Magnetic resonance study of nanocrystalline hematite-ilmenite solid solutions

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Abstract

Nanocrystalline hematite-ilmenite (Fe_2O_3, $FeTiO_3$) solid solutions containing small amounts of hematite have been prepared and investigated by magnetic resonance technique in the 4-300 K temperature range. At room temperature the magnetic resonance spectra have been fitted by two Lorentzian lines centered at H_r=325.3(1) mT (g_{eff}=2.054(1)) and H_r=335.3(1) mT (g_{eff}=2.015(1)) with linewidth ΔH_{pp}=83.0(1) mT and ΔH_{pp}=54.0(1) mT, respectively. Temperature dependence of the resonance lines suggests that the first line arises from the ferromagnetic agglomerates (ferromagnetic resonance, FMR) and the second line from isolated high spin trivalent iron(III) ions (electron paramagnetic resonance, EPR). Below 100 K additional lines centered at 159.5(4) mT (g_{eff}=4.236) and 334.2(4) mT (g_{eff}=2.007) has appeared. As their intensity increases with decreasing temperature a probable source of that signal are the trivalent iron(III) ions placed at sites with a low symmetry of the crystal field. At room temperature the position of the resonance line and the value of its linewidth is consistent with a small concentration of the Fe_2O_3 in a non-magnetic matrix. The temperature derivate of the resonance field $\Delta H_r/\Delta T$ is over two times greater in comparison with other diamagnetic matrices. This points out on more intense reorientation processes of the magnetic moments in nanocrystalline hematite-ilmenite solid solutions (Fe_2O_3, $FeTiO_3$).

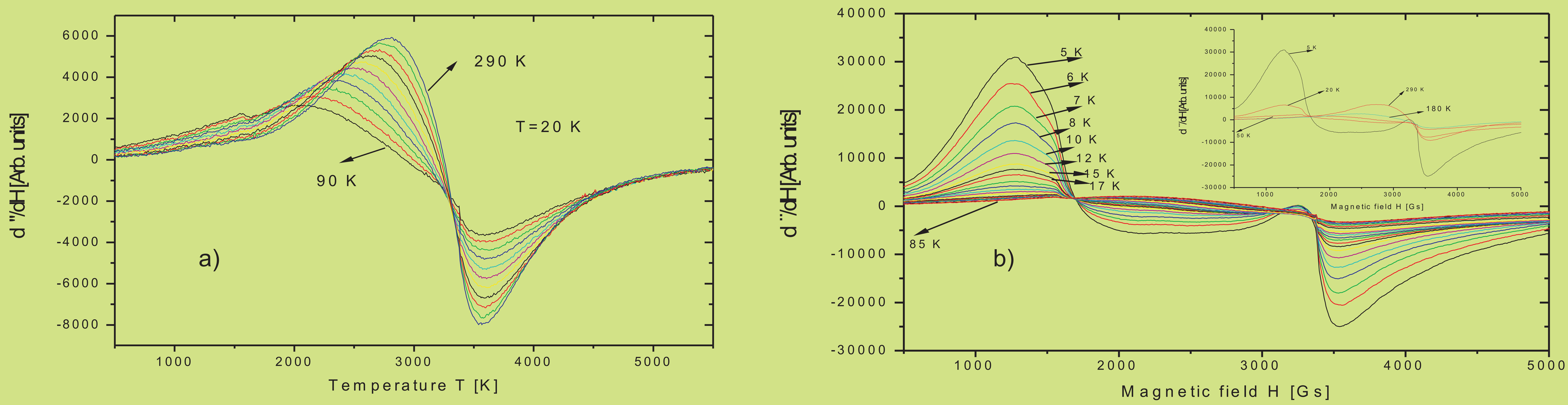

Figure 1. Temperature dependence of the FMR spectra in high temperature (a) and low temperature ranges (b). Inset in (b) shows comparison of FMR spectra at very different temperatures.

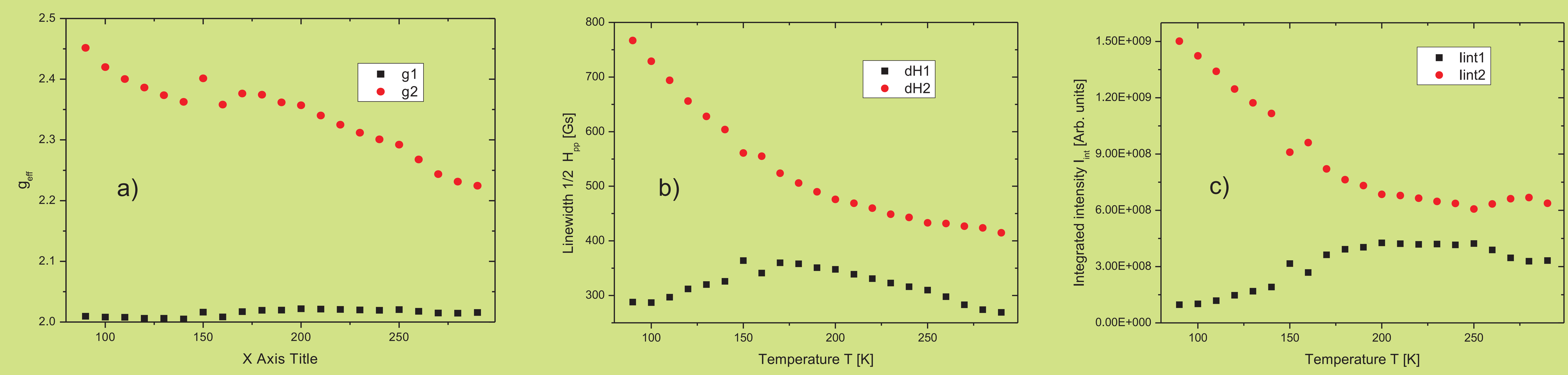

Figure 2 Temperature dependence of the FMR parameters, (a) g_{eff}, (b) linewidth ΔH_{pp} and (b) integrated intensity I_{itegr} (c).

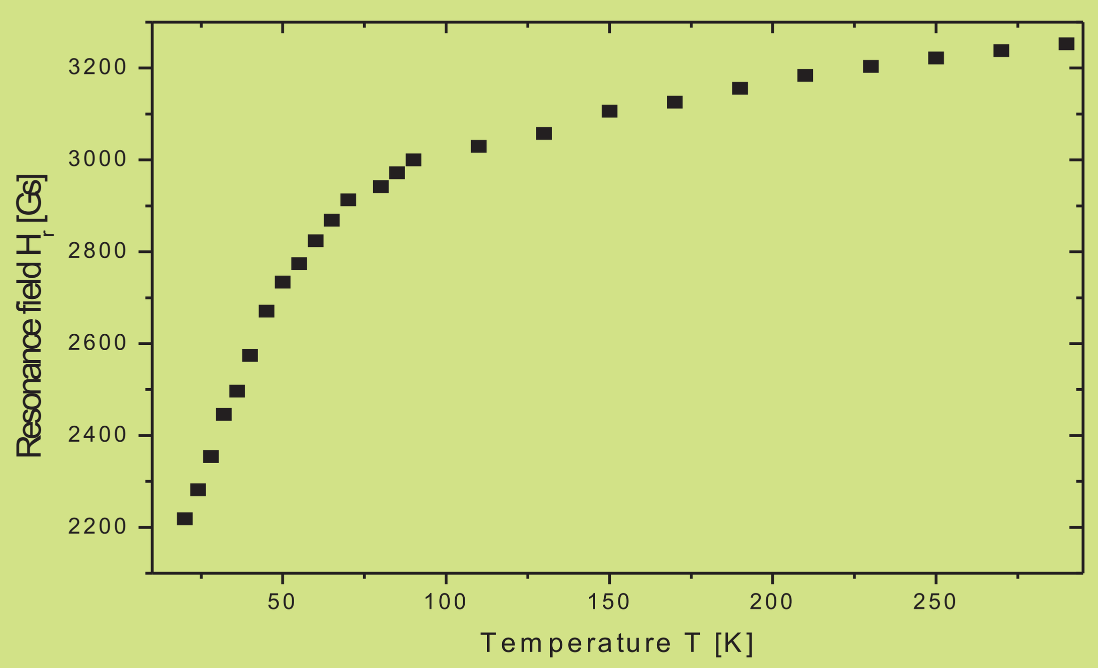

Figure 3 The temperature dependence of the average resonance field.

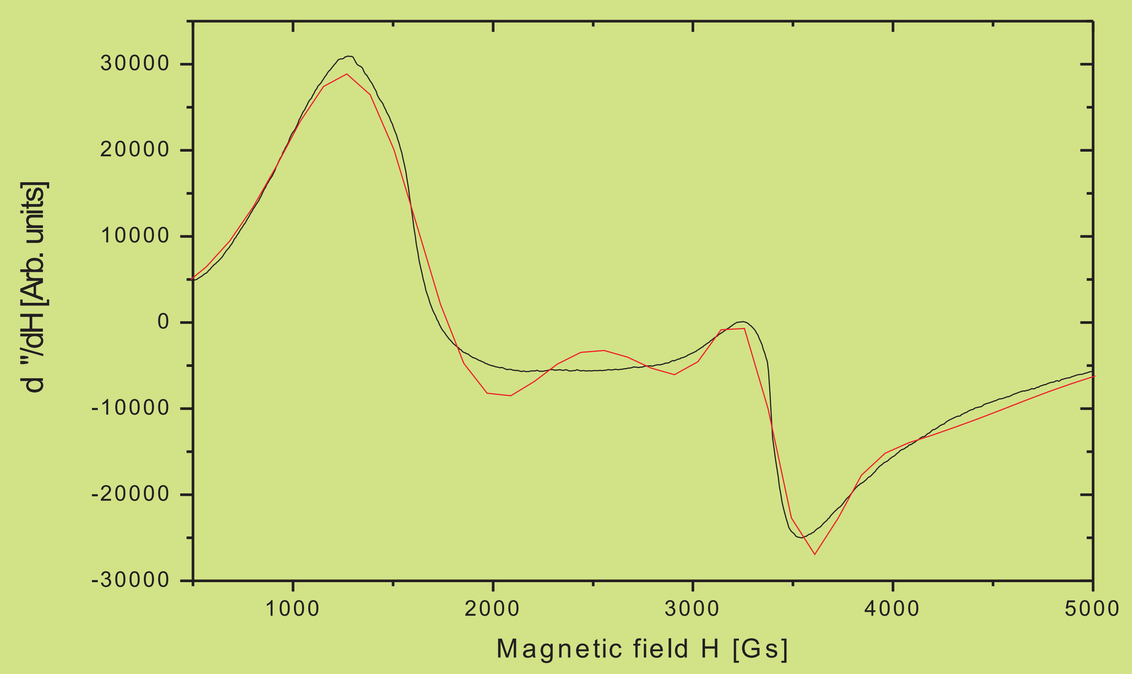

Figure 4 The fitting of magnetic resonance spectra at 5 K.

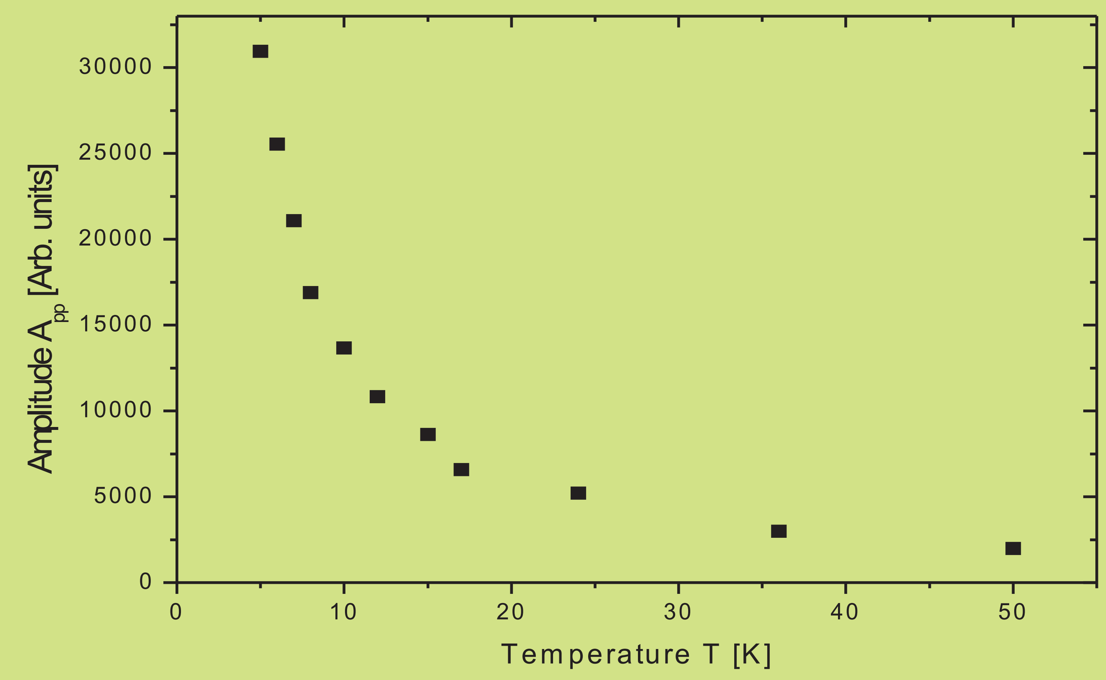

Figure 5 The temperature dependence of the amplitude of EPR spectra of iron ions.