## SHORT COMMUNICATIONS

### FERROMAGNETIC RESONANCE STUDY OF CHROMIUM PLATED AMORPHOUS $Fe_{40}Ni_{40}B_{20}$ ALLOY

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ADDITION of chromium to amorphous alloys is known to substantially influence their thermal and chemical stability[1,2], corrosion[3,4] and magnetic properties[5,6]. In chromium containing alloys, a Cr-enriched surface layer is formed which prevents the bulk material from attack of oxygen, sulphur and chlorine. Being an antiferromagnet, it lowers the Curie temperature[6]. Such modifications produce appreciable changes in the structure sensitive properties of the alloy which could precisely be probed using Ferromagnetic Resonance (FMR) technique[7,8]. Incorporation of chromium ions into magnesium aluminium ferrite reduces its coercive force, FMR linewidth and also its maximum induction[9]. In this letter we report the effect of chromium plating on the FMR parameters in isothermally annealed amorphous $Fe_{40}Ni_{40}B_{20}$ alloy.

FMR measurements were carried out at room temperature on $Fe_{40}Ni_{40}B_{20}$ (VITROVAC 0040) amorphous alloy specimens. Since significant differences in FMR lineshape and linewidth were observed for shiny and dull sides of 'as received' samples exposed to the microwave field, they were carefully polished on both sides using emery paper (400 grade) so as to reduce its thickness from 20 $\mu$m to ~10 $\mu$m. The differences in spectra were now negligible. A thin (~ 160 A) layer of chromium was electrolytically deposited on the polished ribbon using a standard chromium plating bath[10]. Specimens cut from the plated ribbon were isothermally annealed at 373, 473 and 573 K, *i.e.*, well below its crystallization temperature (700 K). First derivative, X-band FMR spectra were recorded on a JEOL FE-3X EPR spectrometer with 100 kHz modulation; the DC magnetic field being swept from 0 to 0.5 Tesla. The specimens were mounted on a teflon sample holder. Two sets of spectra were recorded with the long axis of the specimen kept parallel and perpendicular to the magnetic field, which correspond to 'parallel vertical' (PV) and 'parallel horizontal' (PH) configurations, respectively.

Figure 1 shows typical FMR spectra of two chromium-plated $Fe_{40}Ni_{40}B_{20}$ specimens annealed at 573 K for 30 and 5 min in the PV and PH configurations. A single resonance curve is obtained for short anneals which upon prolonged annealing becomes asymmetric suggesting that a new magnetic phase is emerging. Chromium gets bonded to the unsaturated ions on the amorphous alloy surface thereby changing its compositional short range order. Thus the origin of this new phase lies in the diffusion of chromium into the ribbon surface. Further, these diffused chromium atoms would act as nucleating centres and hasten the crystallization process. Comparison of the linewidth $\Delta H_{pp}$ shows that $[\Delta H_{pp}]_{PV}$ is always larger than $[\Delta H_{pp}]_{PH}$.

Figure 2 gives the dependence of linewidth on annealing time for (1) Cr-plated specimens annealed at 373, 473 and 573 K and (2) uncoated mechanically

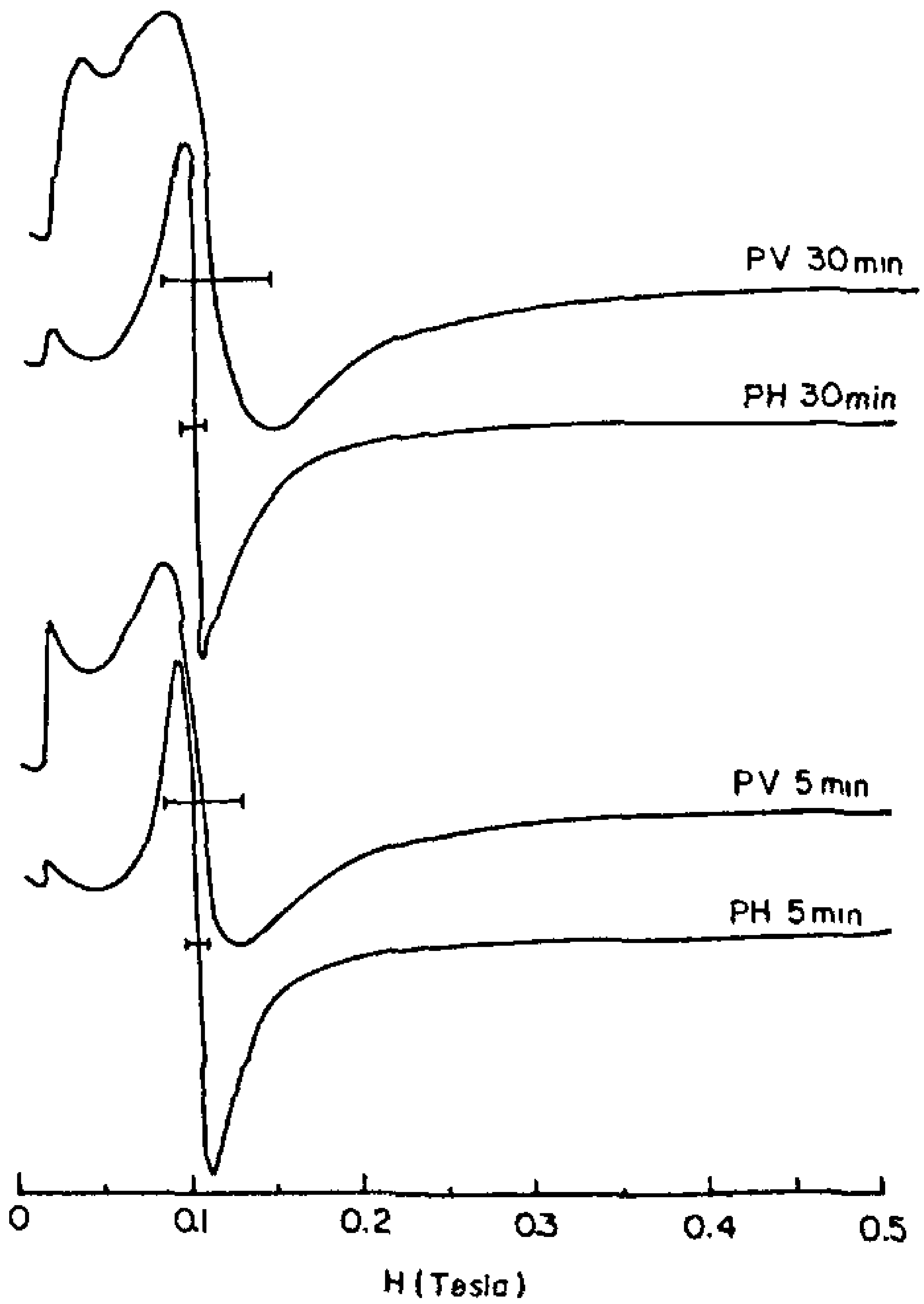


**Figure 1.** FMR spectra of chromium-plated $Fe_{40}Ni_{40}B_{20}$ amorphous alloy specimens annealed at 573 K.

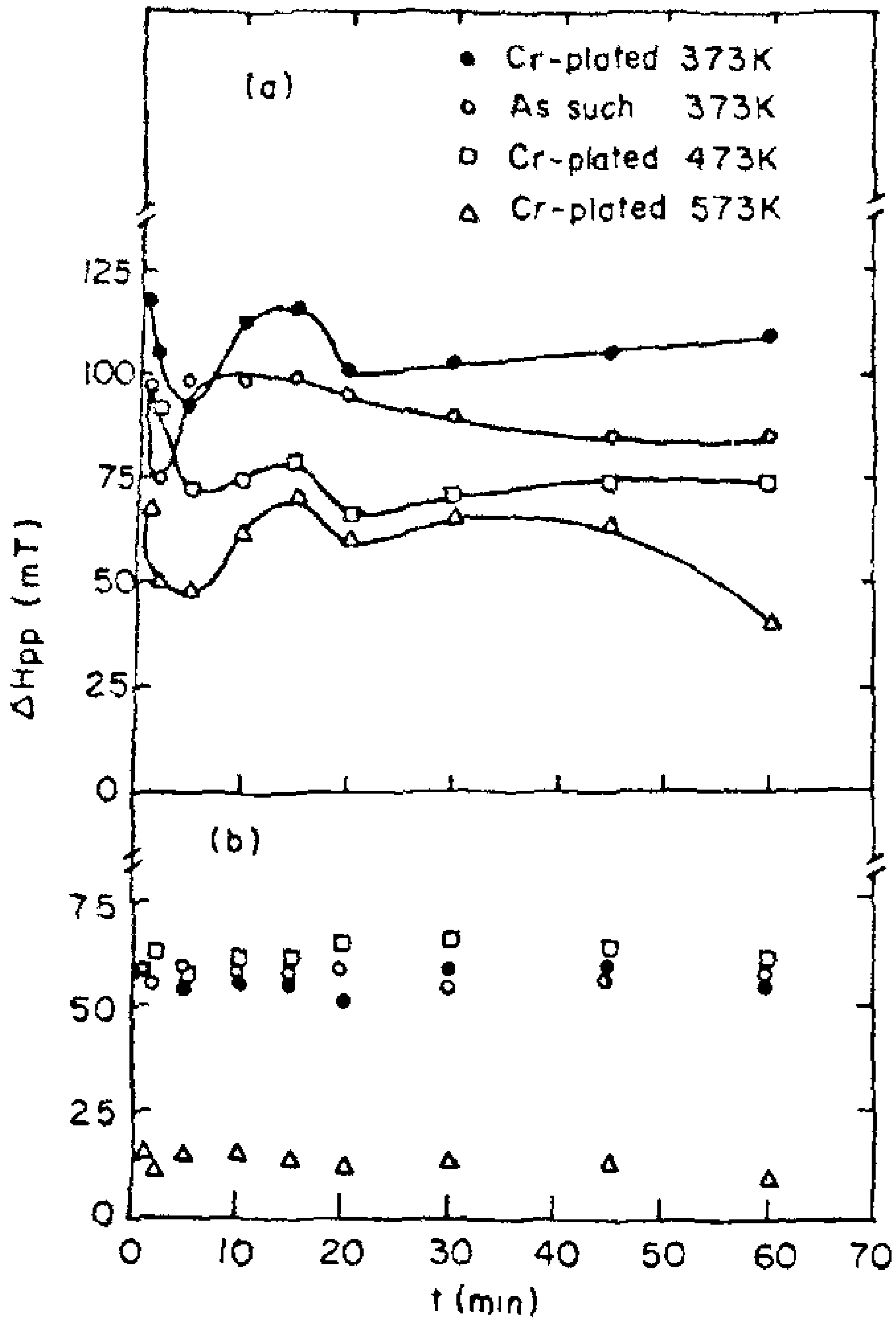


**Figure 2.** Dependence of FMR linewidth, $\Delta H_{pp}$ of mechanically polished and chromium-plated $Fe_{40}Ni_{40}B_{20}$ glassy specimens on annealing time *t* in (a) PV and (b) PH configurations.

polished specimens annealed at 373 K. In the PV configuration uncoated specimen shows a sharp dip in $\Delta H_{pp}$ around 2 min followed by a broad hump around 10–15 min. For longer periods of annealing a systematic but slow decrease in linewidth is observed. In the Cr-plated specimens the initial dip is flattened out and the subsequent hump narrows down. Annealing at higher temperatures brings down the linewidth. This reduction may be attributed to the increased dipolar interactions between magnetic atoms. Similar linewidth narrowing has also been observed in isochronally annealed amorphous $Fe_{40}Ni_{40}P_{14}B_6$ ribbons[11]. Initial linewidth narrowing upon annealing (figure 2) arises from rapid changes in the number and distribution of quenched-in defects due to structural relaxation[12]. FMR *linewidths for Cr-plated specimens are generally* larger than uncoated, polished ones. This is probably due to the presence of antiferromagnetic Cr atoms on the ribbon surface. Earlier studies on amorphous Fe-Ni base alloys have also shown such broadening upon addition of chromium.

The resonance field, $H_0$ is found to be lower for Cr-plated specimens. The variation in $H_0$ is in the range $0.10 < H_0 < 0.12$ T and $0.12 < H_0 < 0.13$ T for Cr-plated and unplated specimens respectively. Possible reasons are (1) enhancement of surface inhomogeneity by Cr-layer, (2) differences in the saturation magnetization and Curie temperatures of antiferromagnetic chromium and the ferromagnetic $Fe_{40}Ni_{40}B_{20}$ ribbon.

To conclude, structural relaxation in amorphous $Fe_{40}Ni_{40}B_{20}$ alloy is influenced by the chromium layer, which is reflected through FMR line broadening and decrease in the resonance field upon Cr-plating. Isothermal annealing produces significant changes in short-range order. Detailed studies now under way will be reported elsewhere.

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