学　位　論　文　内　容　の　要　旨

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学　位　論　文　題　名

Development of Innovative Co-based Oxide Dispersion Strengthened (ODS) Superalloys
(革新的 Co 基酸化物分散強化 (ODS) 超合金の開発)

In order to develop Co-based oxide dispersion strengthened (ODS) superalloys with excellent mechanical properties and oxidation resistance at the temperature above 1000 °C, a novel Co-20Cr-(5,10)Al (wt. %) ODS superalloys containing 2.4 wt. % Hf and 1.5 wt. % Y_2O_3 were designed and fabricated by mechanical alloying (MA), spark plasma sintering (SPS), hot rolling and the final annealing at 1200 °C. Based on the results of microstructure characterization, the superalloys were found to contain a Co solid solution phase with face-centered cubic (fcc) structure and a CoAl phase with body-centered cubic (B2) structure, which offers the guarantee for good ductility and favorable strength, respectively. Composition and volume fraction of the both phases are almost consistent with the Co-Cr-Al ternary phase diagram computed with the Pandat software. Fine Y-Hf oxides particles are densely distributed inside the fcc solid solution and the B2 phase. Grain boundaries and phase boundaries are decorated with the oxide particles, which are beneficial to grains and phases stability at elevated temperature. Moreover, a unique core-shell structure of $Y_2Hf_7O_{17}$ in core and $Y_2Hf_2O_7$ at periphery was observed, which is responsible for the coarsening of the Y-Hf oxides. High-temperature oxidation behavior of the Co-based ODS superalloys was investigated by the isothermal oxidation test at 900 °C and 1000 °C in air. With the increase of Al content from 5 wt. % to 10 wt. %, the oxidation resistance of the superalloys had been significantly improved by the formation of a single alumina scale, which is far better than conventional Co-based alloys. A faster θ- to α-alumina transformation at higher temperature was found to be responsible for the smaller weight gain at 1000 °C than at 900 °C for the 10 wt. % Al specimens. Besides, the effect of Cr and Y_2O_3 addition on the oxidation behavior of the Co-based superalloys was investigated, as well. The results indicate that the addition of Cr is beneficial to the oxidation resistance by accelerating the formation of an exclusive Al_2O_3 scale, i.e., changing the oxide scales morphologies from the multilevel scales with an external CoO/$CoAl_2O_4$ and an internal Al_2O_3 to the single Al_2O_3 scale. With Y_2O_3 addition, the grain size of Al_2O_3 scale was decreased, and even though the weight gain of Co-20Cr-10Al ODS superalloys has been slightly accelerated, the Co-based ODS superalloys possess far better oxide-scale adherence than that in free Y_2O_3 alloys. Tensile strengths of two Co-based ODS superalloys with 5wt. % and 10wt. % Al addition were measured at 23 °C, 250 °C, 500 °C, 700 °C and 1000 °C. 10Al shows less ultimate tensile strength (UTS) at low temperature since a brittle fracture caused by high B2 volume fraction. 5Al exhibits outstanding UTS of 2.85 GPa at room temperature, which is associated with the distribution of fine Y-Hf oxides and the nano-twins deformation during strain. Along with the increasing of temperature, a drastic reduction in tensile strength was observed, which is associated with grain boundary deformation due to the ultrafine grains of 500 nm in the 5Al and 800 nm in the 10Al Co-based superalloys.