MAGNETIC BEHAVIOUR OF Ce (Fe1-xAlx)2 AND Ce (Fe1-xSix)2

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MAGNETIC BEHAVIOUR OF $Ce(Fe_{1-x}Al_x)_2$ AND $Ce(Fe_{1-x}Si_x)_2$

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Abstract. – Small quantities of Al or Si substituted at Fe in $CeFe_2$ lead to a double transition at a temperature lower than the bulk ordering temperature. At the second transition the Fe moments reorient and get locked to produce a state with near zero net magnetization.

$CeFe_2$ is a unique ferromagnet which has a considerably lower values of T_C and μ_B / Fe compared to other isostructural alloys and on substitution of Fe by Co results in the appearance of a second transition with complete loss of magnetization at a temperature T_2 lower than the bulk magnetic ordering temperature T_1 [1]. This transition at T_2 was shown to be associated with a reorientation of Fe moments into presumably a spin glass state [2]. Double transition in this system has also been seen on substitution of Fe by Al or Ru [3, 4]. We report here that Si substitution also results in a similar behaviour thereby suggesting insensitivity of the host to the size and nature of the substituent element.

Samples used were prepared by arc melting stoichiometric amounts of end members, followed by annealing and were characterized by powder X-ray diffraction. Figure 1 shows the χ_{ac} data in Al and Si specimens. The transition temperatures T_1 and T_2 decrease and increase, respectively, with increasing x. Double transition behaviour is visible in 2 and 3.5 % specimens while the 7.5 % specimens show only a composite transition identified by a relatively sharp peak. Figure 2 shows magnetic isotherms using a pulsed field magnetometer in Si specimens at 77 K. The measurement temperature, 77 K, is below T_{peak} of the 7.5 % sample but lies

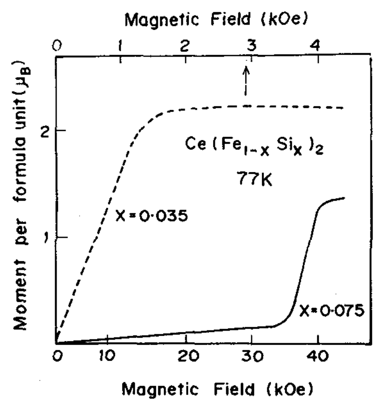

Fig. 2. – *M vs. H* at 77 K for Si samples in a pulsed field of 40 kOe.

in between T_1 and T_2 of the 3.5 % sample. The magnetization saturates at 2 kOe for 3.5 % sample while for 7.5 % sample a meta magnetic transition, like seen in Al samples [5], is observed at ~ 36 kOe.

The ^{57}Fe Mössbauer spectra of all the Al and Si specimens were taken between 300 and 15 K. A quadrupole split doublet was obtained in the paramagnetic state. Figure 3 shows typical spectra at selected tempera-

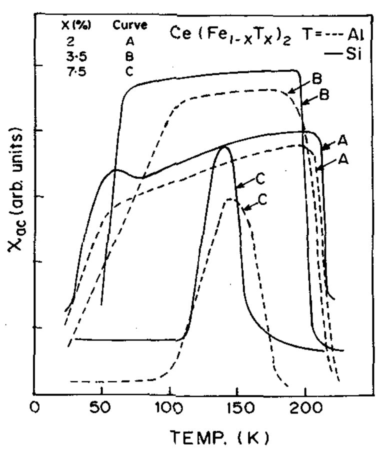

Fig. 1. – χ_{ac} data for Al or Si substituted $CeFe_2$ samples.

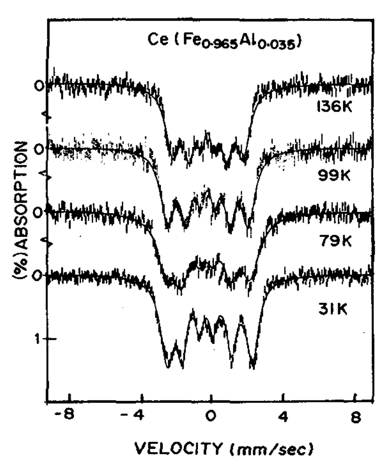

Fig. 3. – Mössbauer spectra of 3.5 % Al sample at selected temperatures.

tures for 3.5 % Al sample above and below T_2. The spectra indicate clearly a change in symmetry at T_2.

The Fe atoms of $CeFe_2$, arranged in tetrahedra in the C15 structure, in general, are not magnetically equivalent. The Mössbauer spectrum below T_1 will therefore be a superposition of several sextets depending on the relative orientation (θ) of the magnetization and the local symmetry axis [2, 4]. The random replacement of Fe by nonmagnetic atoms would introduce a distribution in HF seen by different Fe nuclei, thus, the resultant Mössbauer spectra would be a composite sextet with broad individual lines. It is easy to show that only if the easy axis of magnetization is along any crystallographic directions the composite spectra is a symmetric sextet with $\langle \cos^2 \theta \rangle = 1/3$ [4]. However, if the Fe moments are randomly distributed then $\langle \cos^2 \theta \rangle = 1/2$. We have fitted the spectra in terms of $\langle HF \rangle$ and an average $\cos^2 \theta$ [2, 4] (Fig. 2). The derived value of $\langle HF \rangle$ and $\langle QI \rangle$ are shown in figure 4 for Si specimens. The HF evolves at T_1 and grows smoothly down to the lowest temperature. For the 2 and 3.5 % alloys there is a sudden change in $\langle QI \rangle$ value close to T_2 implying a change in the value of $\langle \cos^2 \theta \rangle$. The derived $\cos^2 \theta$ are $\sim 1/3$ for $T > T_2$ and $\sim 1/2$ for $T < T_2$. In the 7.5 % Si specimen, HF is seen to evolve at T_{peak} and $\cos^2 \theta \sim 1/2$. Similar results were obtained for Al substituted samples.

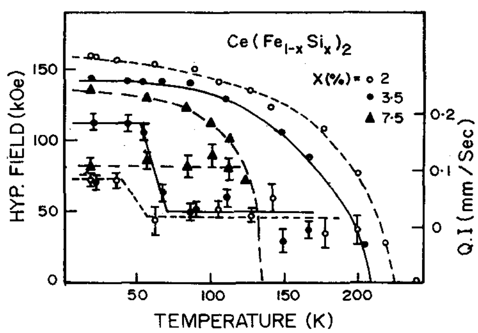

Fig. 4. – $\langle HF \rangle$, $\langle QI \rangle$ *vs.* temperature, $T < T_1$, for Si substituted samples.

Figure 5 shows the variation of $\langle HF \rangle$ at 18 K, the QI above T_1 and the T_1, T_2 values as a function of x in Al and Si specimens. Similar trends have been seen in Ru alloys [4]. It is apparent that the observed changes reflect the universality of the response of the Fe sublattice on substitution in $CeFe_2$ matrix. Neutron studies are desired to elucidate the nature of the nonmagnetic state obtained below T_2.

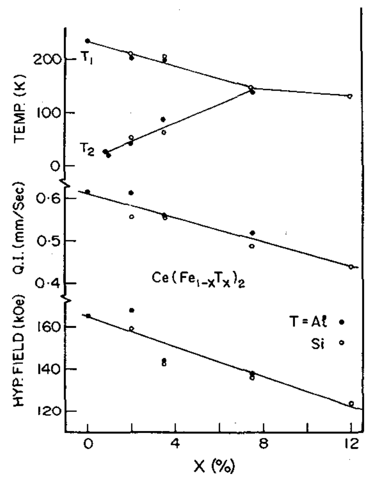

Fig. 5. – $\langle HF \rangle$ at 18 K, QI at 295 K and T_1, T_2 as a function of concentration for Al and Si substituted samples.

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