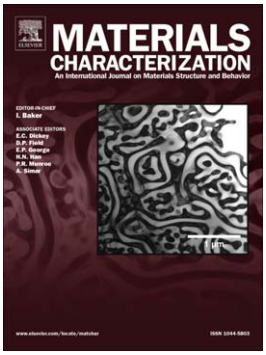

Microstructural characteristics of σ phase and P phase in Ru-containing single crystal superalloys

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Title: Microstructural characteristics of σ phase and P phase in Ru-containing single crystal superalloys

Abstract: Microstructural instability caused by topologically close-packed (TCP) phase precipitation restricts the useful compositional range of advanced Ni-base single crystal superalloys in industrial applications. Limited systematic investigations of TCP formers (Cr and Mo) additions on microstructural evolution of both the σ phase and the P phase in Ru-containing single crystal superalloys have been reported. In this study, the microstructural characteristics of σ phase and P phase were investigated in three Ru-containing superalloys with different levels of Cr and Mo additions at 950 °C and 1100 °C by using phase extraction, X-ray diffraction, scanning electron microscope and high resolution transmission electron microscopy. The experimental results indicated that the high level additions of Cr and Mo promoted the formation of σ phase and P phase, respectively. The amount of σ phase was much higher than that of P phase after long term exposure at 950 °C and 1100 °C. The sheet-like σ phase existed in the alloy with higher Cr addition after thermal exposure at 950 °C and 1100 °C for 1000h, while the needle-like P phase precipitated in high Mo content alloy after thermal exposure at 1100 °C for 1000h and the intergrowth of σ phase and P phase was observed after thermal exposure at 950 °C for 500h. Both the σ phase and P phase were enriched in Re, W, Cr and Mo, but the σ phase contained more Re and Cr while the P phase contained more Mo and Ni, and Ru was found in both phases. The nucleation of σ phase was much easier than P phase due to the more ledge steps in the interfacial structure between σ phase and matrix, as well as the higher partitioning ratios of Re, Cr and Mo. This study is helpful to understand the microstructural evolution of σ phase and P phase, and to optimize