single isolated particle and also two neighboring particles. A zone axis parallel to [001] has been selected. The interfaces have been indicated by a dotted line. The γ´phase shows a typical contrast owing to the different concentration that ordering promotes. The strain fields are different according to the local environment. They have been measured after exit wave reconstruction by using TrueImage (FEI ®). An example of the quantitative evaluation is given in Fig. 2 where the reconstructed area is shown (Fig. 2a) together with a two dimensional map (Fig. 2b) and a linear profile produced by averaging measurement along specific columns in the image (Fig. 2c). The measurements are made along two directions here called *a* and *c*, parallel and perpendicular to the interface, respectively. Fig. 1a shows an arrow indicating the *c* direction of measurement. Measuring *a* spacings produces a flat profile while measuring across the interface shows the results in Fig. 2c with a characteristic discontinuity produced by the required continuity of elastic deformation between a coherent particle and the matrix. Application of elasticity theory shows that these measurements render a lattice mismatch of around 0.013. More interfaces have been analyzed to determine the possible limitations of the technique but they clearly show that an accurate determination can be reached under specific situations. As all figures show the γ–γ' interface is sharp both chemically and from the deformation field that the corresponding mismatch produces.

References

[1] J.Z. Zhu et al., *Acta Materialia* 52 (2004) 833-840.

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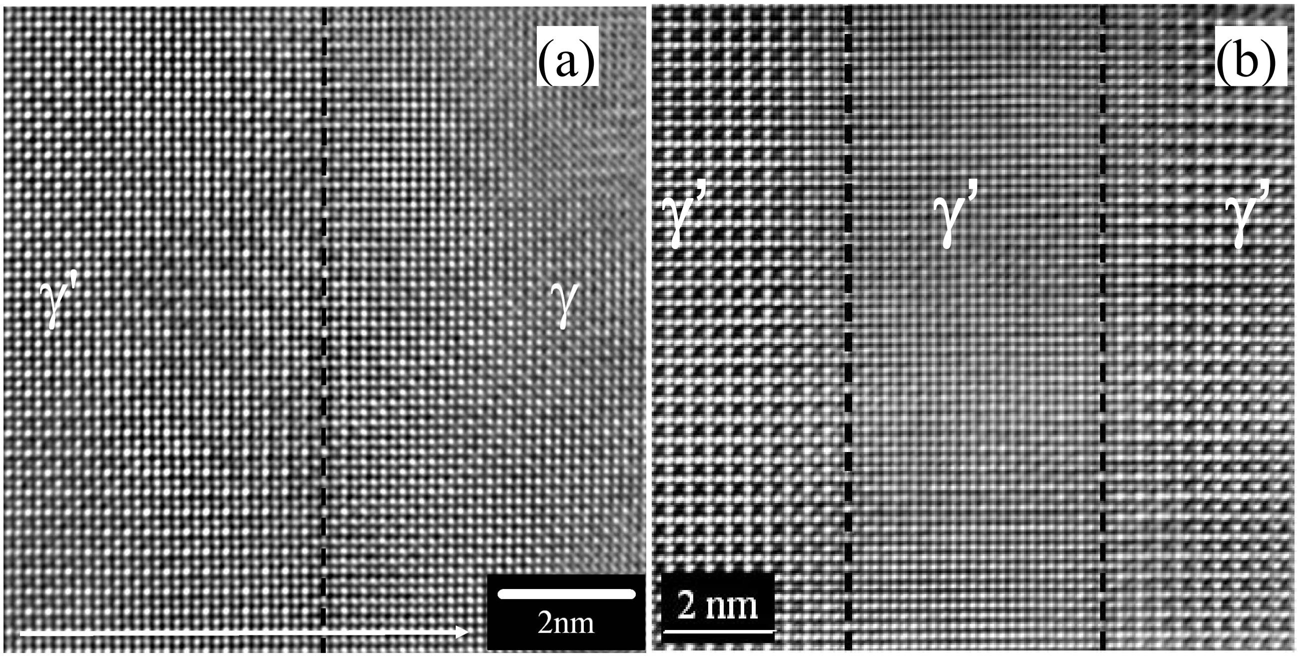
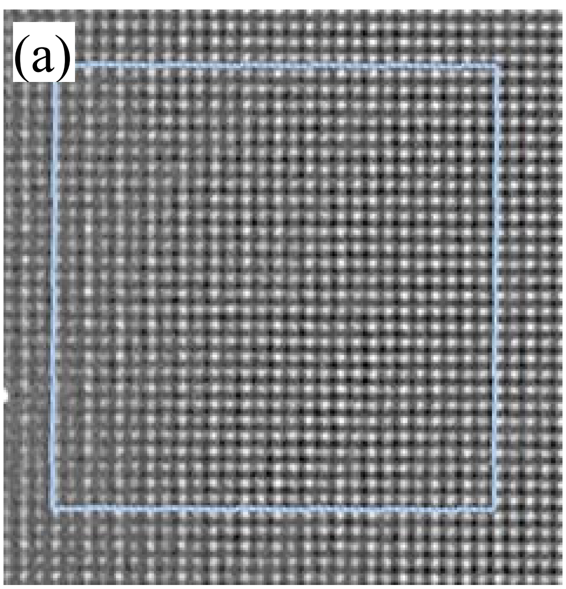


Fig. 1. Ni – 12 at% alloy in HREM aged at 923 K for 1200 h. (a) Experimental image of single γ-γ' interface and (b) interfaces of two neighboring particles. The arrow indicates the c direction.



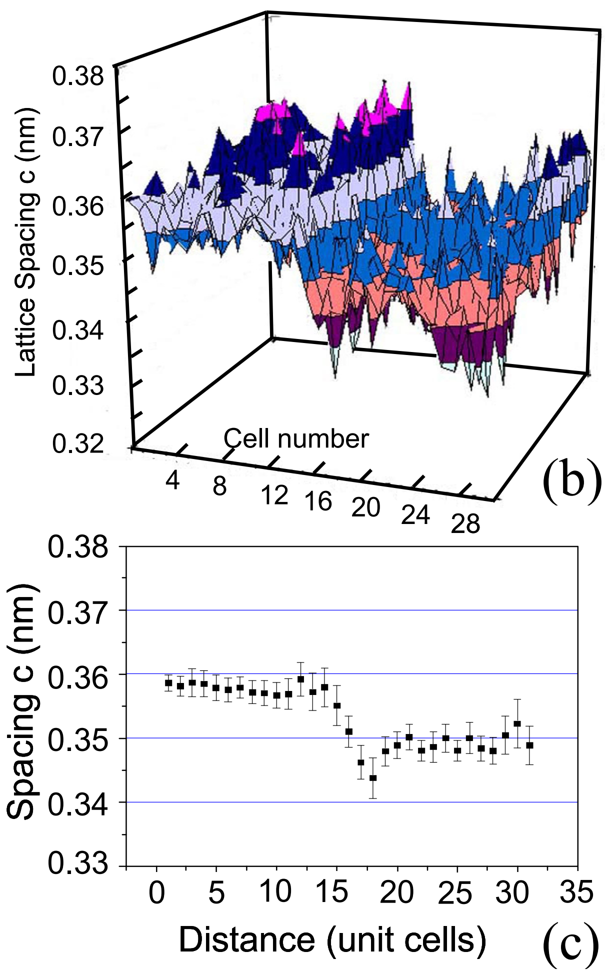


Fig. 2. Unfiltered phase image after image reconstruction from the central area in Fig. 1a. (b) Lattice spacings as a function of position, (c) averaging of lattice spacing measurements.

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