Mössbauer study of swift heavy ion irradiated Fe-Ni-Cr multilayers

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Sample preparation and irradiation

- FeNiCr multilayers were deposited by e-gun onto a plastic (UPILEX-S) substrate, at a pressure of about $6 \cdot 10^{-6}$ Pa.

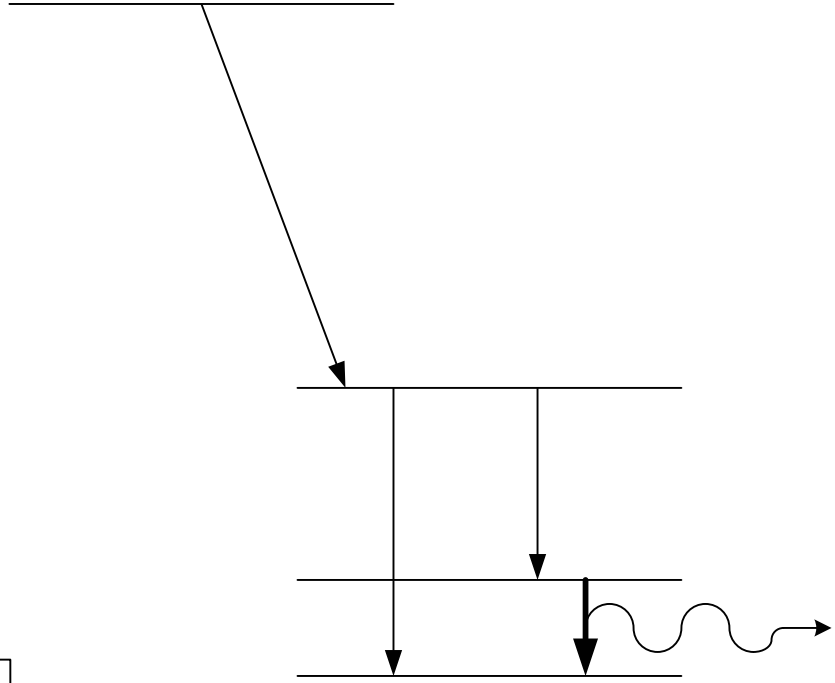
- Irradiation was carried out with 246 MeV energy $^{86}Kr^{8+}$ ions at room temperature and at a vacuum of about 10^{-3} Pa. The ion fluences attained were $1 \cdot 10^{14}$ ion$\cdot$cm^{-2} and $3 \cdot 10^{14}$ ion$\cdot$cm^{-2}.

- Heat treatment of the irradiated samples was performed in a quartz tube in a furnace at temperatures of 450 ºC and 600 ºC isothermally for 3 h each time in a vacuum of about 10^{-3} Pa.

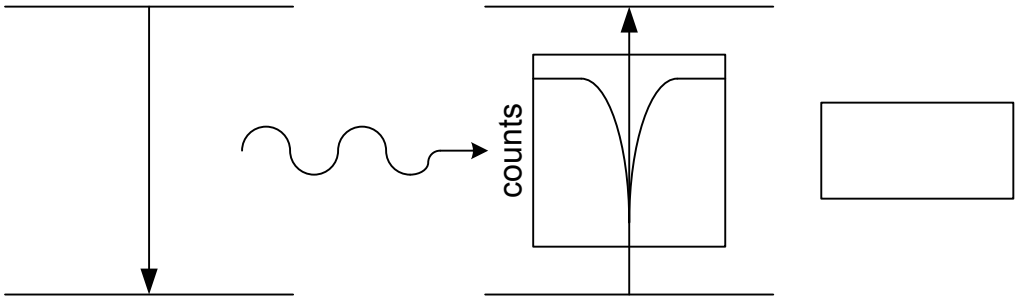
Mössbauer spectroscopy

- Mössbauer spectroscopy is based on the recoil-free resonance absorption of γ-photons observed with certain atomic nuclei.

Nuclear decay scheme of Co

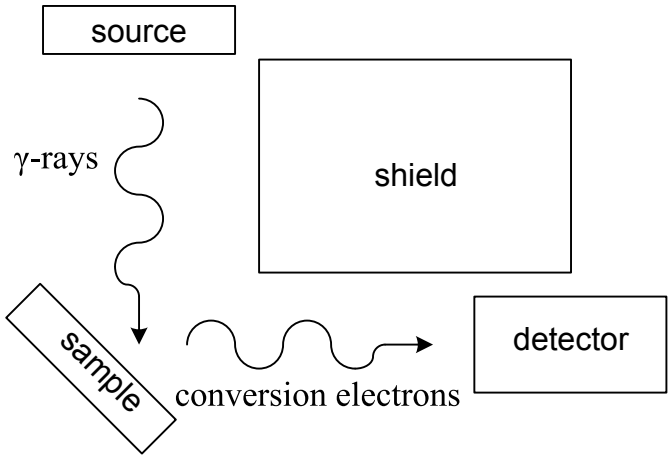


Schematic representation of Mössbauer spectroscopy



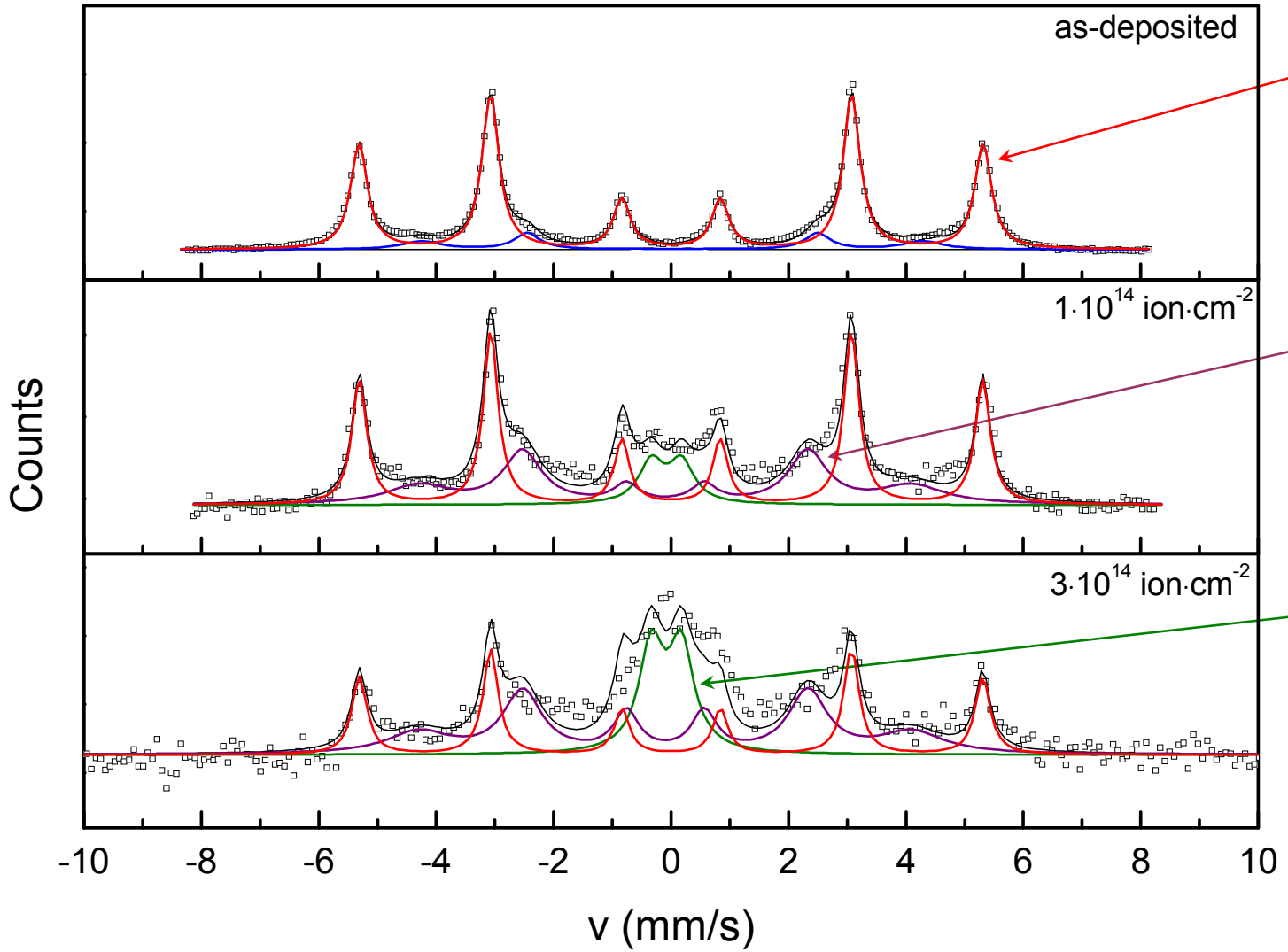
Mössbauer spectroscopy

Schematic representation of
conversion electron
Mössbauer spectroscopy



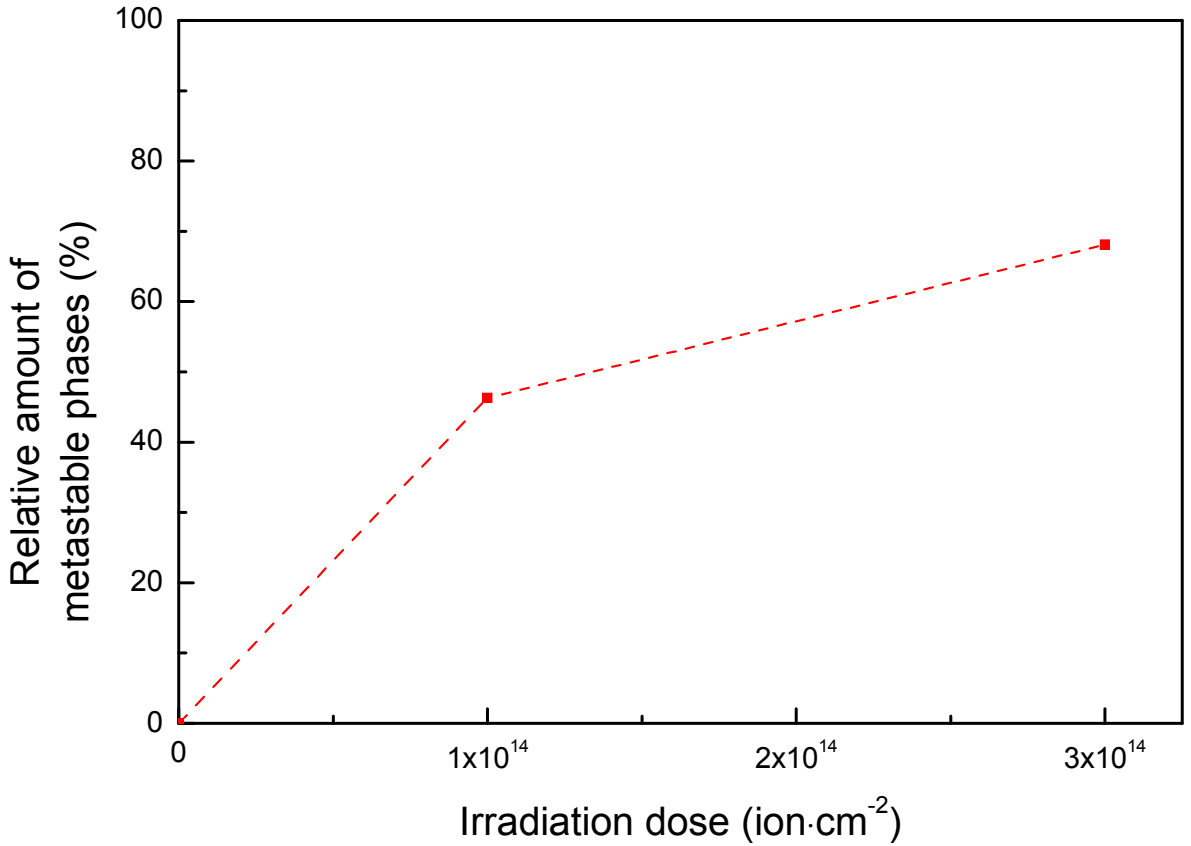
- Conversion electron Mössbauer spectra were recorded by a conventional mössbauer spectrometer (WISSEL) at room temperature with a flowing gas (96%He, 4%CH_4) proportional counter and a ^{57}Co(Rh) source of 1.85 GBq activity.

Effect of irradiation



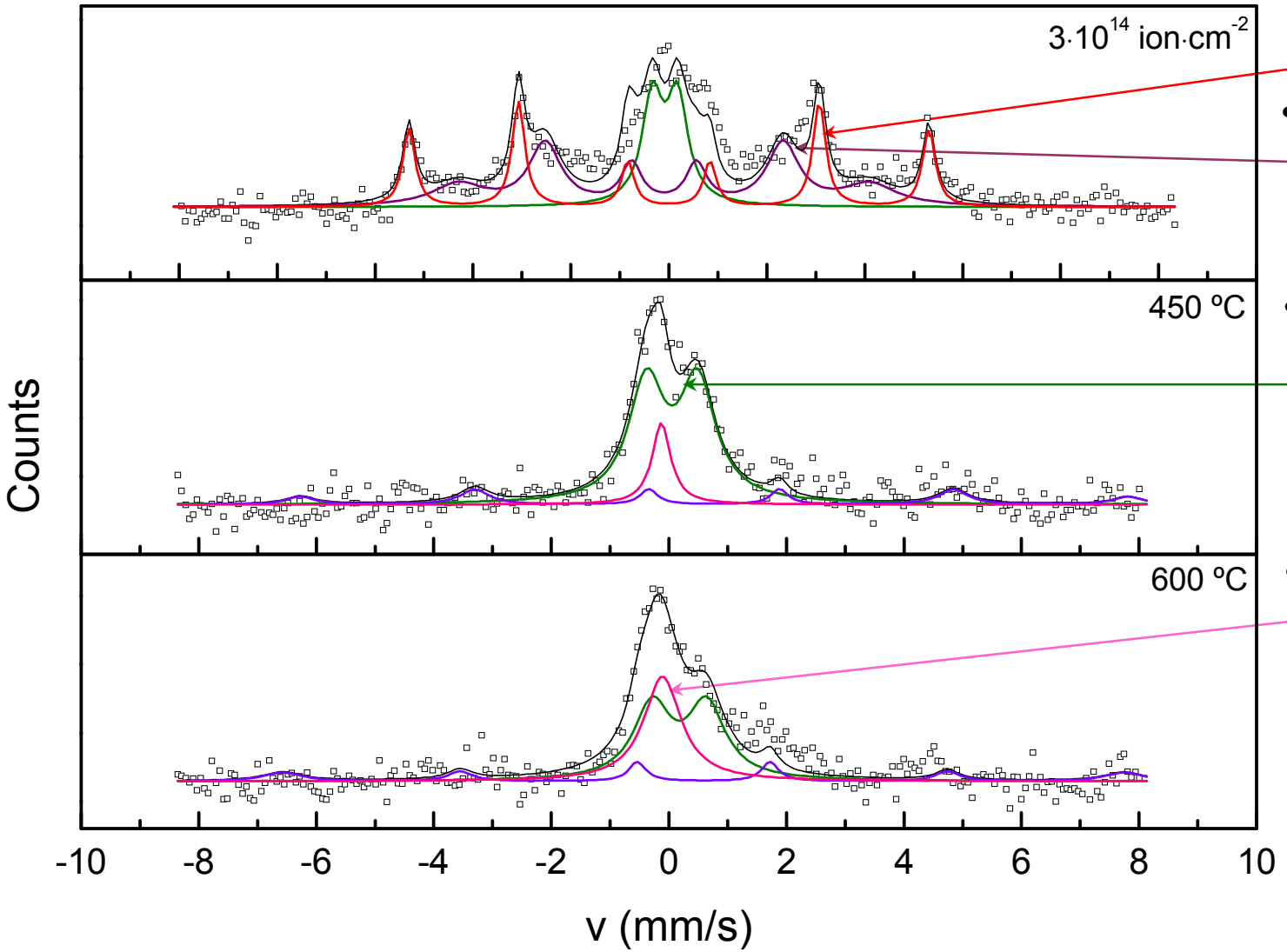
- α-Fe
- ferromagnetic Fe-Ni-Cr solid solution
- paramagnetic Fe-Ni-Cr solid solution

Effect of irradiation



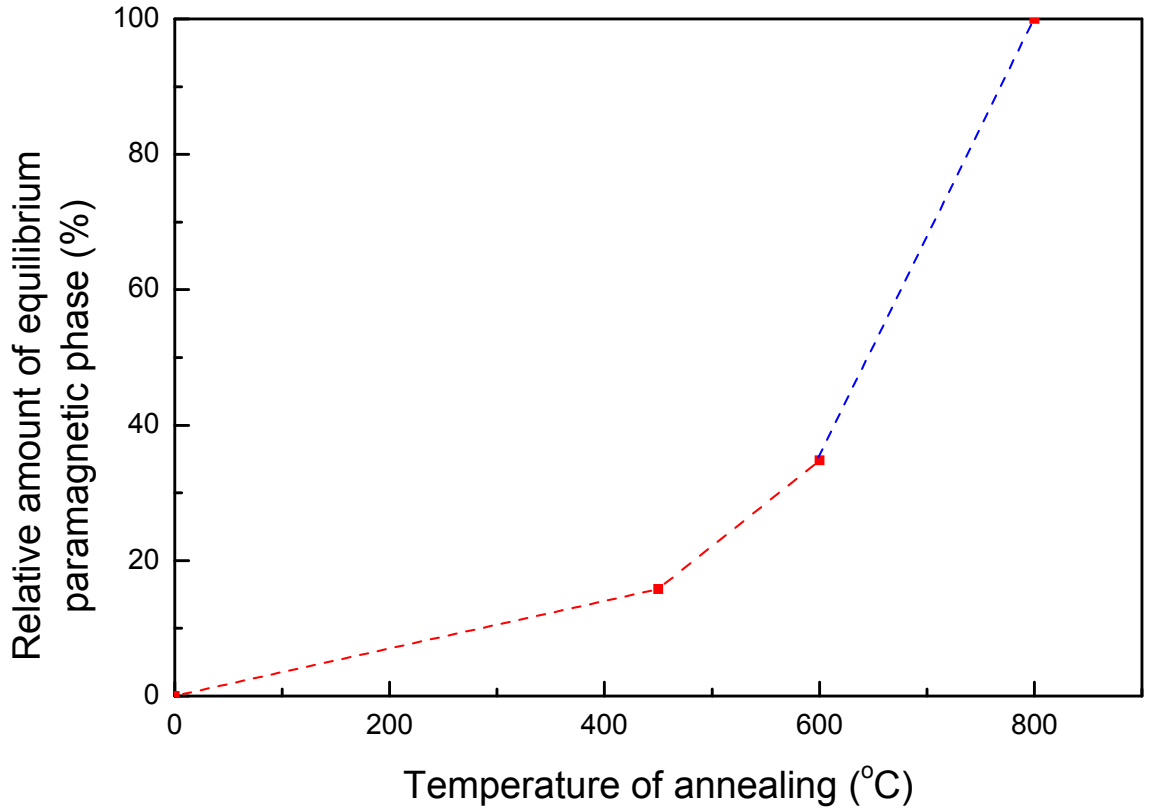
- Relative amount of the new metastable phases increases with the irradiation fluence.

Effect of heat treatment



- α-Fe
- ferromagnetic Fe-Ni-Cr solid solution
- paramagnetic Fe-Ni-Cr solid solution
- equilibrium Fe-Ni-Cr alloy

Effect of heat treatment



- Relative amount of the equilibrium paramagnetic phase increases with the temperature of annealing.

Summary

- Energetic heavy ion irradiation proved to be an excellent tool to prepare Fe-Ni-Cr alloys by ion beam mixing.
- Irradiation of Fe-Ni-Cr multilayers by 246 MeV energy $^{86}Kr^{8+}$ ions results metastable highly disordered ferromagnetic and paramagnetic phases which never occur in thermally prepared equilibrium alloys.
- Quantity of metastable phases increases with the dose of irradiation.
- Metastable phases of irradiated multilayers transform to the paramagnetic equilibrium phase due to heat treatment.
- Mössbauer spectroscopy is a sensitive analytical method to study the metastable and stable phases in Fe-Ni-Cr alloys.

Publications

- E. Kuzmann, G. Principi, C. Tosello, K. Havancsák, S. Stichleutner, I. Gerőcs, Z. Homonnay and A. Vértes, Mössbauer study of metastable phase formation in vacuum deposited FeNiCr multilayers due to swift heavy ion irradiation, Nucl. Instr. and Meth. B 183 (2001) 425-431

- E. Kuzmann, S. Stichleutner, M. El-Sharif, C. U. Chisholm, L. Sziráki and A. Vértes, Mössbauer investigation of electrodeposited Sn-Zn, Sn-Cr, Sn-Cr-Zn and Fe-Ni-Cr coatings, Hyp. Int. 141/142 (2002) 425-433

- E. Kuzmann, S. Stichleutner, M. El-Sharif, C. U. Chisholm, G. Principi, C. Tosello, K. Havancsák, I. Gerőcs and A. Vértes, Mössbauer studies of radiation effects in swift heavy ion irradiated Fe-Ni-Cr multilayers and electrodeposited alloys, Hyp. Int. C, 5 (2002) 591-594