Fundamental Core Effects in FCC Co-Cr-Fe-Ni-based Multi-Principal Element Alloys

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High entropy and sluggish diffusion core effects were investigated via solid-to-solid diffusion couple approach in Co-Cr-Fe-Ni based transition metal multi-principal element alloys. High entropy effect was examined for off-equatomic compositions of Al-Co-Cr-Fe-Ni and Al-Co-Cr-Fe-Ni-Mn systems, generated by Al_{48}Ni_{52} vs. Co_{25}Cr_{25}Fe_{25}Ni_{25} and Al_{48}Ni_{52} vs. Co_{20}Cr_{20}Fe_{20}Ni_{20}Mn_{20} diffusion couples, respectively. Thermodynamic analysis was carried out as a function of temperature (900-1200°C) by comparing the thermodynamic stability parameters (i.e. ΔH, −TΔS, and ΔG) in off-equatomic compositions with the equiatomic Al_{x}CoCrFeNi and Al_{x}CoCrFeNiMn compositions, determined using calculated equilibrium pseudo-binary phase diagram. Analyses suggest that the role of enthalpy of mixing may be significant in achieving higher thermodynamic stability in alloy compositions with lower entropy of mixing (i.e off-equatomic compositions).

Sluggish diffusion effect was examined by measuring diffusion coefficients (i.e. interdiffusion and tracer diffusion coefficients) in near-equatomic CoCrFeNi, CoCrFeNiMn and Al_{0.25}CoCrFeNi alloys. Average effective interdiffusion coefficients were measured using Dayananda-Sohn [1] approach and tracer diffusion coefficient of Ni was measured using Belova et al. [2] formalism coupled with Gaussian distribution function. Comparison of diffusion coefficients with conventional solvent-based multicomponent alloys suggests that diffusion is not always sluggish in high entropy alloys. The potential energy fluctuation model [3] was utilized to determine fluctuations in lattice potential energy (LPE). Contrary to previous findings, larger fluctuations in LPE of an alloy may not always result in anomalously slow diffusion kinetics.