Comment on "Mechanically Driven Alloying of Immiscible Elements"

In a recent Letter [1] the formation of metastable fcc FeCu solid solution by mechanical alloying has been reported. The authors have studied several physical properties of the system, including the magnetization of a CuFe sample as a function of temperature from 300 to 750 K [Fig. 1(a), reproduced from Fig. 8 in Ref. [1]]. There are three main observations about these magnetic measurements: (1) The metastable fcc FeCu compound has a Curie temperature $T_c = 500$ K. (2) By heating, the metastable phase precipitates bcc Fe with a much higher T_c. (3) The magnetizations of the two states are very similar at 300 K. These observations seem to be in agreement with results obtained in fcc FeCu solid solutions obtained by vapor deposition [2]. In particular the third observation has been explained in [1] using an idea of Chien *et al.* [2]. According to that, the magnetic moment per iron atom in both pure Fe and fcc FeCu have to be equal, because the *d* band of Cu does not overlap the *d* band of Fe and therefore the latter cannot be significantly modified by the former.

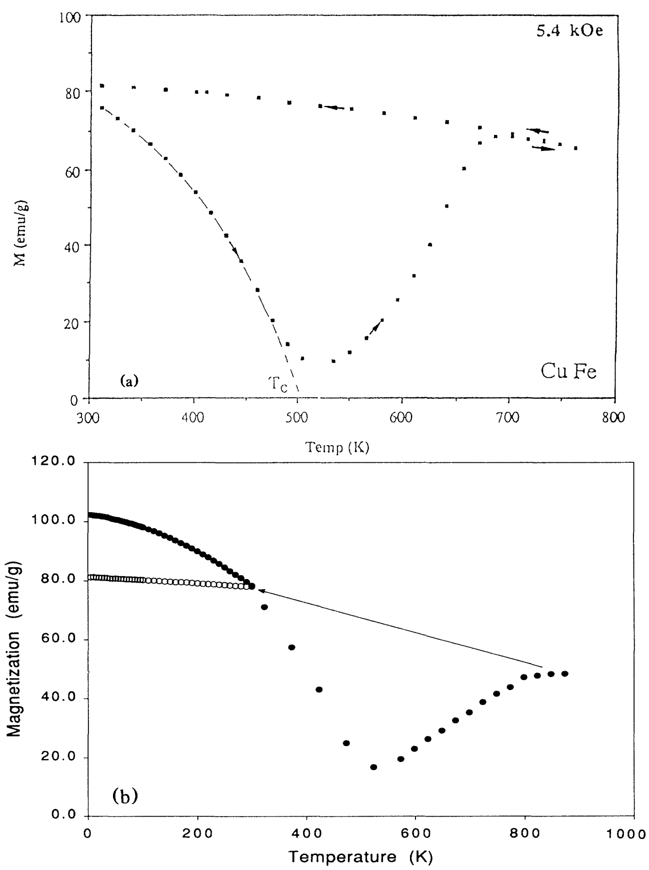

FIG. 1. (a) High temperature magnetization measurements of the alloyed CuFe taken from [1]. (b) Low and high temperature magnetization measurements of a similar alloy (●) showing the crossover at room temperature and the lower magnetic moment (○) after the precipitation of bcc Fe.

However, this is not what the results plotted in Fig. 1(a) indicate. Although the room temperature magnetizations coincide, the magnetization at low T is not the same for the two systems because of the different critical temperatures. Moreover, the state obtained after bcc Fe segregation would exhibit a lower magnetic moment per Fe atom because of the flat temperature dependence of its spontaneous magnetization around room temperature compared with that of the fcc FeCu metastable solution.

In order to resolve this problem we have performed magnetization measurements using a SQUID magnetometer down to 5 K to find the results presented in Fig. 1(b). They show that the bcc Fe phase obtained by heating has, in fact, a 20% lower saturation magnetization than the former fcc FeCu solid solution. The most plausible explanation of this fact is that part of the Fe is not in the bcc form nor in the original fcc solid solution with Cu.

Further experiments have been performed and it can be said that the lack of magnetization is due to the possible formation, in the process of segregation of bcc Fe, of a fraction of either fcc Fe nanoparticles with no magnetic ordering [3] or nonmagnetic Fe atoms giving no contribution to the magnetic moment of the system [4].

In conclusion we have proven that the fact that both fcc FeCu and bcc Fe magnetization agree at 300 K is simply an accident and our data at low temperature show clearly that the Fe contribution after precipitation from the metastable phase has a deficiency in magnetization of at least 20% with respect to the Fe state in fcc FeCu metastable solid solution.

We acknowledge discussions with A. R. Yavari.

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Received 16 February 1993
PACS numbers: 81.30.Hd

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