Hyperfine field distributions in $Fe_{51}Ni_{49}$ alloy with a locally differentiated crystal structure

Mieszko Kołodziej[a,b], Jean-Marc Greneche[c], Sandy Auguste[c], Jozef Marcin[d], Jozef Kovac[d], Ivan Skorvanek[d], Zbigniew Śniadecki[a], Bogdan Idzikowski[a]

[a] *Institute of Molecular Physics, Polish Academy of Sciences, Poznań, Poland*
[b] *NanoBioMedical Centre of Adam Mickiewicz University, Poznań, Poland*
[c] *Institut des Molécules et Matériaux du Mans (UMR CNRS 6283), Le Mans University, Le Mans, France*
[d] *Institute of Experimental Physics, Slovak Academy of Sciences, Košice, Slovakia*

We describe the Mössbauer spectrometry (MS) results obtained for the $Fe_{51}Ni_{49}$ alloy synthesized by melt spinning from the meteoritic matter and nickel and subjected to high-pressure torsion (HPT) processing. Such obtained series of alloys was then annealed at 296°C, without external magnetic field and in 14 T. The results show that HPT processing increased the potential of the alloys for the diffusion of Fe and Ni after further annealing at temperatures below $L1_0$ FeNi order-disorder transition point. It could not be concluded that the $L1_0$ phase formed during the experiment, but minor signs of its presence could be noticed on the Mössbauer spectra. Moreover, presence of external magnetic field during annealing increased Fe and Ni segregation, crucial for $L1_0$ FeNi phase formation.

Keywords: soft magnetic matter, Mössbauer spectrometry, hyperfine fields

1. Introduction

It is known that numerous phases are difficult to synthesise on our planet due to a lack of specific physical and/or chemical conditions. Iron and nickel are two of our planet's most abundant metallic elements but also main components of Fe-type meteorites. The study of their structural and magnetic properties is, therefore, extremely valuable, both from a fundamental and practical point of view. The synthesis procedure and magnetic properties of quasi-equiatomic $Fe_{51}Ni_{49}$ alloys based on meteoritic material of the Morasko Meteorite (MM) are described in another abstract presented at current SMM27 Conference.

2. Results and discussion

Mössbauer spectrometry (MS) measurements of Fe-Ni alloys were performed to better understand their structure and magnetic behaviour. Ferromagnetic order is favoured for a quasi-equiatomic composition of Fe and Ni [1], so a sextet is expected in the MS spectrum. Furthermore, according to [2], the Mössbauer spectra of the FeNi alloy appear similar for 10 to 65 at.% of Fe. If the Fe content were to increase further (above 70 at.% of Fe), a drastic change in the spectrum would be observed, caused by the magnetic disorder, resulting in the appearance of a doublet. The mean value of the hyperfine field was determined to be equal to 31.2±0.5 T for each sample analysed. No paramagnetic phase was observed. As a final step, the model comprising six sextets characterized by hyperfine field values of 26.5, 28, 29.5, 31, 32.5 and 34 T was used (see Fig.1). Each sextet corresponds to different nearest neighborhoods of the Fe atom, with varying Ni content in the first coordination shell. Consequently, by comparing the MS spectra for other investigated samples, it can be concluded that the neighborhood of the Fe atoms differs for each sample, even considering a similar mean value of the hyperfine field.

In conclusion, MS investigations proved that samples are ferromagnetically ordered with no paramagnetic components. While the mean value of the hyperfine field of 31.2±0.5 T was similar in every sample, the evolution of the Fe neighborhood could be easily distinguished for samples treated with HPT and annealed with and without an external magnetic field.

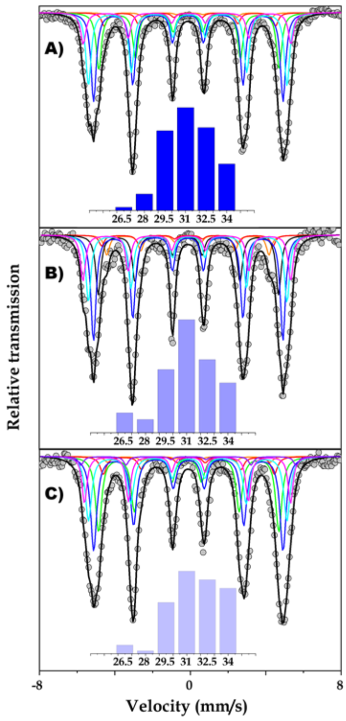

Figure 1: Mössbauer spectra for $Fe_{51}Ni_{49}$ samples in (A) the as-quenched state, (B) annealed at 296°C for 120 h without an external magnetic field, and (C) with an external magnetic field of 14 T. The hyperfine field (B_{hf} in Tesla) distributions are shown in the insets.

The results obtained in this study prove that a temperature of 296°C is sufficient to induce diffusion in FeNi alloy by annealing of the previously plastically deformed samples. Moreover, while an external magnetic field was present, the annealing increased the volume fraction of clusters with Fe central atom surrounded only by other atoms of the same element. This also confirms the ongoing chemical segregation.

References

[1] Ullrich, H., Hesse, J., Hyperfine field vectors and hyperfine field distributions in FeNi Invar alloys, J. Magn. Magn. Mater. **45** (1984) 315.
[2] Ping, J.Y. *et al.*, Physical basis and break down of hyperfine field distribution analysis in fcc-Fe-Ni (5-70 at% Fe), J. Magn. Magn. Mater. **103** (1992) 285.

Acknowledgements: The authors thank dr. N. Lindner and dr. Yu. Ivanisenko for high-pressure torsion experiments.