SUPERPARAMAGNETISM IN Ni-Co-Mn-Sn SHAPE MEMORY ALLOYS

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The quaternary shape memory Heusler alloys $Ni_{50-x}Co_xMn_{40}Sn_{10}$ with $5 \leq x \leq 8$, have attracted attention recently because of their interesting properties and potential for technological applications. The materials exhibit low thermal hysteresis at the martensitic (M) transformation at temperature T_M [1]. A discontinuity in the magnetization accompanies the transformation from a ferromagnetic (F) austenite (A) phase for $T > T_M$ to a low magnetization state without long-range order at $T < T_M$. The microscopic nature of the M phase has remained elusive.

In the present experiments ^{55}Mn NMR spin-echo measurements have been made as a function of T in the large *internal* hyperfine fields at ^{55}Mn sites (20 – 50 T) in the M phase for $x = 7$. For comparison, NMR measurements have also been made on $x = 0$ and $x = 14$ alloys. Spectra at 1.6 K for $x = 0$, 7 and 14 alloys with color-coded F and AF components are shown in Fig. 1 while Fig. 2 gives the T-corrected spectral areas for F and AF regions as a function of T.

Information on the magnetic structure of these materials is obtained at the nanoscale. For $x = 7$ and $x = 14$ the incorporation of Co on Ni sites leads to distinct F nanoclusters in a magnetic matrix. The T-dependence of spectral areas is interpreted in terms of a distribution of NMR blocking temperatures linked to the nanocluster size distribution. Similarities in the high frequency spectra for $x = 7$ and 14 suggest that local magnetic variations are due to coexisting A and M regions. The results provide insight into the origins of exchange bias effects in these materials.

[1] K.P. Bhatti, V. Srivastava, D.P. Phelan, S. El-Khatib, R.D. James and C. Leighton in *Heusler Alloys*, edited by A. Hirohata and C. Felser (Springer, 2015).

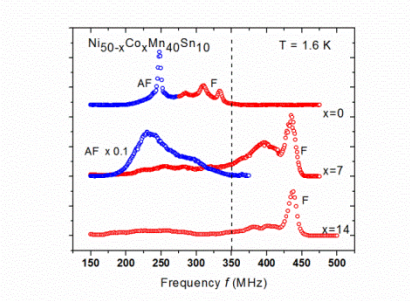

Figure 1. ^{55}Mn NMR (1.6 K) spectra for $x = 0$, 7 and 14 AF (blue) and F (red).

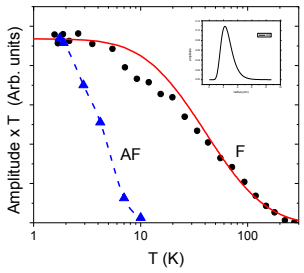

Figure 2. Spectral areas for $x = 7$ as a function of T.

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