Magnetic field driving custom-assembly in (FeCo) nanocrystals

Correlation between reentrant ferromagnetism and lattice expansion in FeCuZr alloys

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Magnetic field driving custom assembly in (FeCo) nanocrystals

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We present the possibility of tuning the nanocrystalline microstructure of Co-rich samples by magnetic field annealing. Custom assembly of nucleated grains, aligned in the field direction, has been observed by means of high resolution transmission microscopy. The organized microstructure was obtained on the basis of the appropriate choice of composition, annealing temperature, related to the initial stages of nanocrystallization process, and magnetic field intensity. The linear pattern of the grains has been explained as a consequence of the counterbalance between magnetic, magnetostatic, and magnetocrystalline couplings, only relevant when the nucleation temperature is well below the Curie temperature of the nucleated phase.
[DOI: 10.1063/1.2222254]

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Enhanced magnetic properties of FeCo ribbons nanocrystallized in magnetic field

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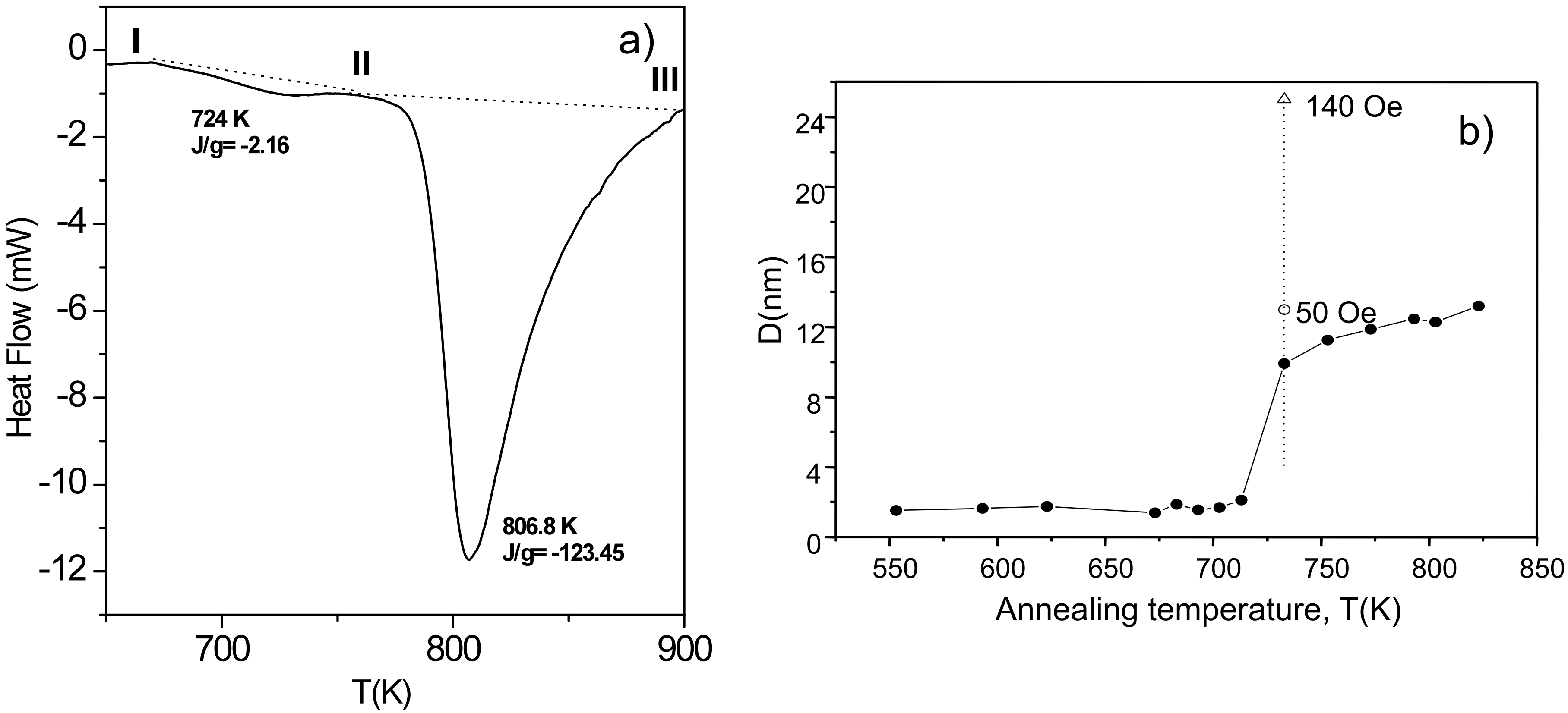
Tailoring the structure of nanocrystalline microstructures is an important step toward controlled design of novel nanostructured materials and devices. We demonstrate how the nanocrystalline microstructure of Co-rich ribbons can be tuned by annealing under magnetic field. The intensity of the field allows controlling different degrees of order at annealing temperatures corresponding to the first stages of the nanocrystallization process. The energy barrier for nucleation is directionally affected by the applied field. The influence of grains assembling on exchange coupling between grains has been analyzed by means of magnetic domains observation and magnetic characterization by means of a hysteresis loop. [DOI: 10.1063/1.3091401]

Keys:

Sample Composition

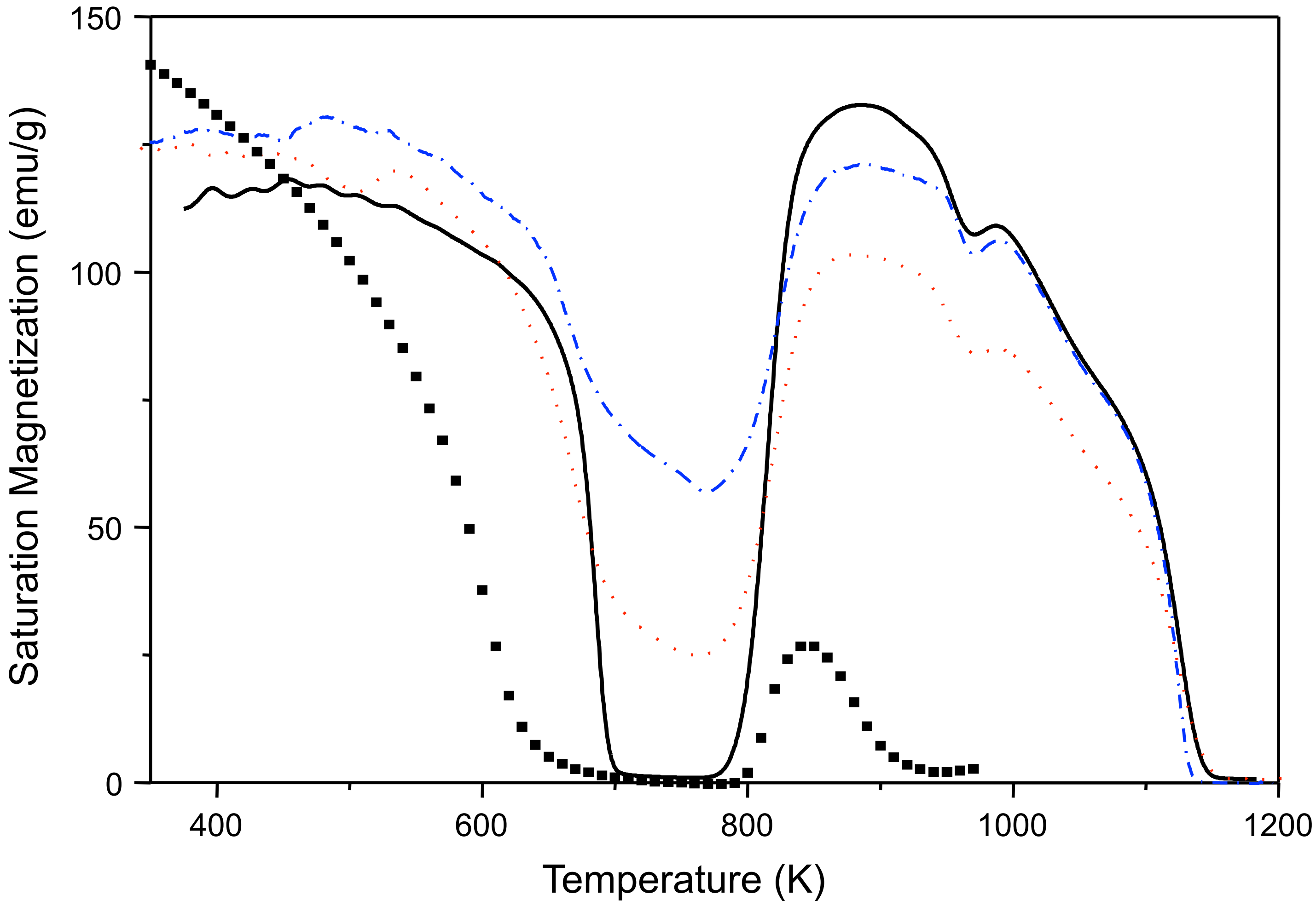
Annealing Temperature

Field intensity

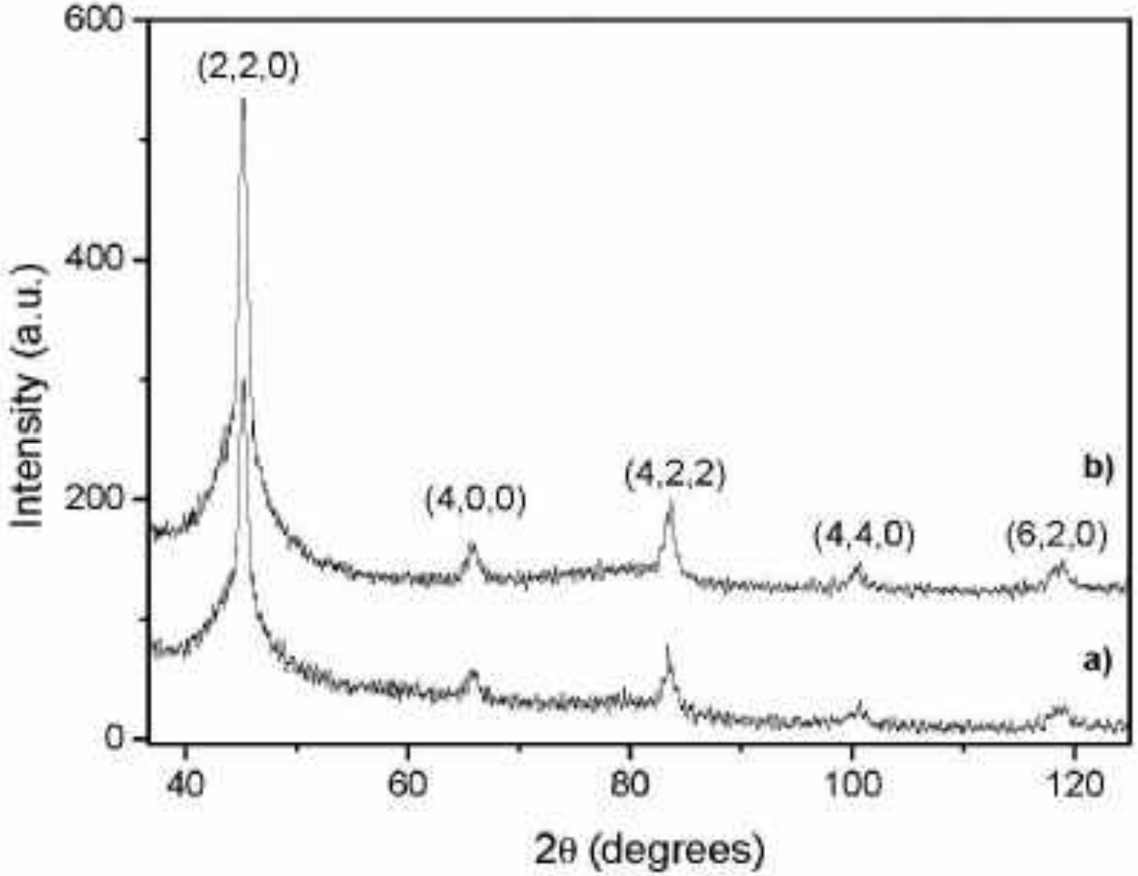


(a) Differential scanning calorimetry of an as prepared $Fe_{28.5}Co_{45}Si_{13.5}Cu_1Nb_3$ sample at a scan rate of 20 K min^{-1}. The areas enclosed by each peak, in units of energy release per gram of sample, are shown in the figure

(b) Grain size evolution with annealing temperature obtained from X-ray diffraction. The observed influence of magnetic field on crystal size at 733 K annealing temperature has been included

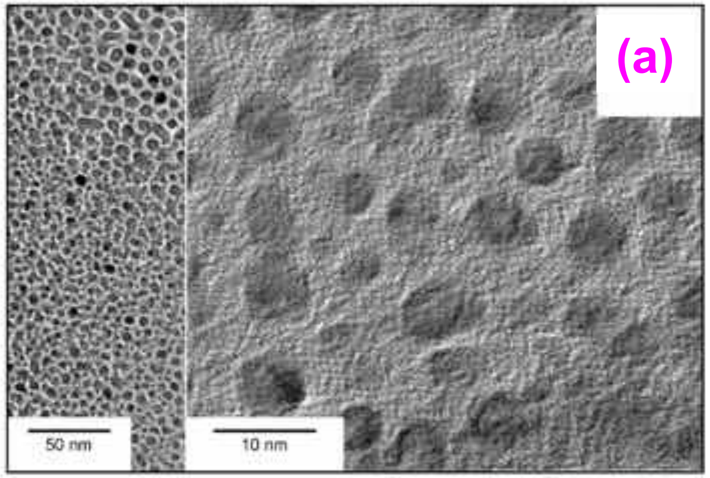


Magnetization under a constant field d.c. versus the measuring temperature for $Co_{45}Fe_{28.5}Si_{13.5}B_9Cu_1Nb_3$: as-cast sample (-) and annealed at 733 K at 0 (---) and 11200 Am^{-1} (.-.-) and $Fe_{73.5}Si_{13.5}B_9Cu_1Nb_3$: as-cast sample (■■)

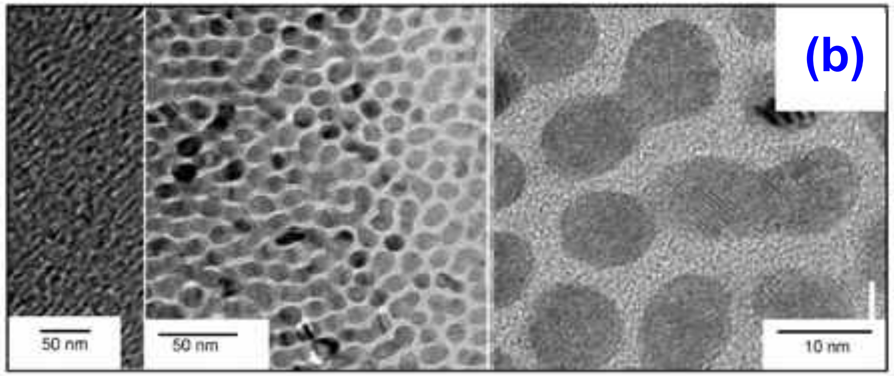


X-ray Diffraction patterns for annealed $Co_{45}Fe_{28.5}Si_{13.5}B_9Cu_1Nb_3$ samples at 773 K: without magnetic field (a) and in the presence of 4000 A/m (b) magnetic field.

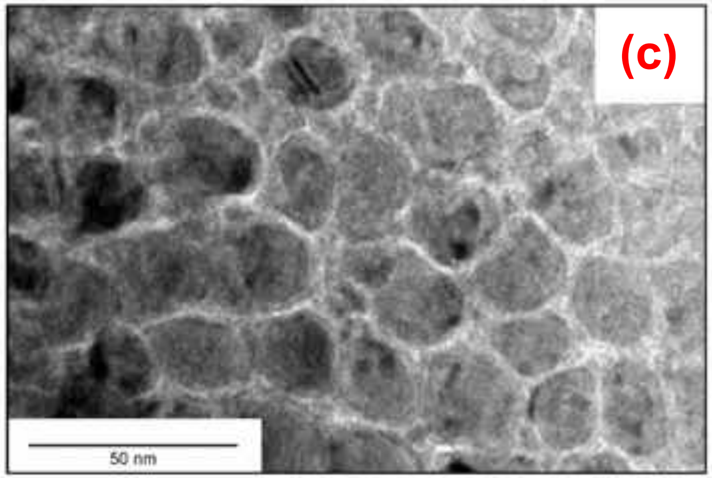
$Fe_{28.5}Co_{45}Si_{13.5}Cu_1Nb_3$ annealed at 733 K



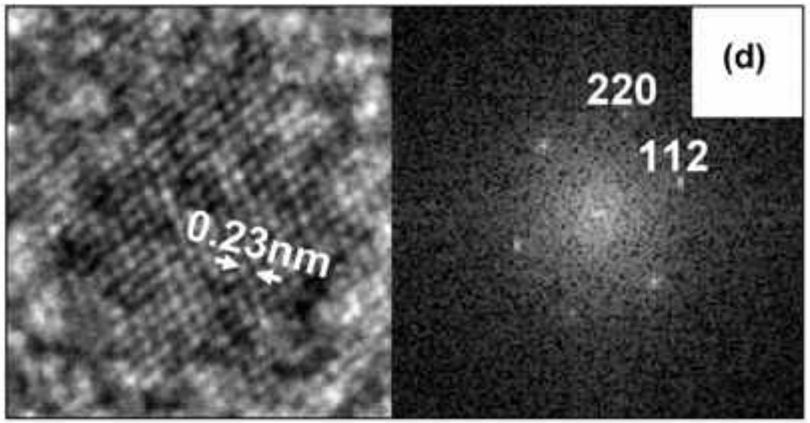
0 A/m



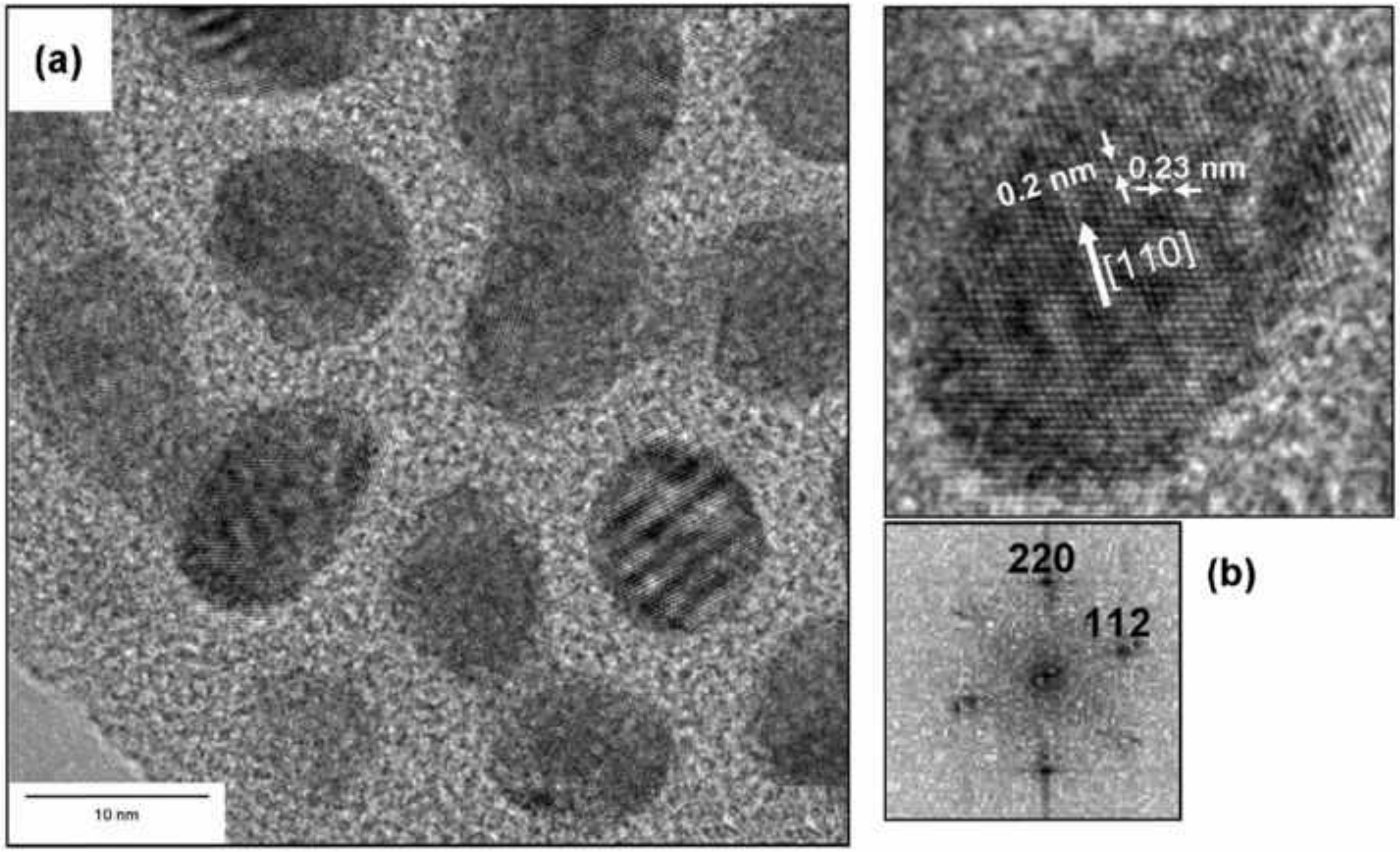
4000 A/m



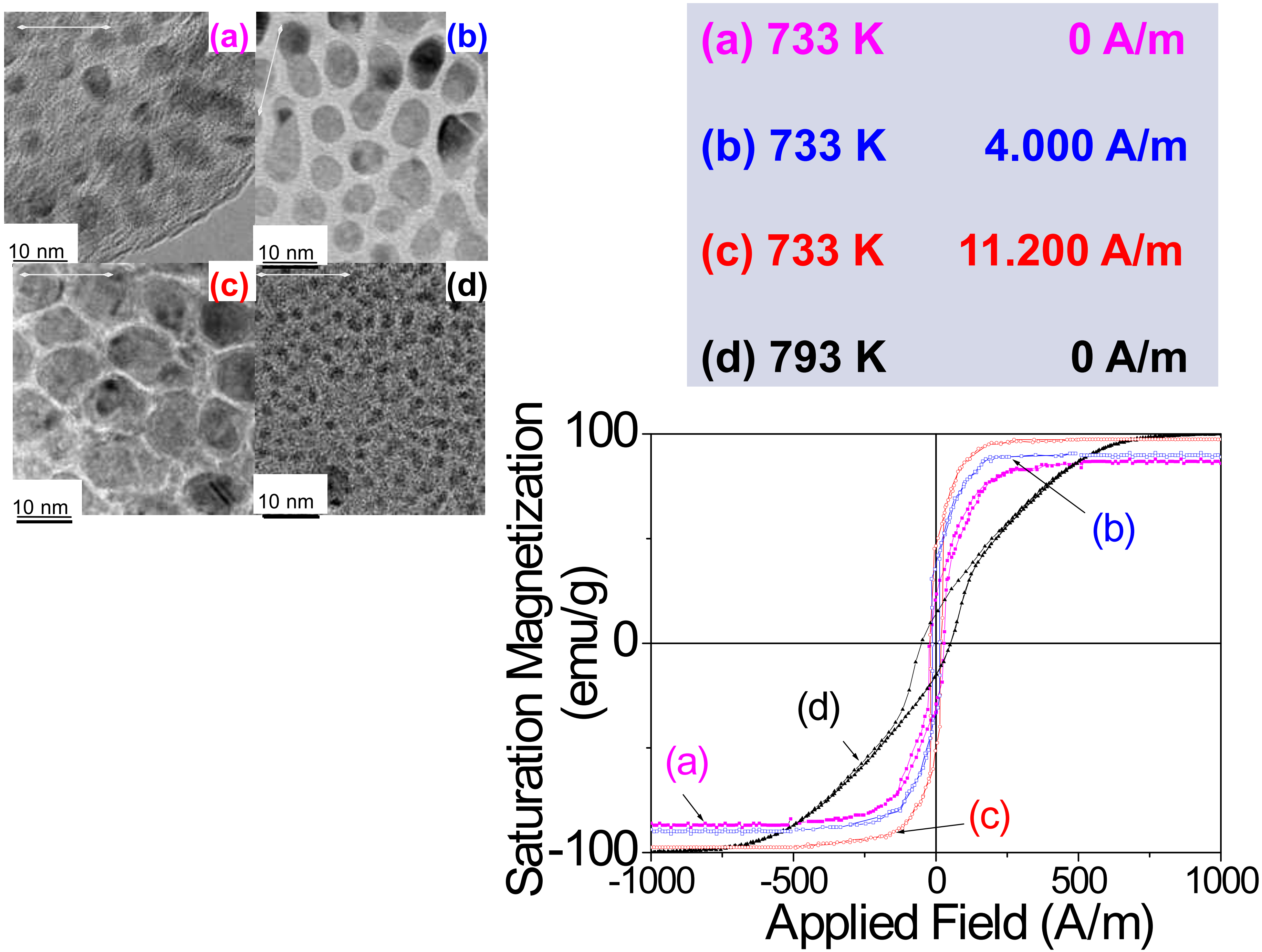
11200 A/m

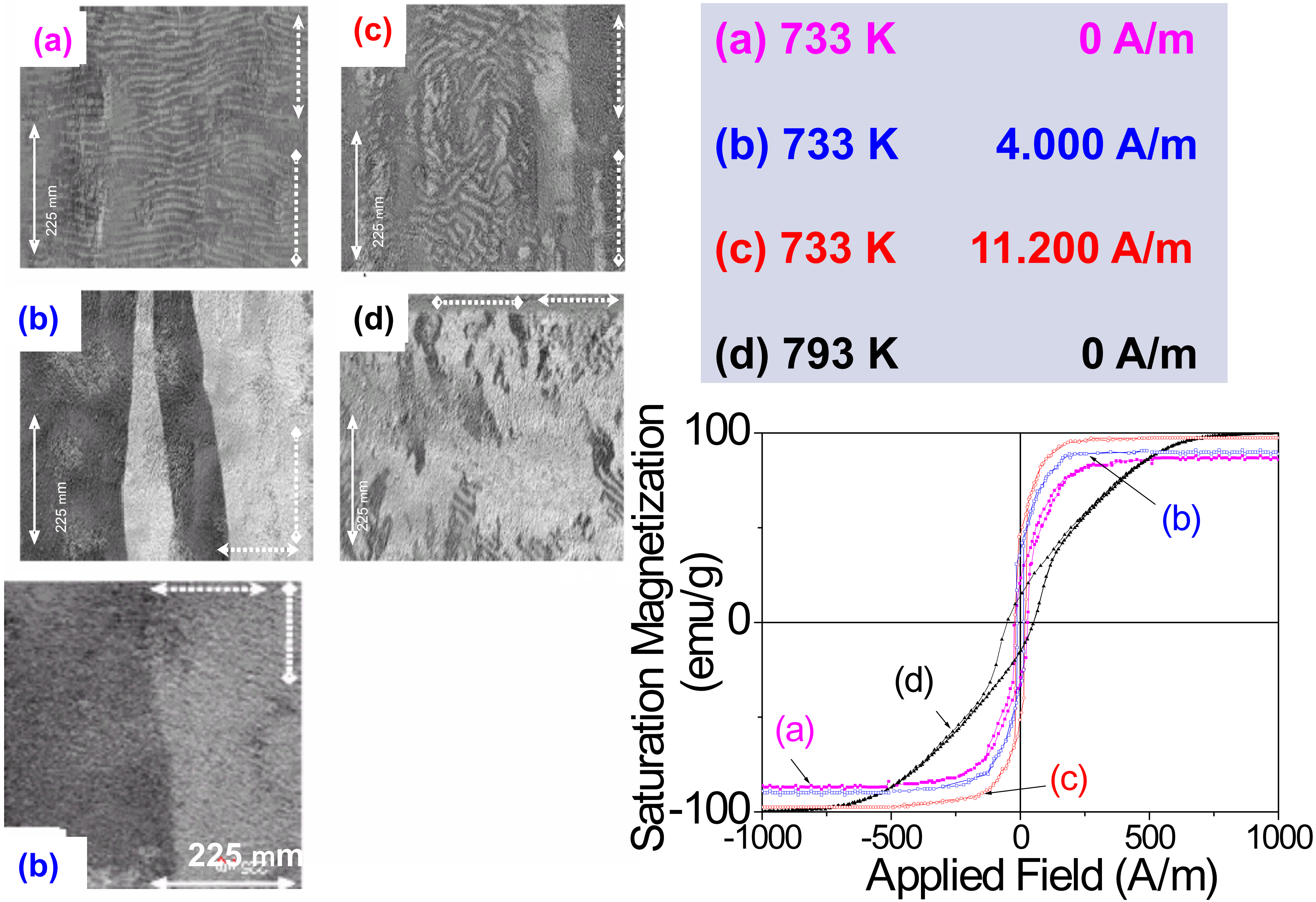


HREM image and its corresponding Fourier Transform (FFT) of a particle of the sample annealed without magnetic field is depicted



HREM micrograph for 733 K annealed $Co_{45}Fe_{28.5}Si_{13.5}B_9Cu_1Nb_3$ sample at 4000 Am-1 (a). An enhanced image of a particle and its corresponding FT along [101] (b) shows the lattice distances and the [110] direction is arrowed.


(a)
(b)
(c)
(d)
10 nm
10 nm
10 nm
10 nm
(a) 733 K 0 A/m
(b) 733 K 4.000 A/m
(c) 733 K 11.200 A/m
(d) 793 K 0 A/m
Saturation Magnetization (emu/g)
100
0
-100
-1000
-500
0
500
1000
Applied Field (A/m)
(a)
(b)
(c)
(d)



(a)
225 mm
(c)
225 mm
(b)
225 mm
(d)
225 mm
(b)
225 mm
(a) 733 K 0 A/m
(b) 733 K 4.000 A/m
(c) 733 K 11.200 A/m
(d) 793 K 0 A/m
Saturation Magnetization (emu/g)
100
0
-100
-1000
-500
0
500
1000
Applied Field (A/m)
(a)
(b)
(c)
(d)

correlation between reentrant ferromagnetism and lattice expansion in FeCuZr alloys

PHYSICAL REVIEW B VOLUME 61, NUMBER 21 1 JUNE 2000-I

Field and temperature dependence of magnetization in FeCu-based amorphous alloys

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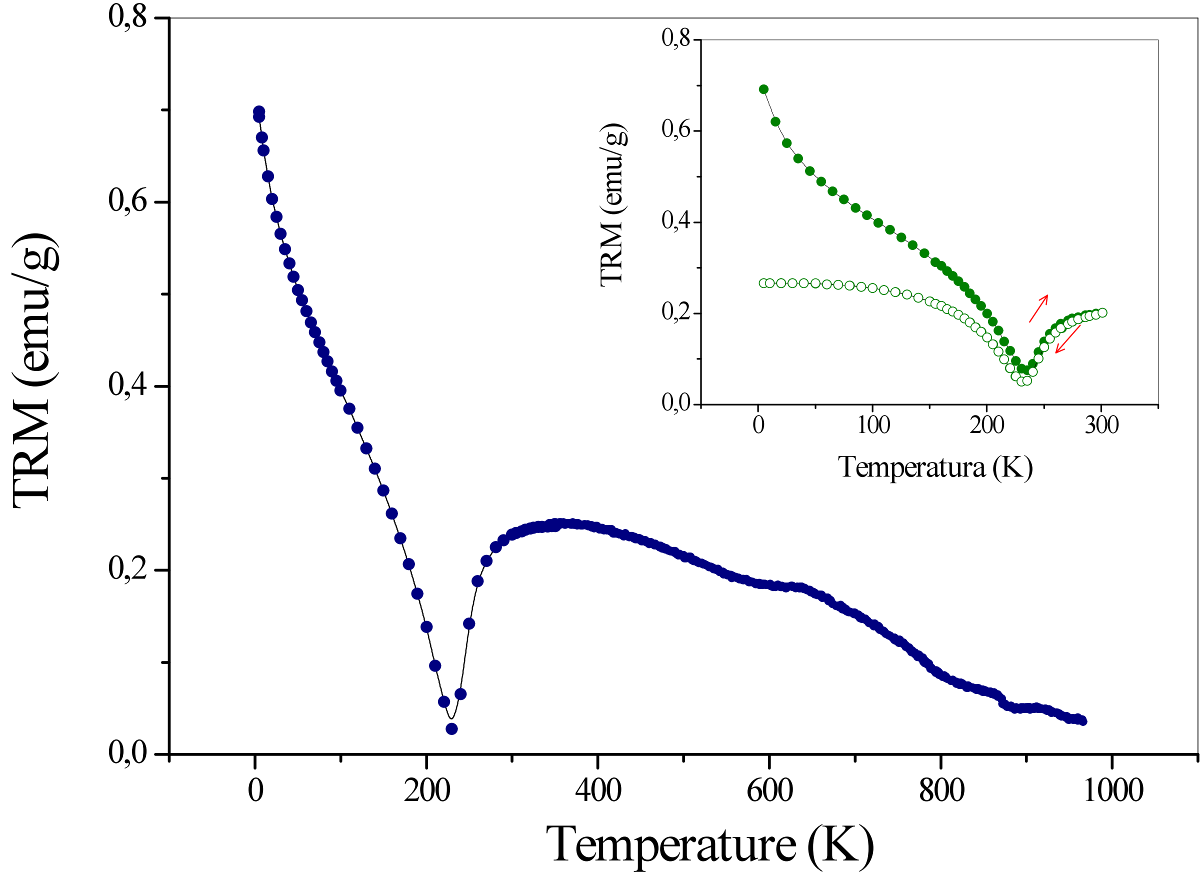
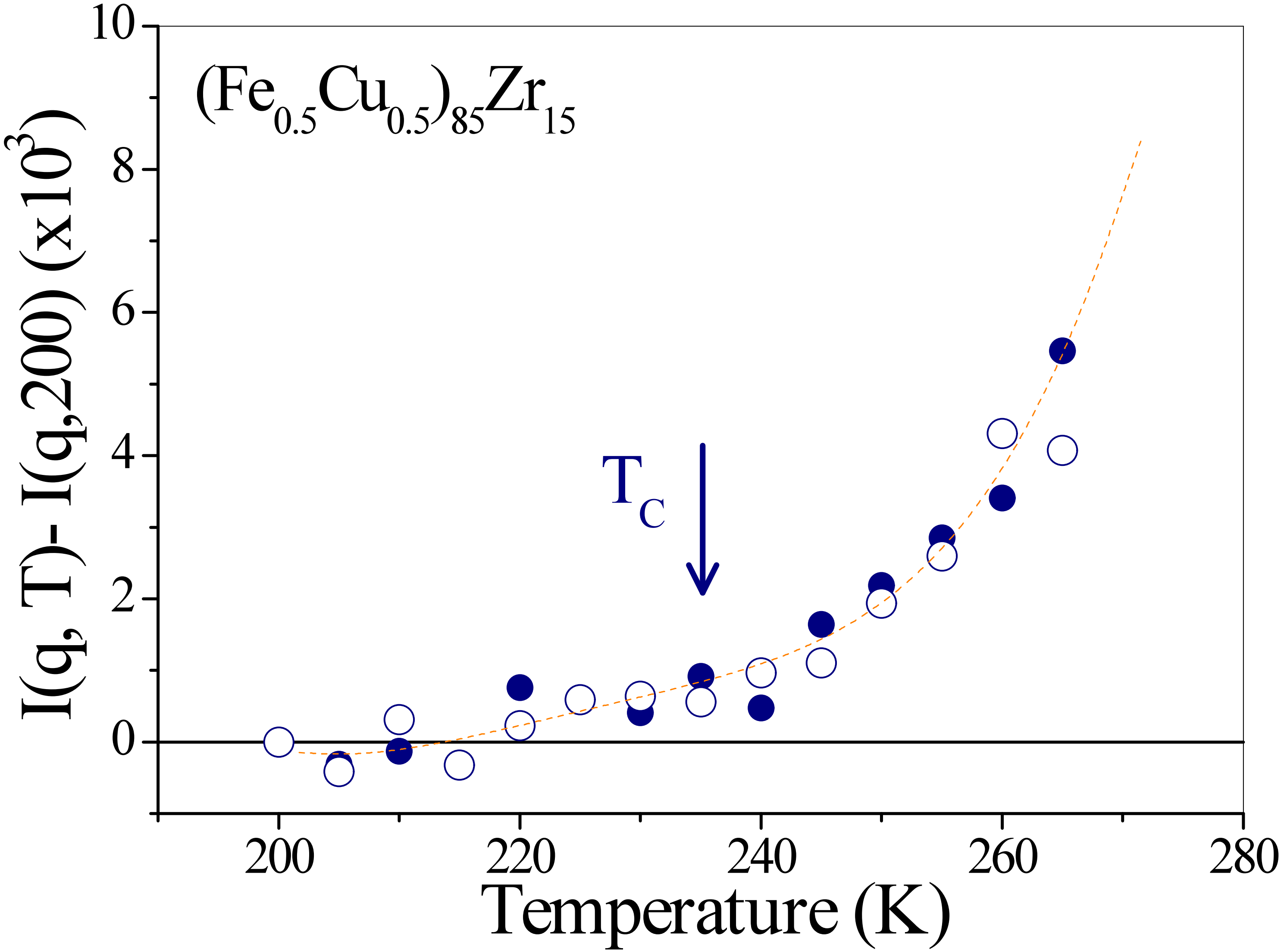
Thermoremanence

- FC (10 Oe)
- TRM is measured as temperature is increased under zero field conditions



- Spontaneous increase of magnetization at T>Tc

Neutron Diffraction



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Direct measurements of the correlation between reentrant ferromagnetism and lattice expansion in FeCuZr alloys

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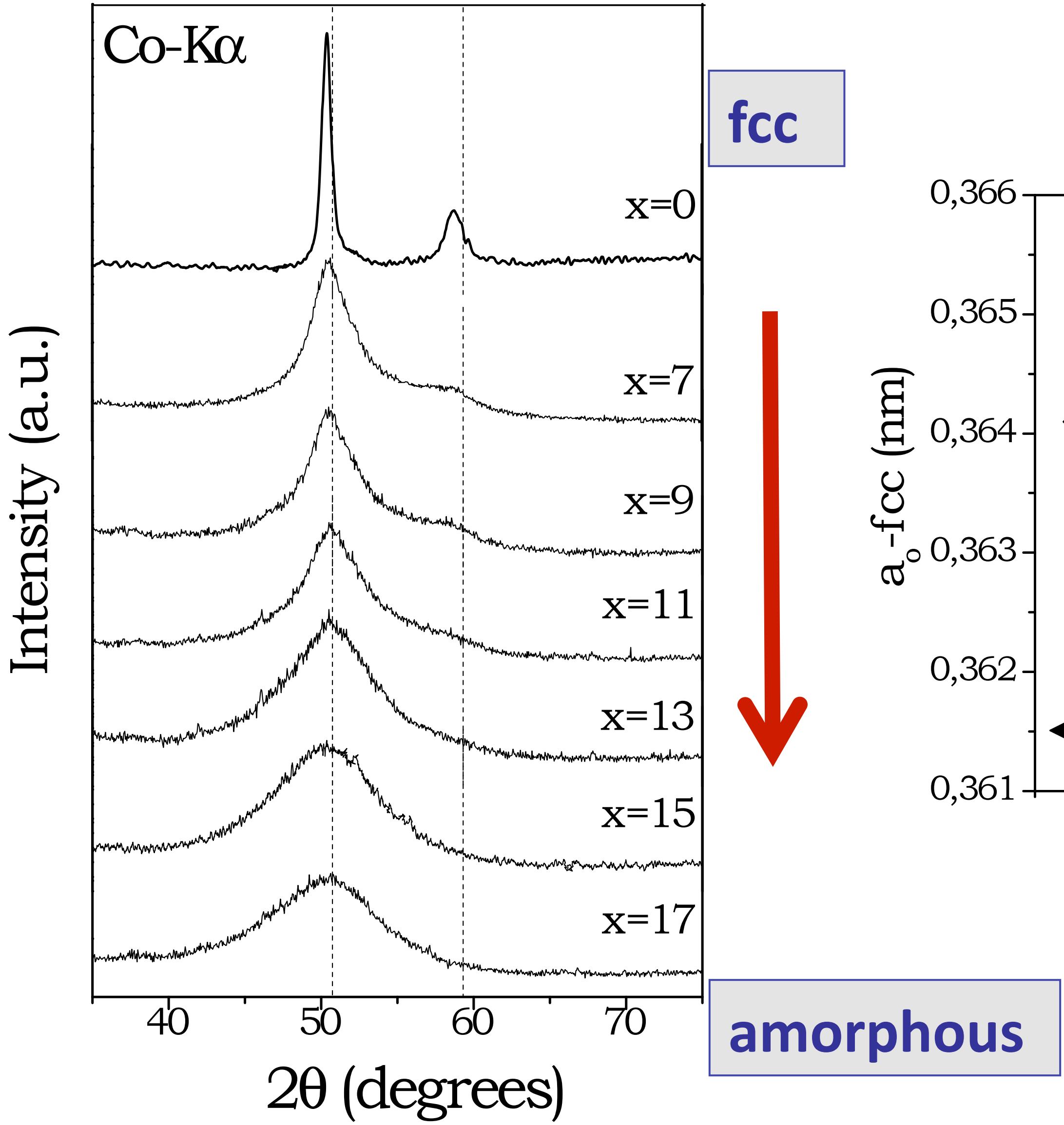
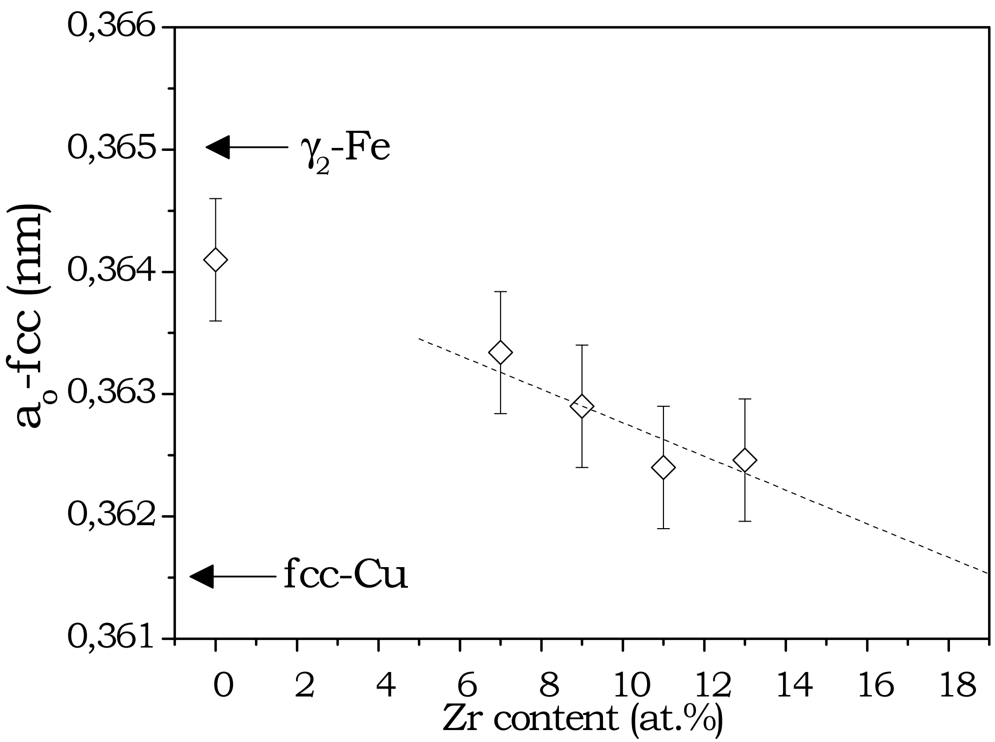
Amorphous metastable alloy of nominal composition $(Fe_{0.5}Cu_{0.5})_{87}Zr_{13}$ has been synthesized by high-energy ball milling. The alloy exhibit a ferromagnetic behavior with a Curie Temperature of T_C=255 K, as determined from low-field measurements whereas no transition to a paramagnetic state is observed under high-enough applied magnetic fields. The evolution of hysteresis loops with temperature as well as thermoremanence measurements indicate an anomalous magnetic behavior characterized by a spontaneous increase in the magnetization values as well as by a magnetic hardening when the temperature is increased above T_C. These effects are strongly correlated with a dilation of the Fe-Fe nearest-neighbor distances, as determined from extended x-ray absorption fine structure (EXAFS) studies. EXAFS results indicate an almost negligible thermal expansion at temperatures below T_C while normal thermal expansion takes place at higher temperatures. Such expansion seems to promote a reinforcement of the ferromagnetic interactions among Fe-Fe atoms that would account for the observed spontaneous increase in the magnetization as well as for the evolution of the coercive field.

$(Fe_{0.5}Cu_{0.5})_{100-x}Zr_x$ ($0<x<30$ at.%) alloys

- High energy ball milling in a planetary device (Ar atmosphere)
  - Starting materials: Powders of Fe, Cu and Zr
  - Milling time: 120 h
- Characterization
  - X-ray diffraction, Co-Ka
  - Mössbauer Spectroscopy
  - SQUID magnetometer

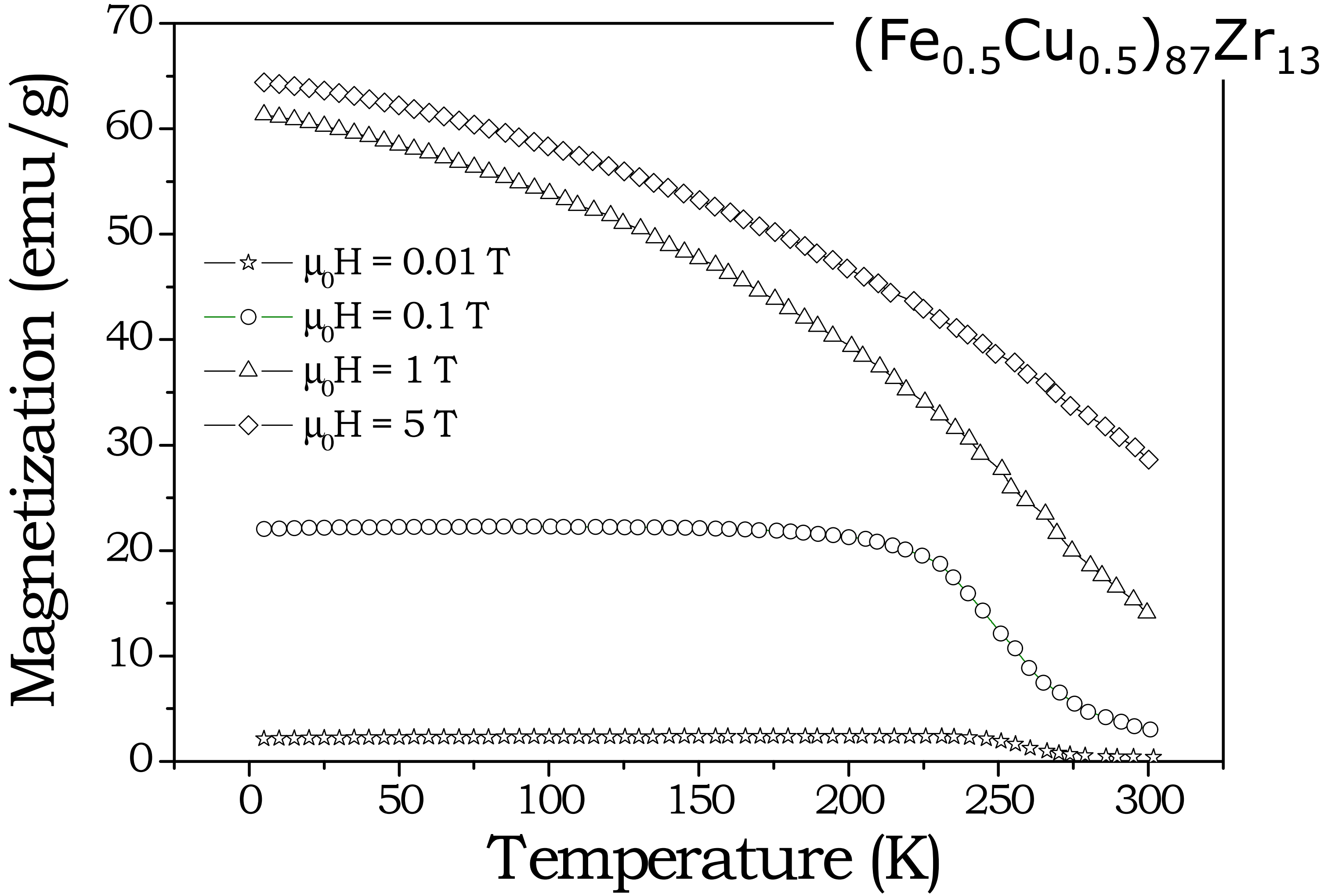
XRD


Co-Kα
x=0
x=7
x=9
x=11
x=13
x=15
x=17
Intensity (a.u.)
40
50
60
70
2θ (degrees)
fcc
amorphous

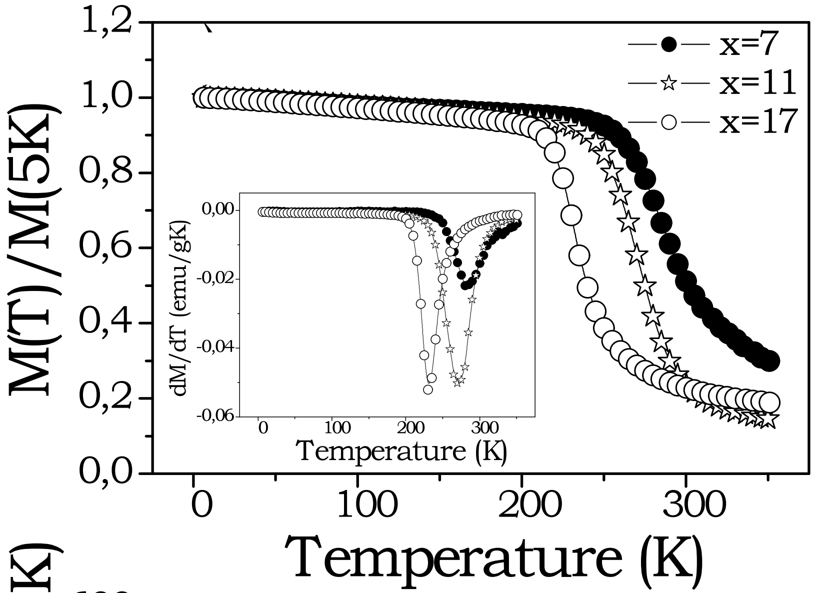

0,366
0,365
0,364
0,363
0,362
0,361
a_o-fcc (nm)
γ_2-Fe
fcc-Cu
0
2
4
6
8
10
12
14
16
18
Zr content (at.%)

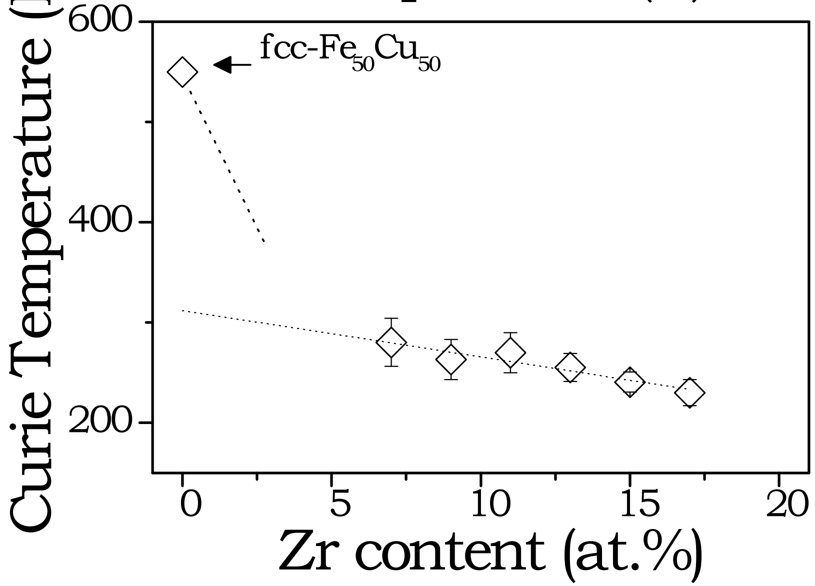
Thermal dependence of the magnetization

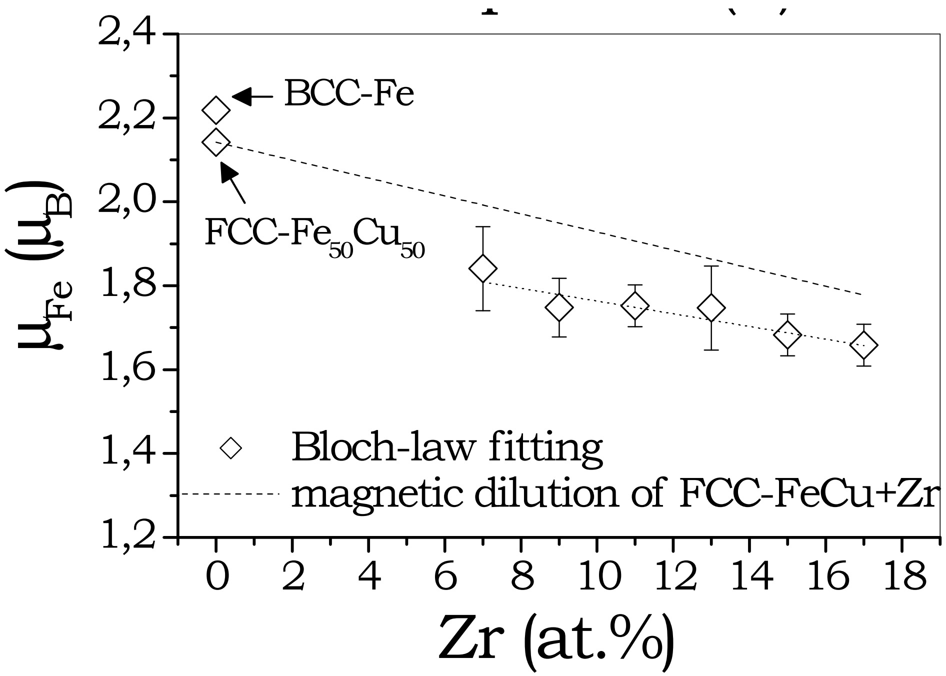
- Strong dependence of the Curie Temperature with the applied field: shift of Tc in at least 50K



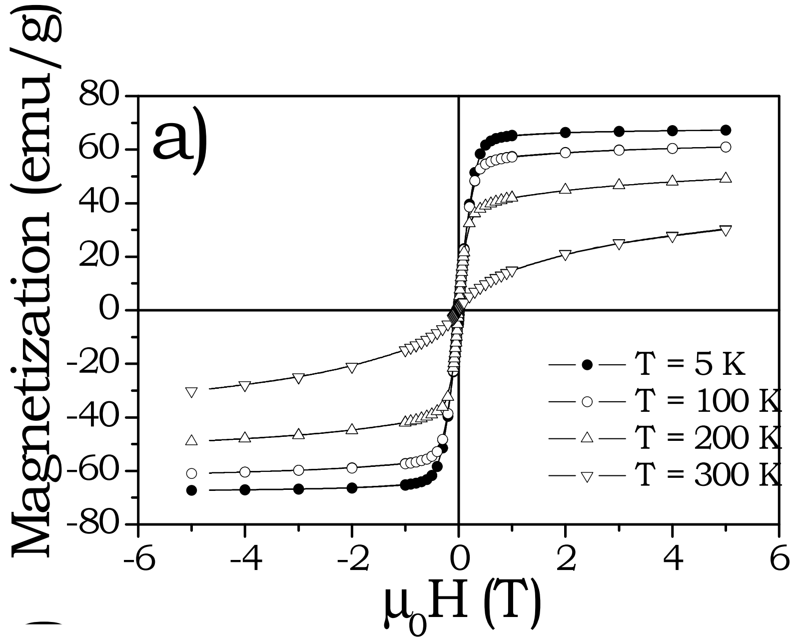
Magnetic behavior



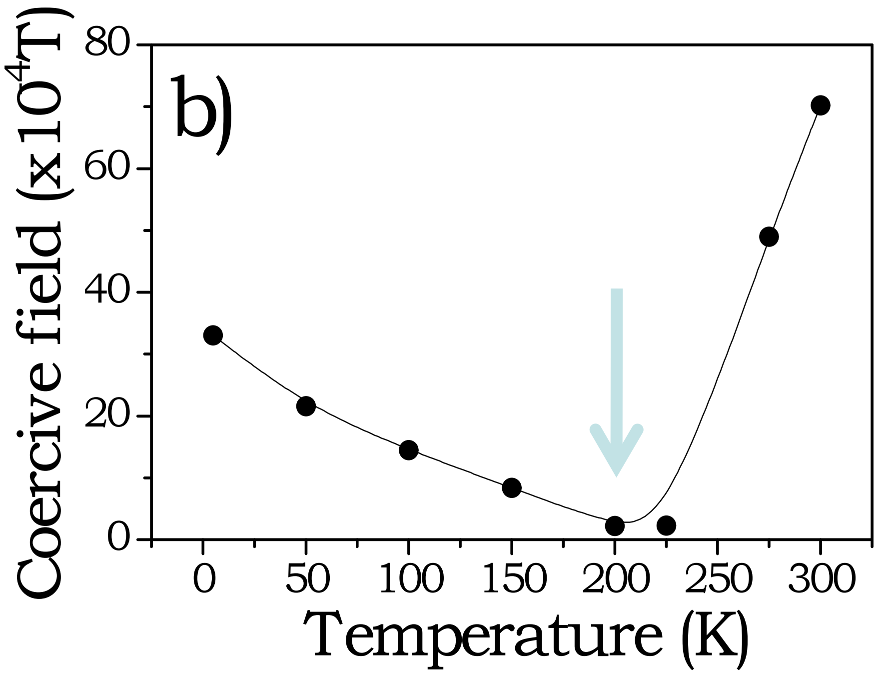




Hysteresis loops & coercive field

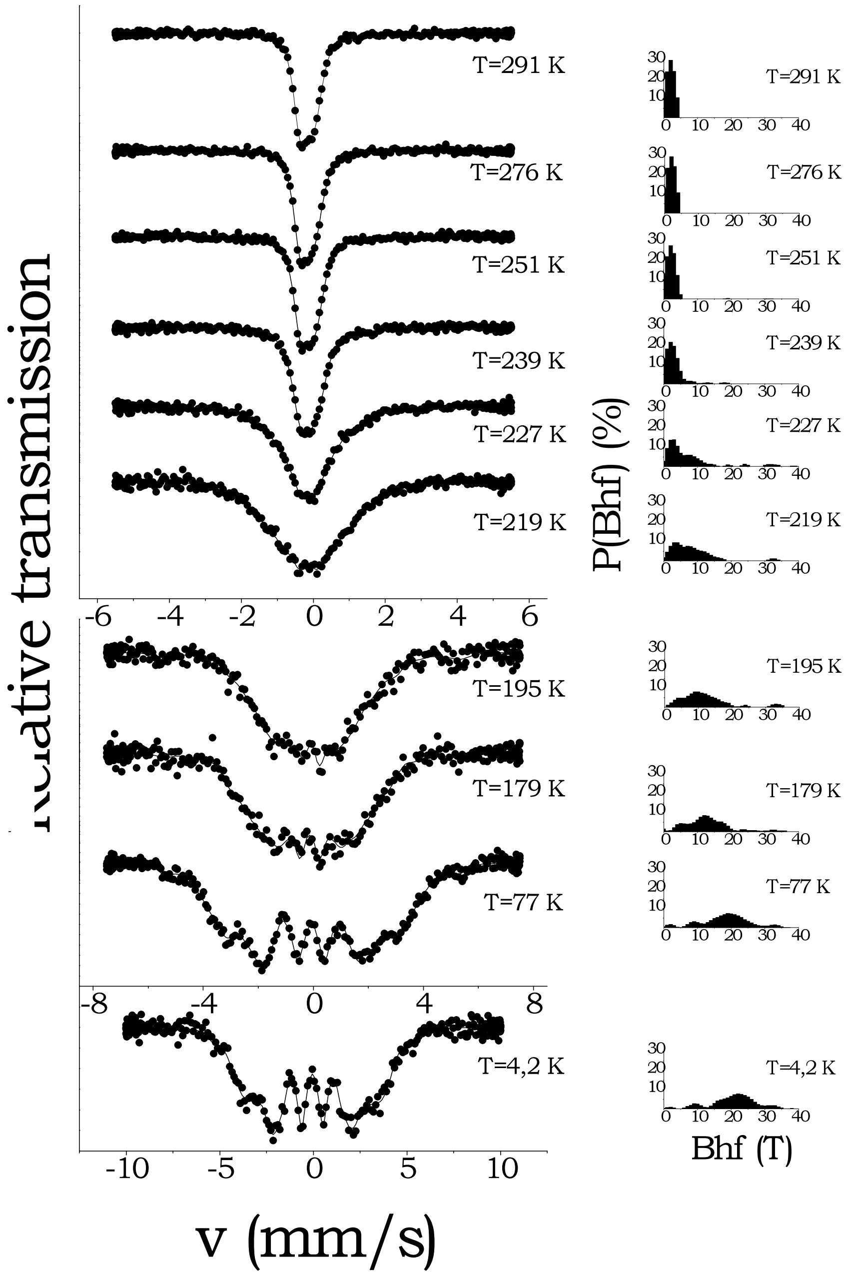


Anomalous thermal dependence of coercive field above Tc



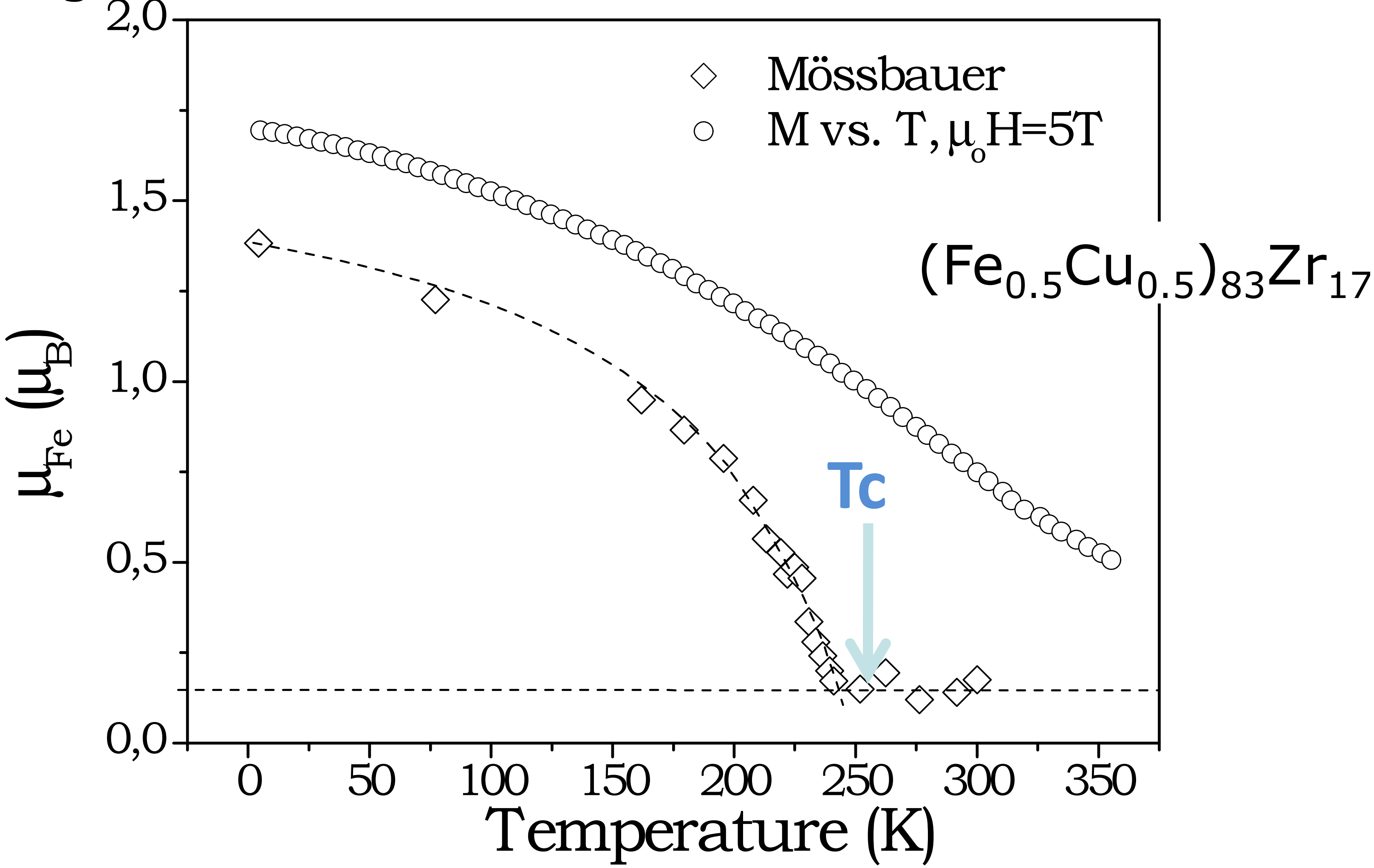
Low T Mössbauer spectroscopy

$(Fe_{0.5}Cu_{0.5})_{83}Zr_{17}$

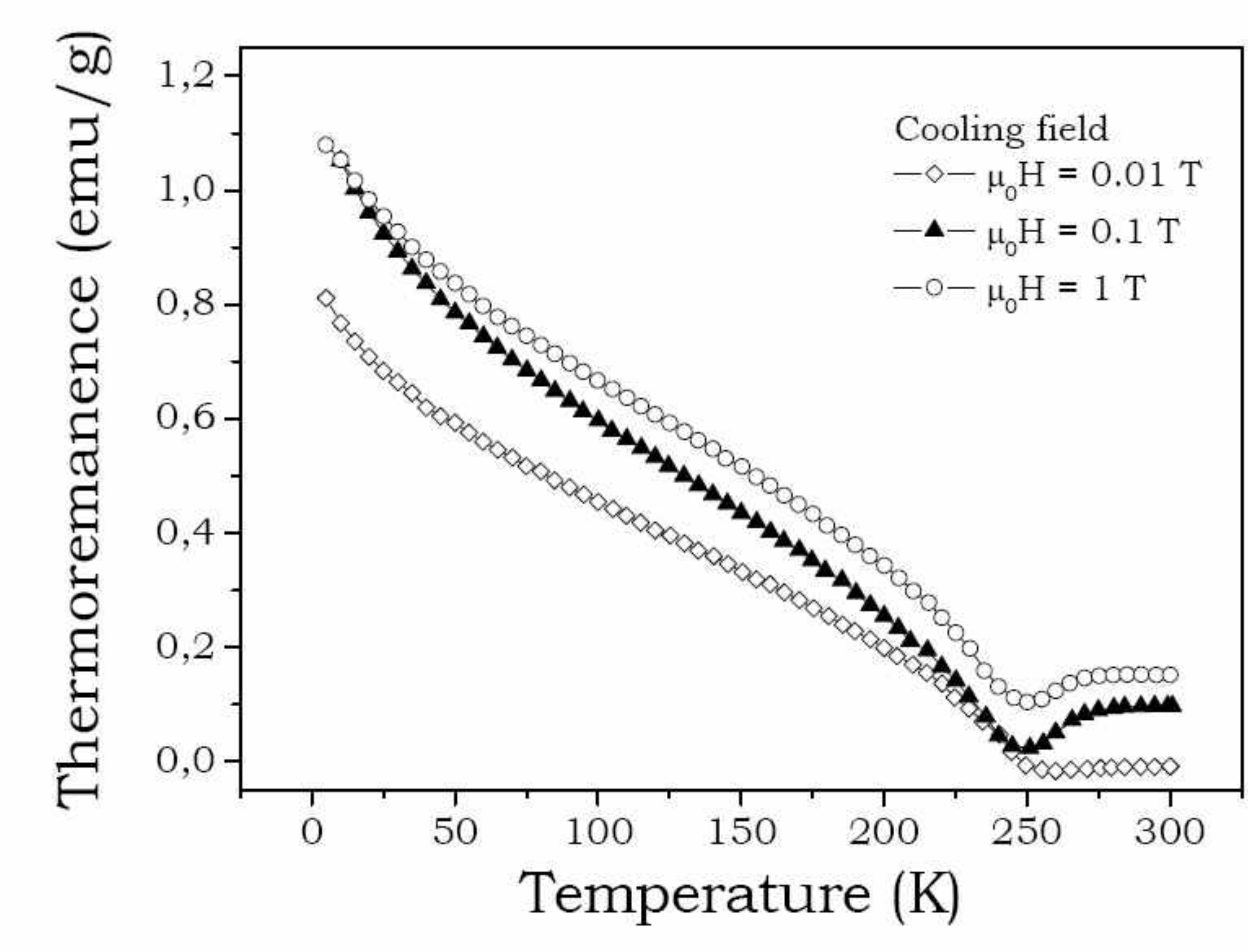


Low T Mössbauer spectroscopy

- Enhancement of mFe by applying high enough magnetic fields

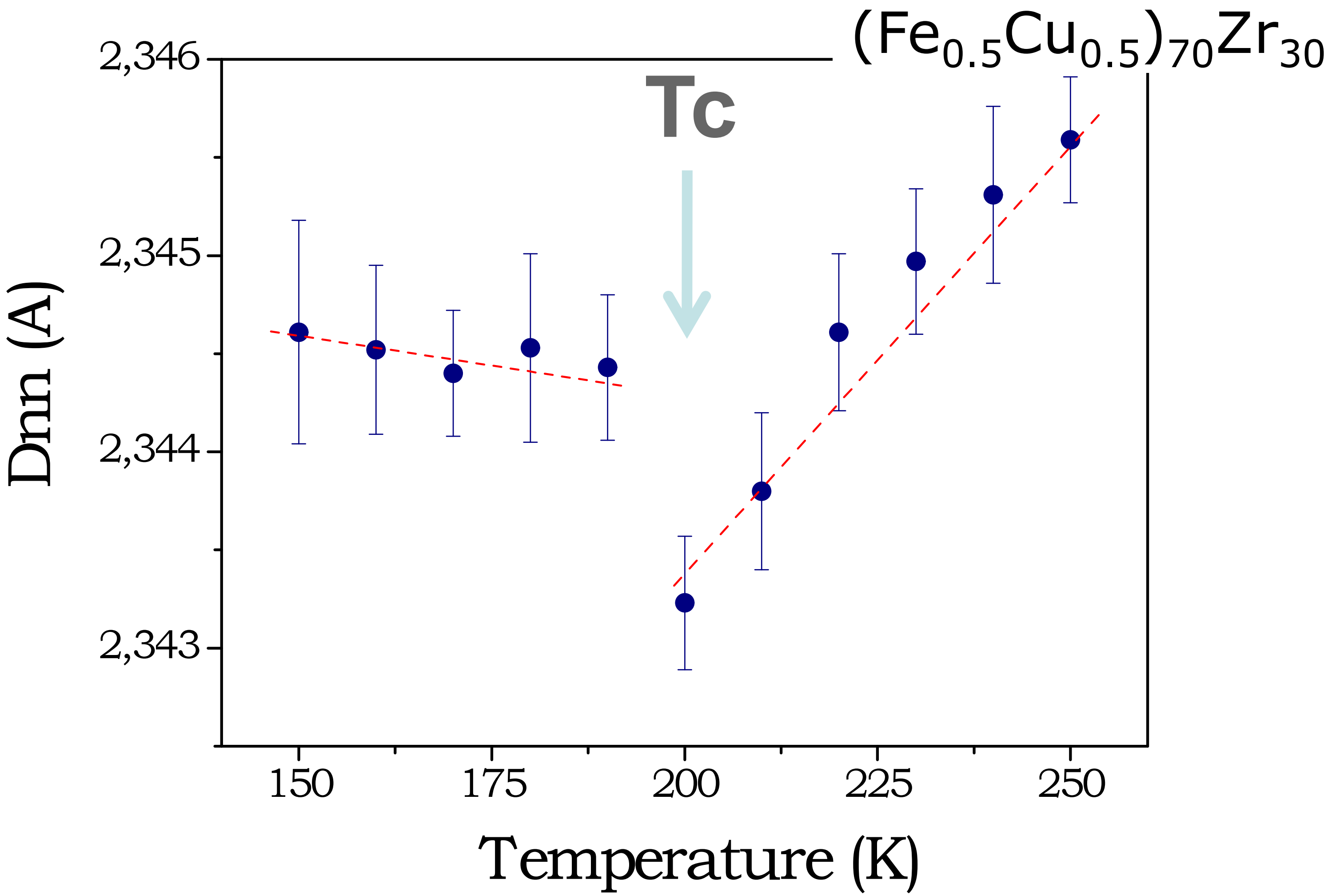


Thermoremanence



EXAFS

- Determination of Fe-Fe nearest neighbours distances



EXAFS

- Correlation between Fe-Fe NN distances&enhancement of magnetization

$(Fe_{0.5}Cu_{0.5})_{87}Zr_{13}$