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Toward an origin of high entropy alloys(HEAs): Diffusion in $(Ni)_x$-$(CoCrFeMn)_{1-x}$

A Thesis Submitted for the award of the degree of Master of Science in Physics

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Abstract

It's been almost 14 years to the discovery of first high entropy alloy (HEA). Meanwhile these materials have attracted the Scientists attention from all around the globe, because of their exceptional mechanical, Electrical and magnetic properties especially after 2010. HEAs base on four main effects which include "High entropy effect","Lattice distortion effect","Sluggish Diffusion effect" and "Cocktail effect". In this Master thesis my objective is to examine the correctness of the concept of the sluggish diffusion in $Ni_{60}(CoCrFeMn)_{40}$, $Ni_{92}(CoCrFeMn)_{8}$ and also pure nickel $Ni_{100}(CoCrFeMn)_{0}$.
First microstructure was investigated by X-Ray diffraction(XRD) at four different pre-annealed temperatures(1073K, 1123K, 1173K and 1223K) for each composition. Scanning electron microscope and Electron back scattered diffraction was only possible for $Ni_{60}(CoCrFeMn)_{40}$, $Ni_{92}(CoCrFeMn)_{8}$ annealed at 1173K. XRD shows that each composition has only single FCC phase and there is no phase transition at any temperature for the time scales studied (about 1 week). The grain size in both systems $Ni_{60}(CoCrFeMn)_{40}$, $Ni_{92}(CoCrFeMn)_{8}$ is several hundreds microns but the size of grains in $Ni_{92}(CoCrFeMn)_{8}$ is higher than $Ni_{60}(CoCrFeMn)_{40}$.
The foremost task is to investigate high entropy alloy effect as the amount of pure Nickel decreases and the amount of CoCrFeMn increases in the alloy by measuring the diffusion using radio-tracer diffusion technique. By this thesis, the self diffusion in $Ni_{60}(CoCrFeMn)_{40}$ and $Ni_{92}(CoCrFeMn)_{8}$ of ^{51}Cr ^{54}Mn ^{57}Co ^{59}Fe ^{63}Ni tracers as well as impurity diffusion of ^{54}Mn in pure $Ni_{100}(CoCrFeMn)_{0}$ is measured using the radiotracer technique for the first time. The radiotracer measurements are analyzed at four temperatures 1073K, 1123K, 1173K and 1223K for different annealing time i.e 12 days, 10.8 days, 16 hours and 5.8 days respectively. It is shown that the concept of "sluggish diffusion" is not valid for the FCC HEAs.

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