EMCMRE-1
Marrakech-Morocco
November 21-25 2011

First Euro-Mediterranean Conference on Materials and Renewable Energies (EMCMRE-1) 21-25 November 2011

X-rays and Mössbauer study of nanocrystalline powders of $Fe_{50}Ni_{25}Al_{25}$ obtained by high – energy milling.

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Abstract:

Nanostructured alloys are attractive for their excepted original physical properties related to the nanometric grain size. Among these alloys, the ternary FeNiAl has remarkable properties at high temperatures and usually presents a high resistance to corrosion.

We have elaborated the nanostructured $Fe_{50}Ni_{25}Al_{25}$ alloy by mechanical alloying of pure elements powders milled during various times, up to 48 hours. Characterizations of powders were carried by usual techniques as X- ray diffraction and Mössbauer spectroscopy. And careful evaluations of the crystallite size and order parameters have been done.

It was observed that after a few minutes of milling, a rich-Al phase was obtained. At milling times of 1 hour, two disordered phases bcc - α Fe (Al,Ni) and fcc- γ appears. As milling times is increasing, there is an induced transformation γ → α. And after 60 hours of milling, the concentrations of the 2 phases are 98 % of α and 2% of γ and the grain size of both phases is below 10 nm. Grains have anisotropic shapes from high microstrains. Variations of inter-reticular parameters, grain size, microstrains and concentrations of both phases have been studied as a function of milling times and can be related to the interdiffusion of elements .

From fittings of the Mössbauer spectra, the mean hyperfine fields are found to decrease rapidly at the early stages of milling from 32 T to 24 T (after 1 hour). It then increases up to 25 T around 20 h of milling. Finally, it decreases smoothly for longer times. These variations reflect the mixing of Al and Ni with the Fe atoms. More insight can be obtained from the evolutions of the hyperfine fields distributions. The rich-Al phase that appears at the early stage is clearly seen as a paramagnetic doublet peak. Then, for longer milling times, there are 4 nearest neighbours configurations where it can be revealed the larger influence of Al around the Fe atoms than the Ni atoms.