



7th International Colloquium
on
**Mössbauer Spectroscopy
in Materials Science**
Kočovce, Slovakia
June 11-15, 2006



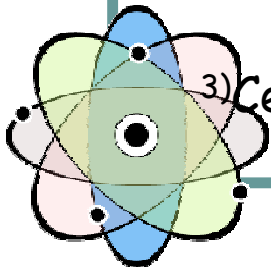
Influence of Composition on Hyperfine Interactions in FeMoCuB Nanocrystalline Alloys

M. Miglierini^{1,3}, T. Kaňuch¹, M. Pavúk¹, P. Švec²,
D. Janičkovič², M. Mašláň³ and R. Zbořil³

¹Slovak University of Technology, Bratislava, Slovakia

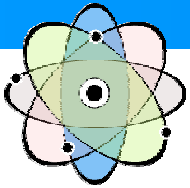
²Slovak Academy of Sciences, Bratislava, Slovakia

³Center for Nanomaterial Research, Olomouc, Czech Republic



Katedra jadrovej fyziky a techniky

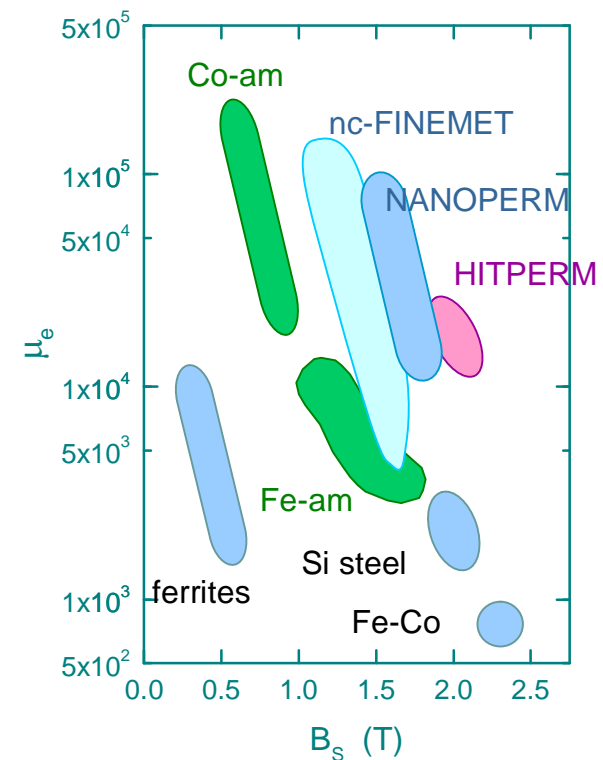
Nanocrystalline Alloys - Features

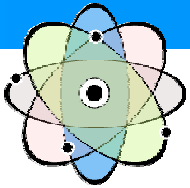


- two-phase structural and magnetic behaviour
- high saturation magnetization and permeability

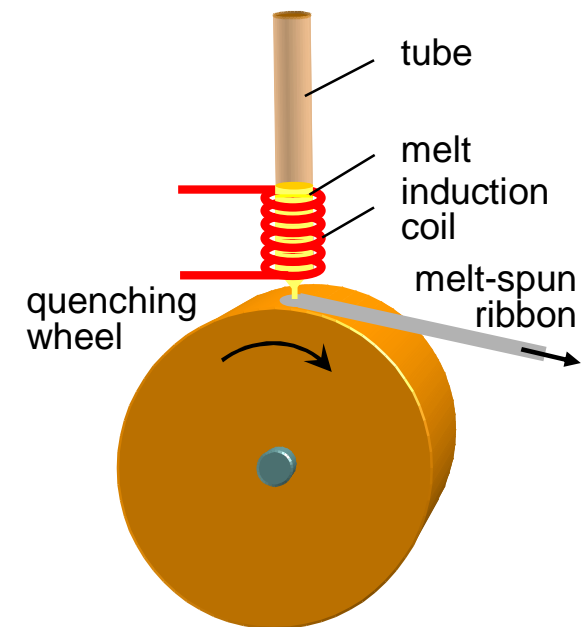
- FINEMET: Fe-Cu-Nb-Si-B
- NANOPERM: Fe-Zr-(Cu)-B
- HITPERM: Fe-Co-Zr-(Cu)-B

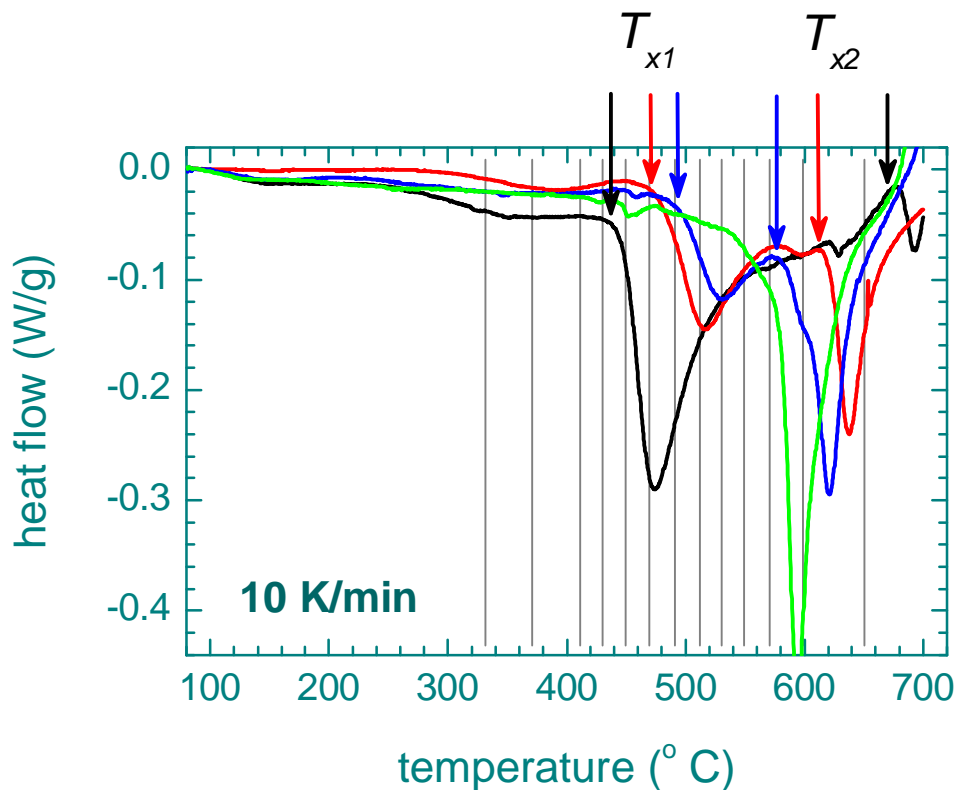
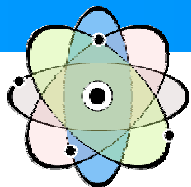
- nanocrystalline grains
 - origin of soft magnetic properties
 - thermal stabilization of the structure



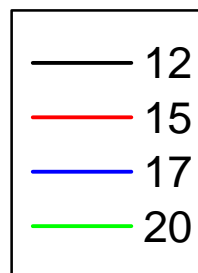


- influence of Fe/B ratio on hyperfine interactions in nanocrystalline NANOPERM-type alloys
- system: $\text{Fe}_{91-x}\text{Mo}_8\text{Cu}_1\text{B}_x$: $x = 12, 15, 17, 20$
 - planar-flow casting
 - ribbons: 6-8 mm wide, 20 μm thick
 - annealing in vacuum \rightarrow nanocrystalline
- experimental methods:
 - DSC
 - XRD
 - TEM, HREM
 - Mössbauer spectrometry
 - TMS, CEMS
 - AFM, MFM





x



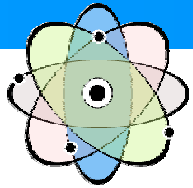
x ↑↑ T_{x1}

x ↑↓ T_{x2}

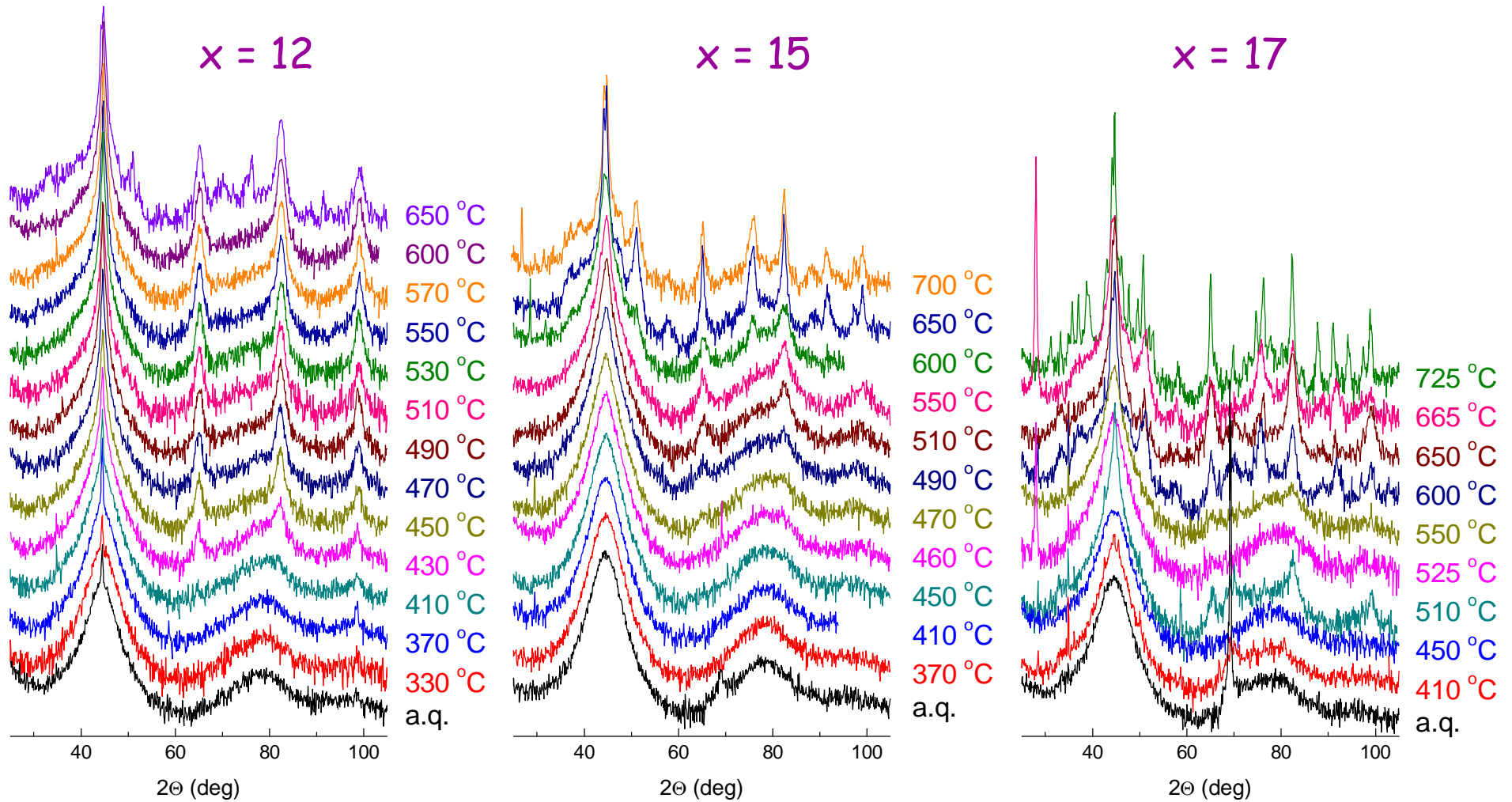
x	12	15	17	20
T_{x1} (°C)	436	470	490	550
T_{x2} (°C)	670	612	576	550

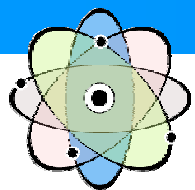
Illeková *et al.*, *JMMM* 304 (2006) e636

X-Ray Diffraction

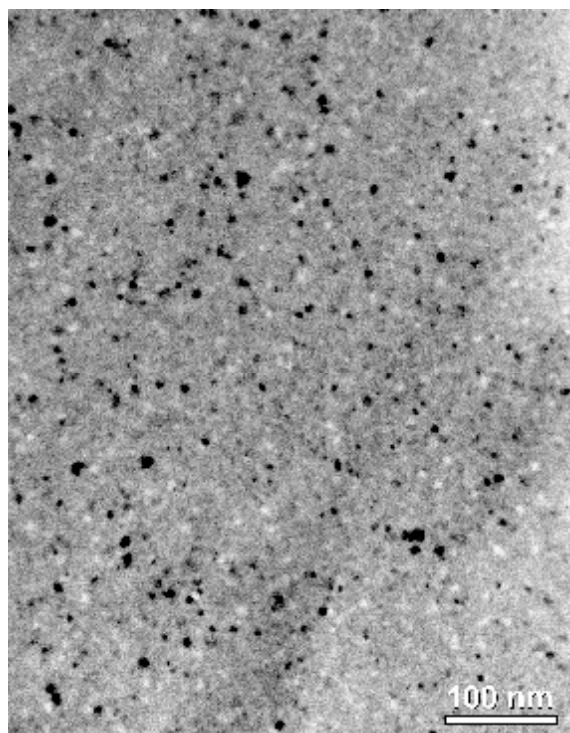


x	12	15	17
$T_{x1}(\text{°C})$	<430	450	<510



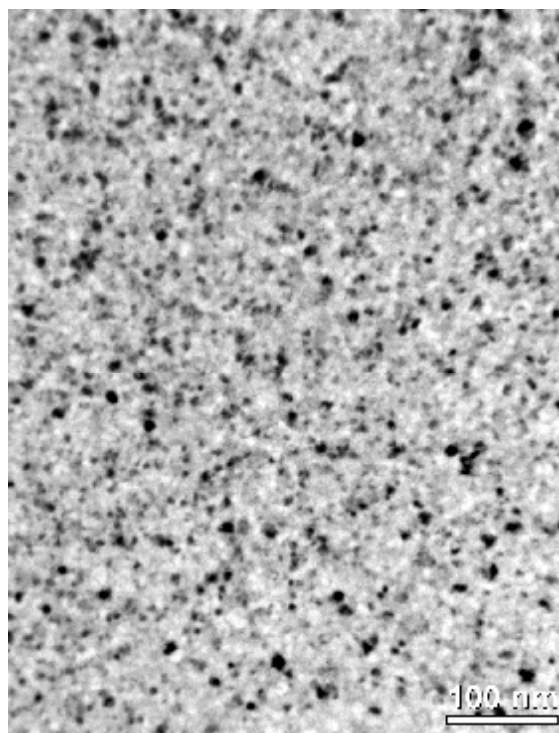


430 °C/1h



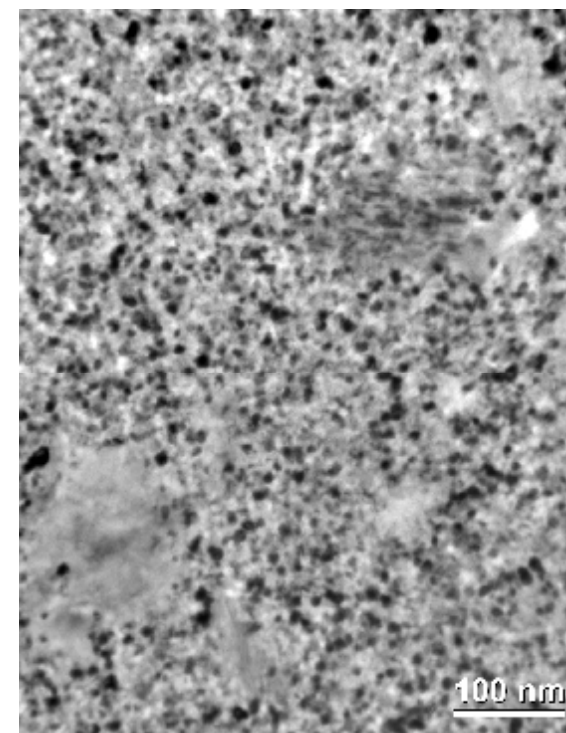
$d \sim 5-8 \text{ nm}$

510 °C/1h

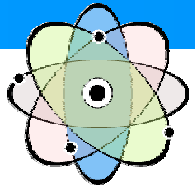


$d \sim 10-12 \text{ nm}$

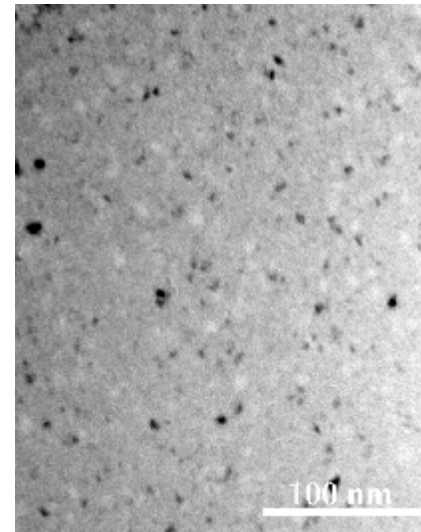
650 °C/1h



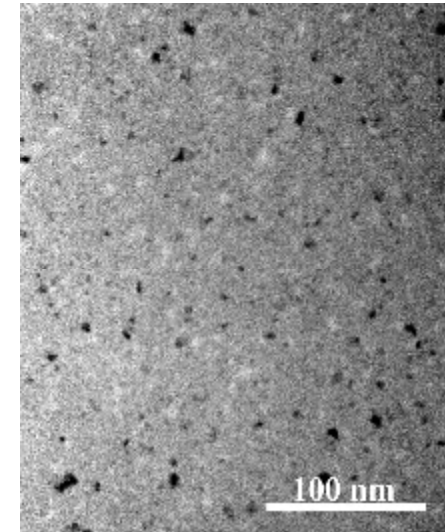
$d \sim 10-13 \text{ nm}$
+ $\text{B}_2\text{Mo}_2\text{Fe}$



450 °C/1h



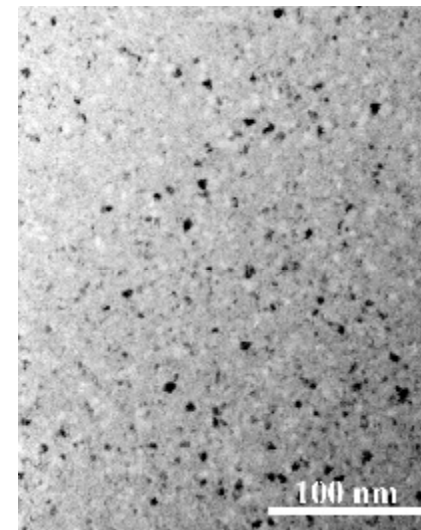
470 °C/1h



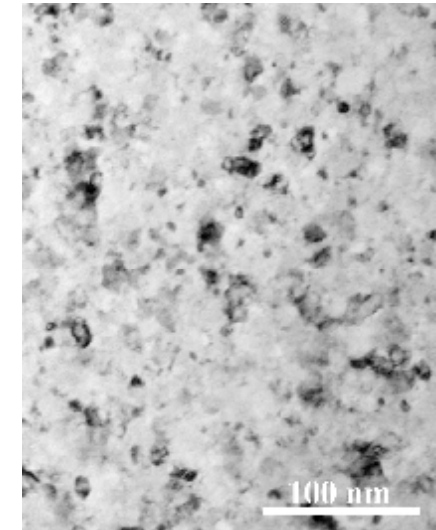
550 °C/1h



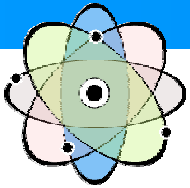
550 °C/1h



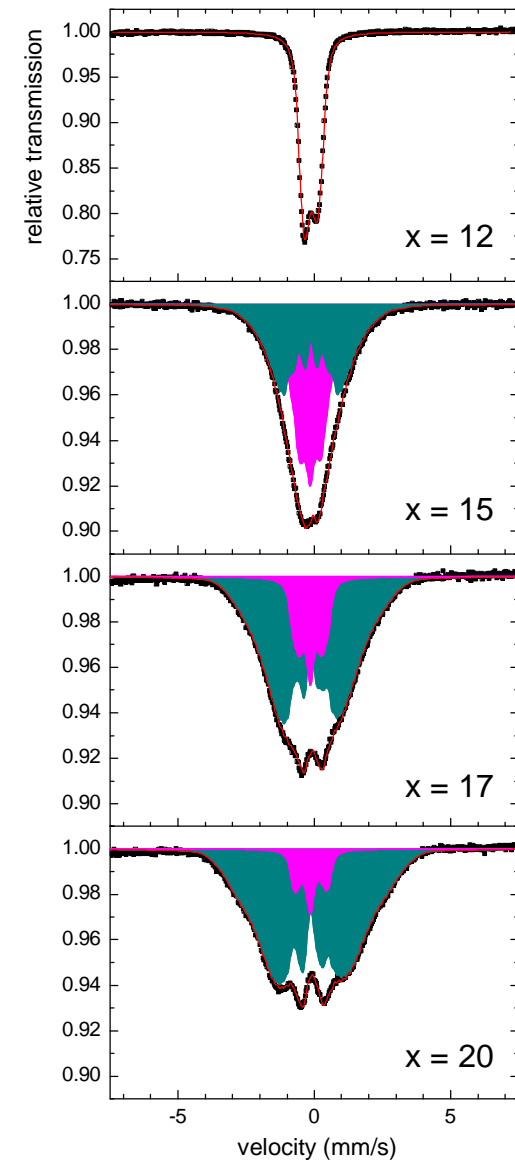
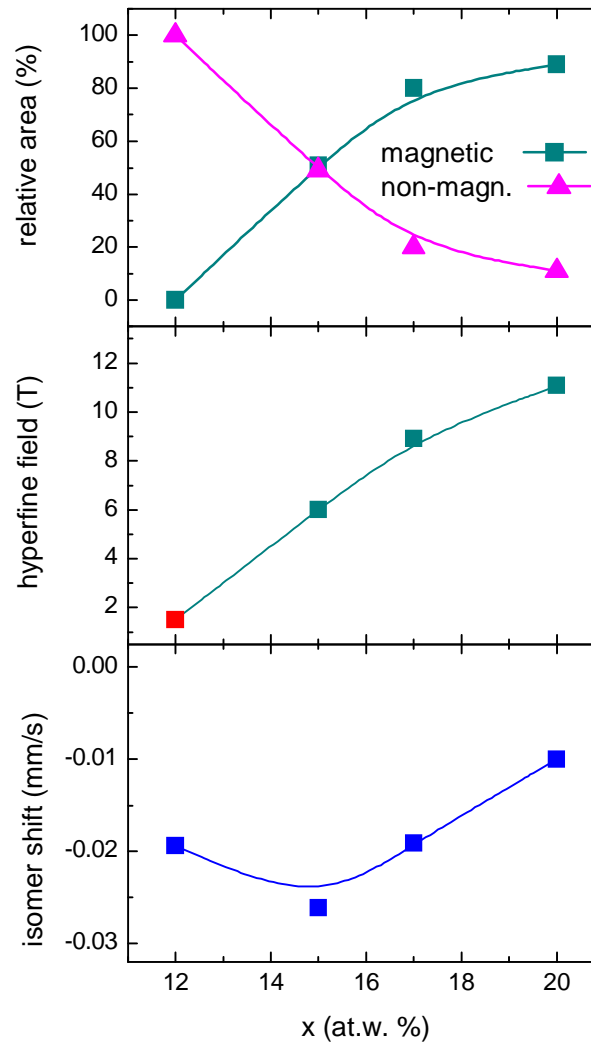
650 °C/1h



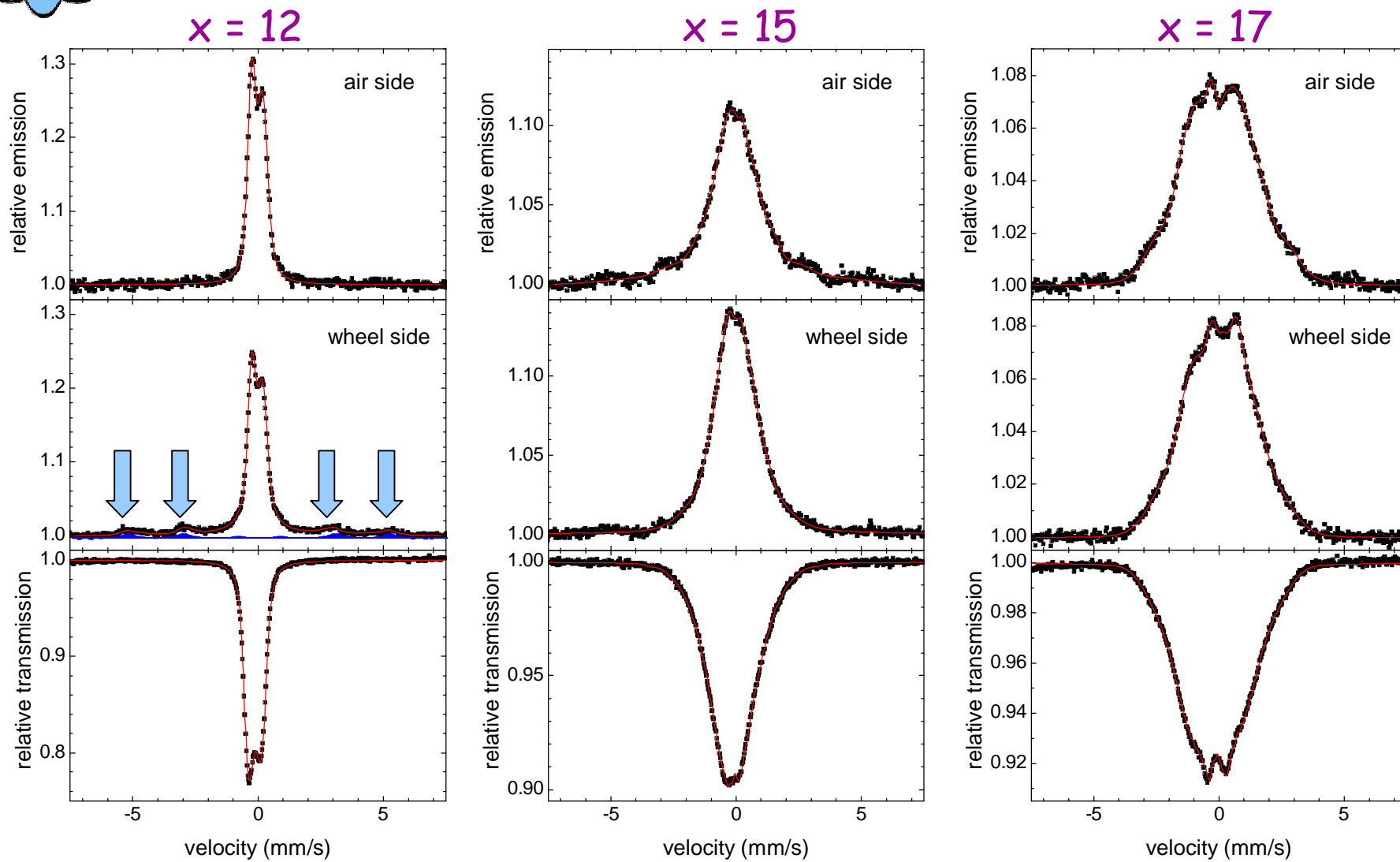
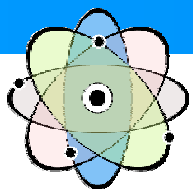
Mössbauer Spectrometry



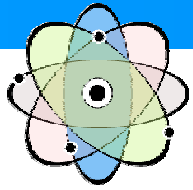
- $\text{Fe}_{91-x}\text{Mo}_8\text{Cu}_1\text{B}_x$
- as-quenched alloys
 - TMS – no traces of crystallization
 - non-magnetic and magnetic regions
 - $T_c \uparrow\uparrow x$



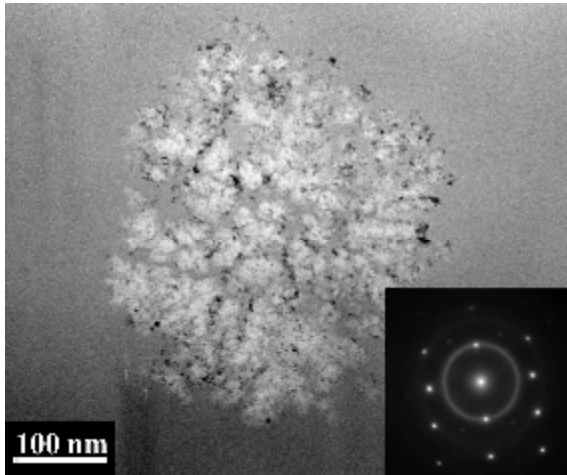
CEMS + TMS: as-quenched



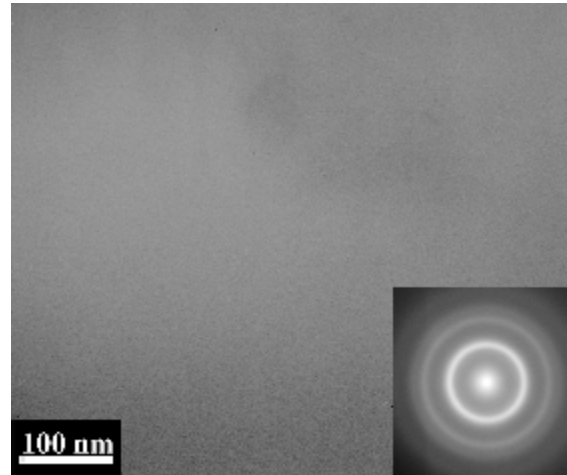
As-quenched B12



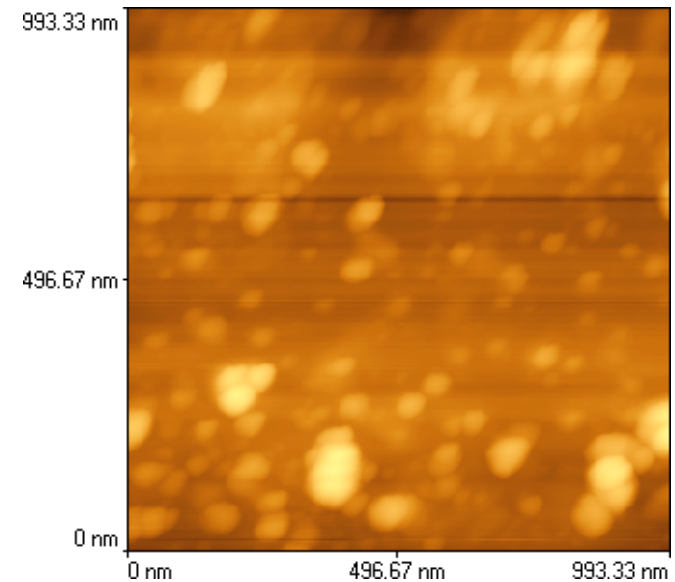
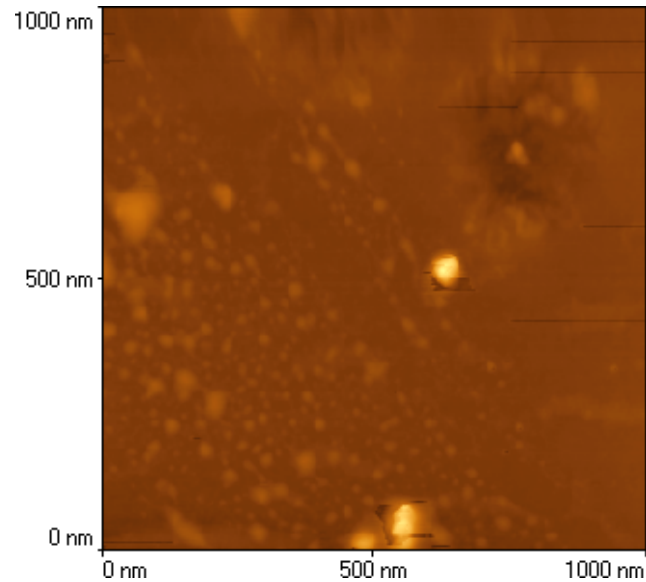
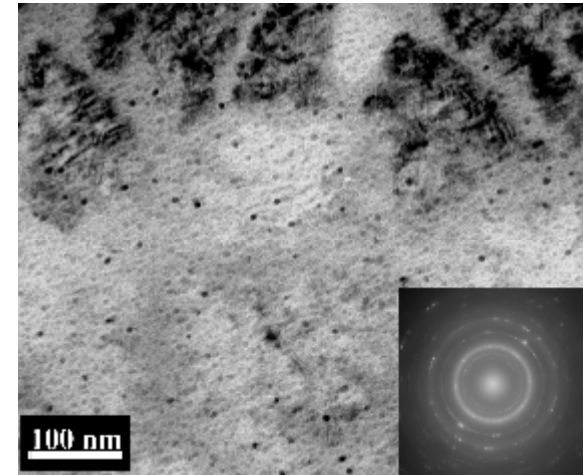
air side



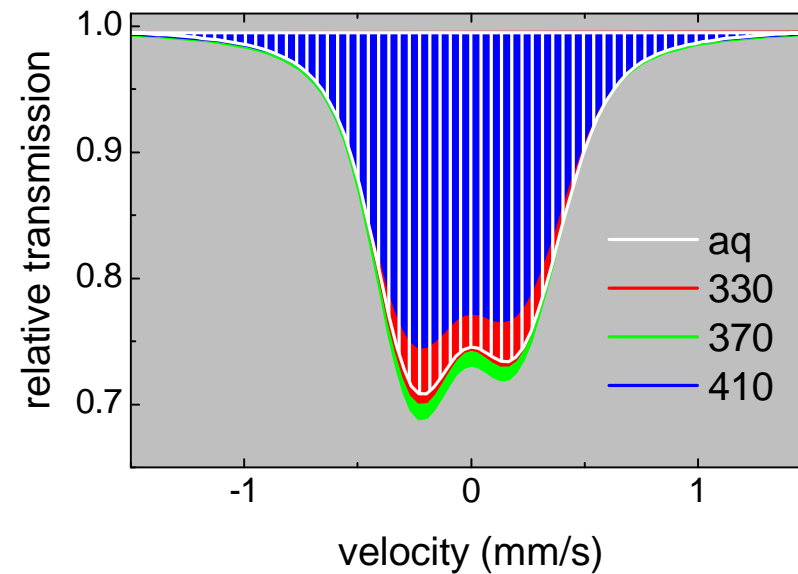
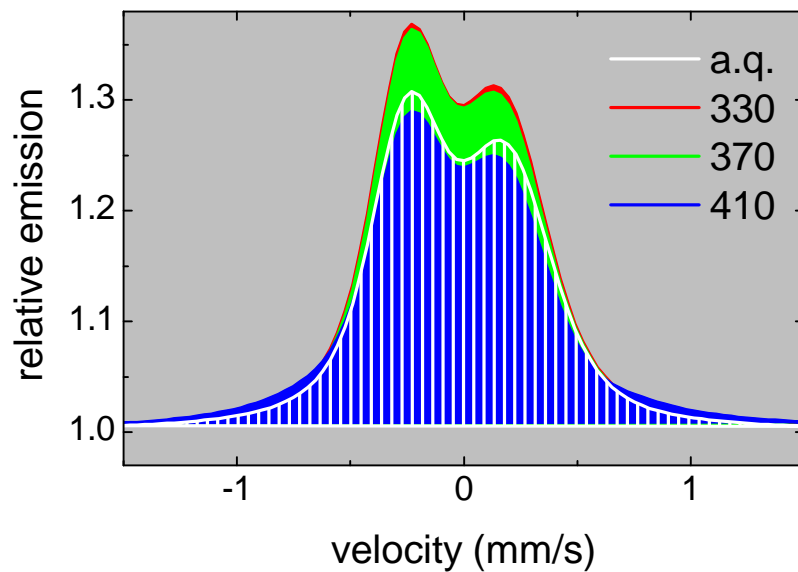
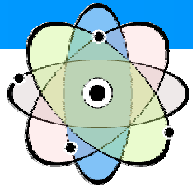
middle



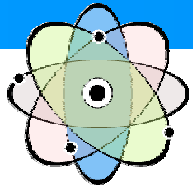
wheel side



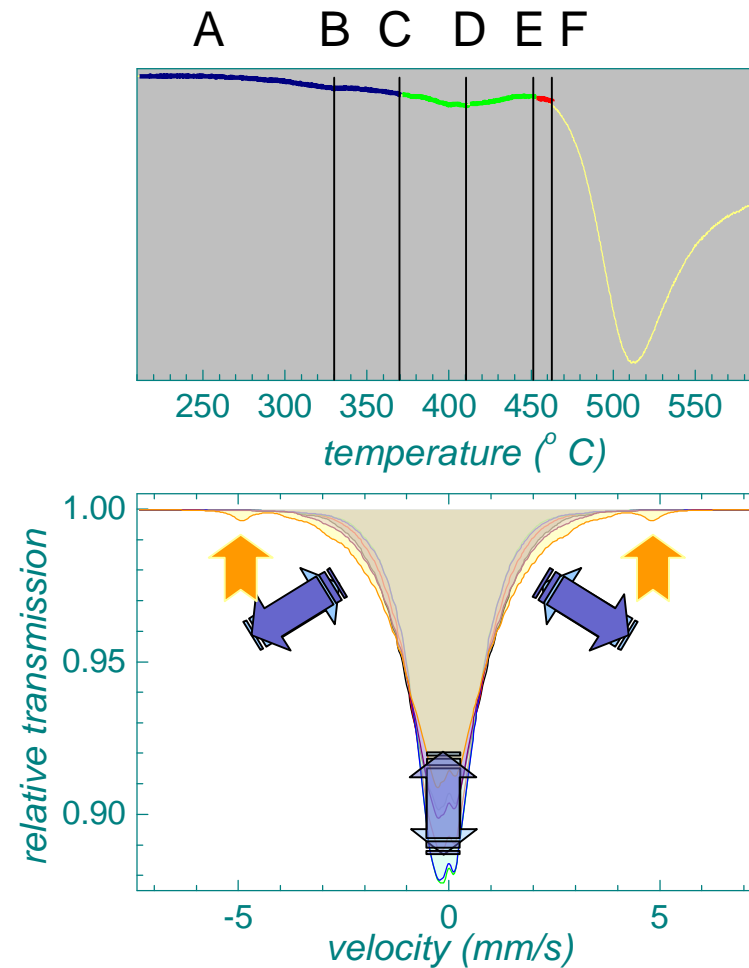
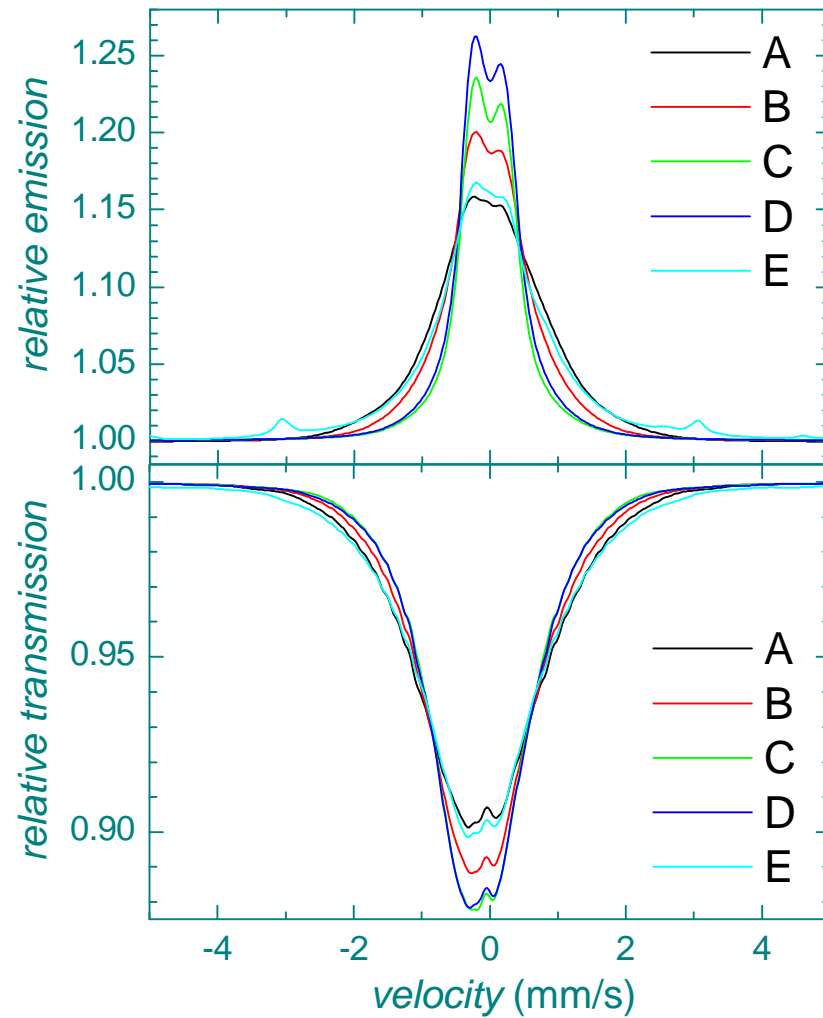
Structural relaxation



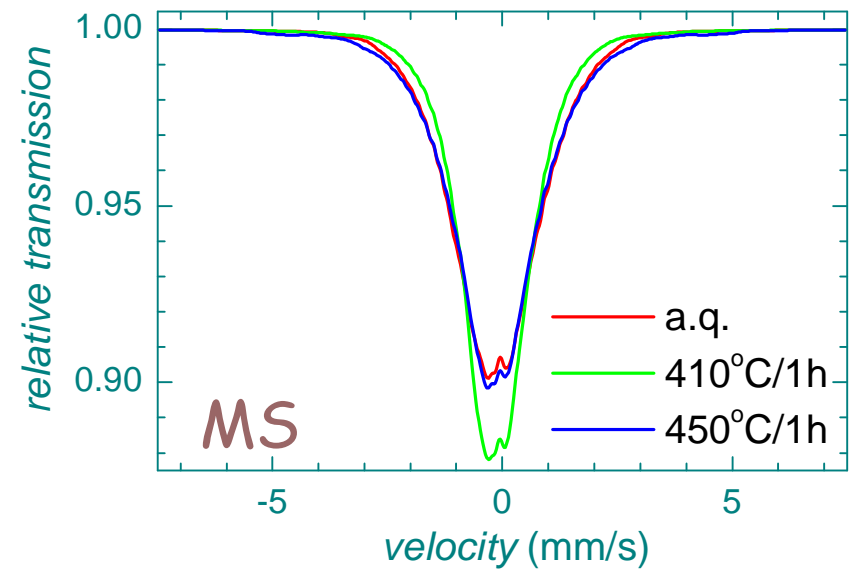
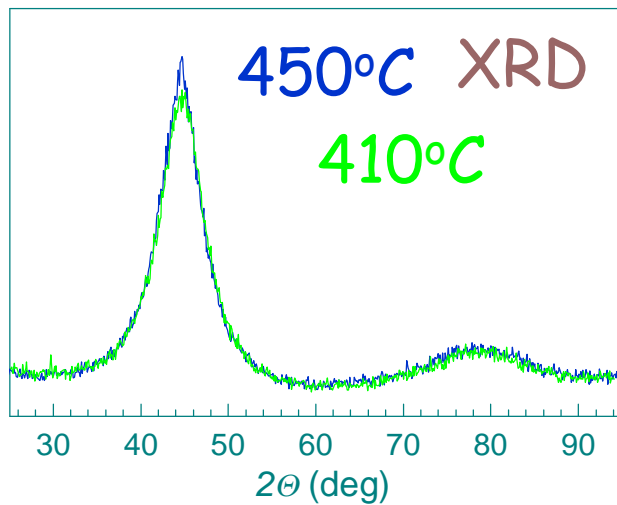
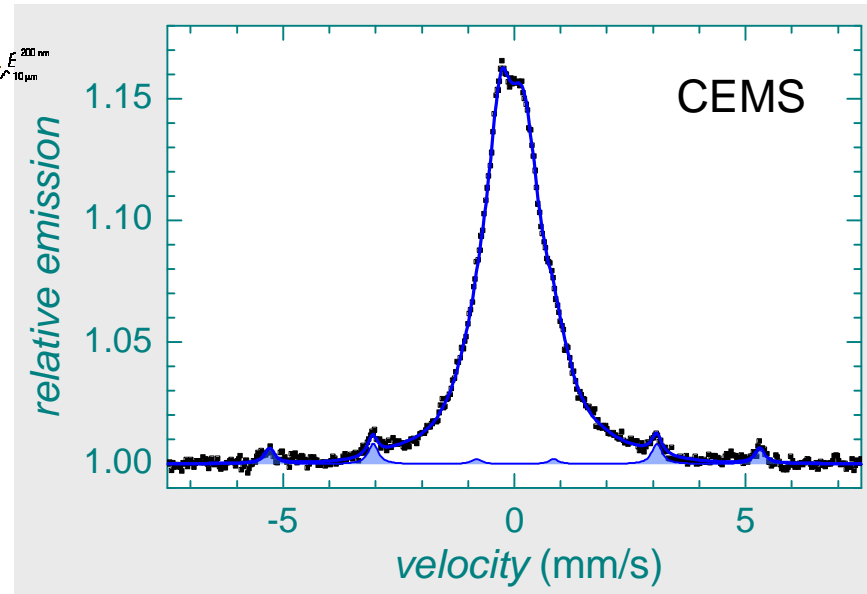
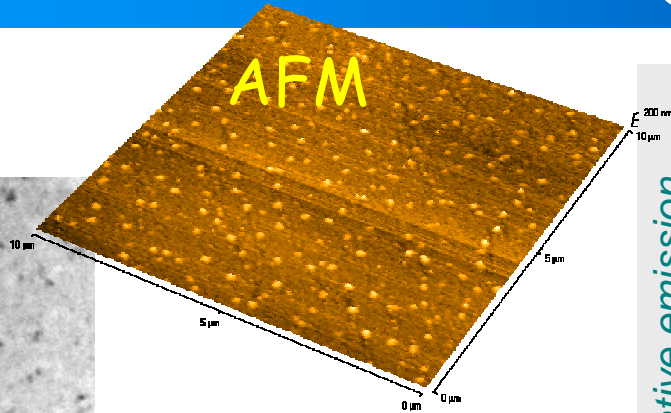
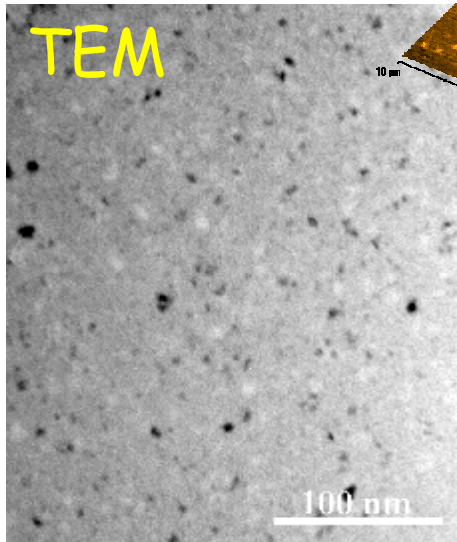
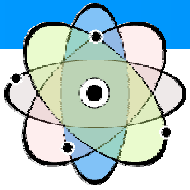
Amorphous State



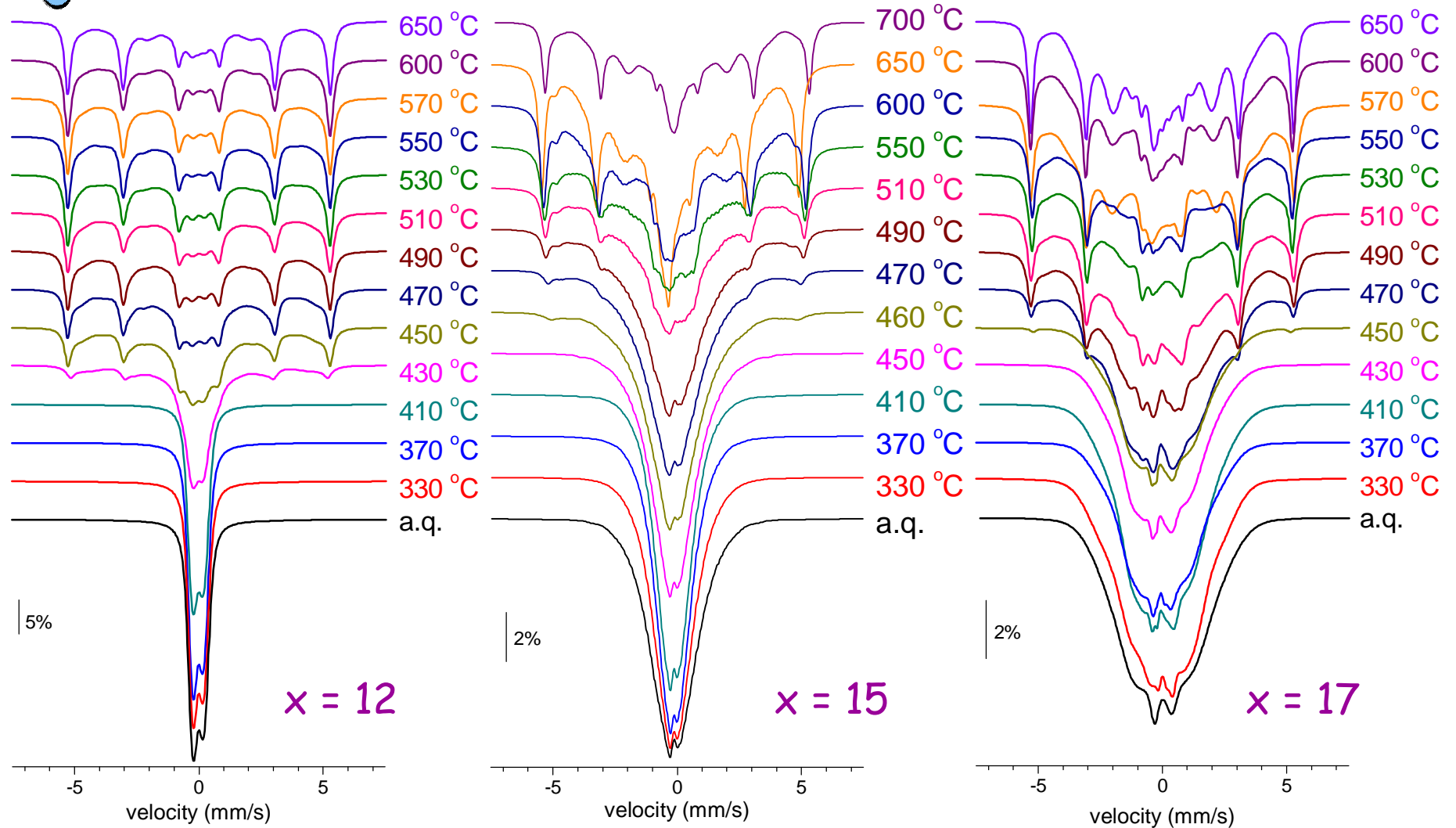
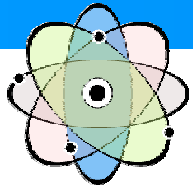
- structural rearrangement

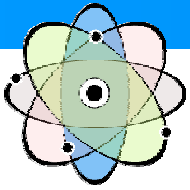


Onset of Crystallization



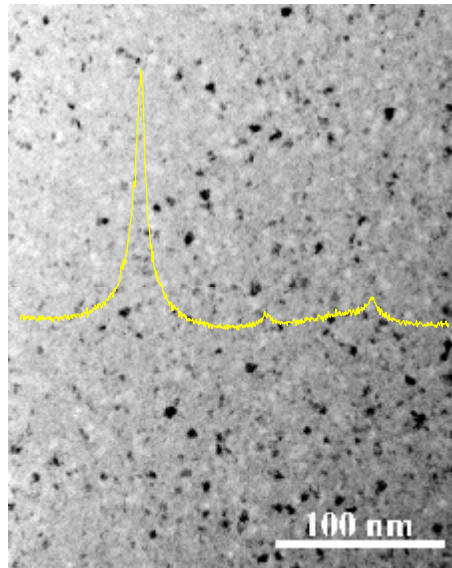
Annealed alloys





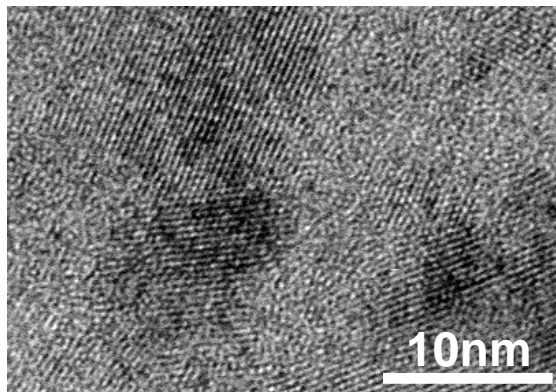
TEM

XRD

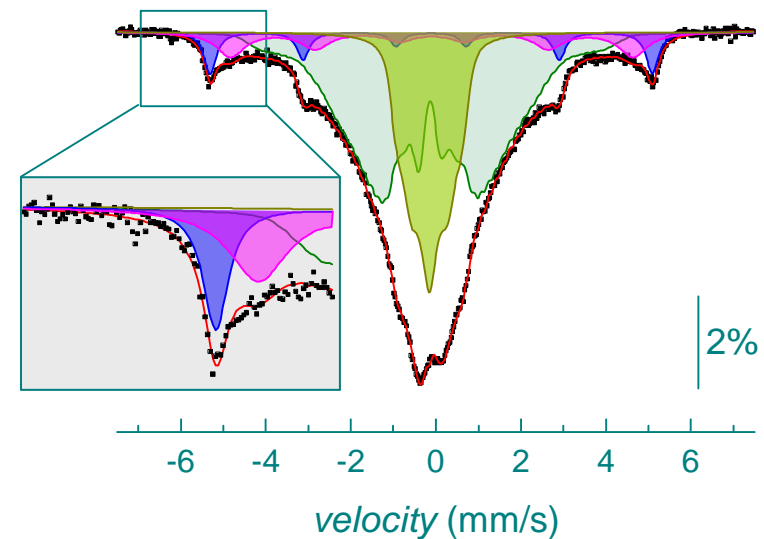


$\text{Fe}_{76}\text{Mo}_8\text{Cu}_1\text{B}_{15}$
490°C

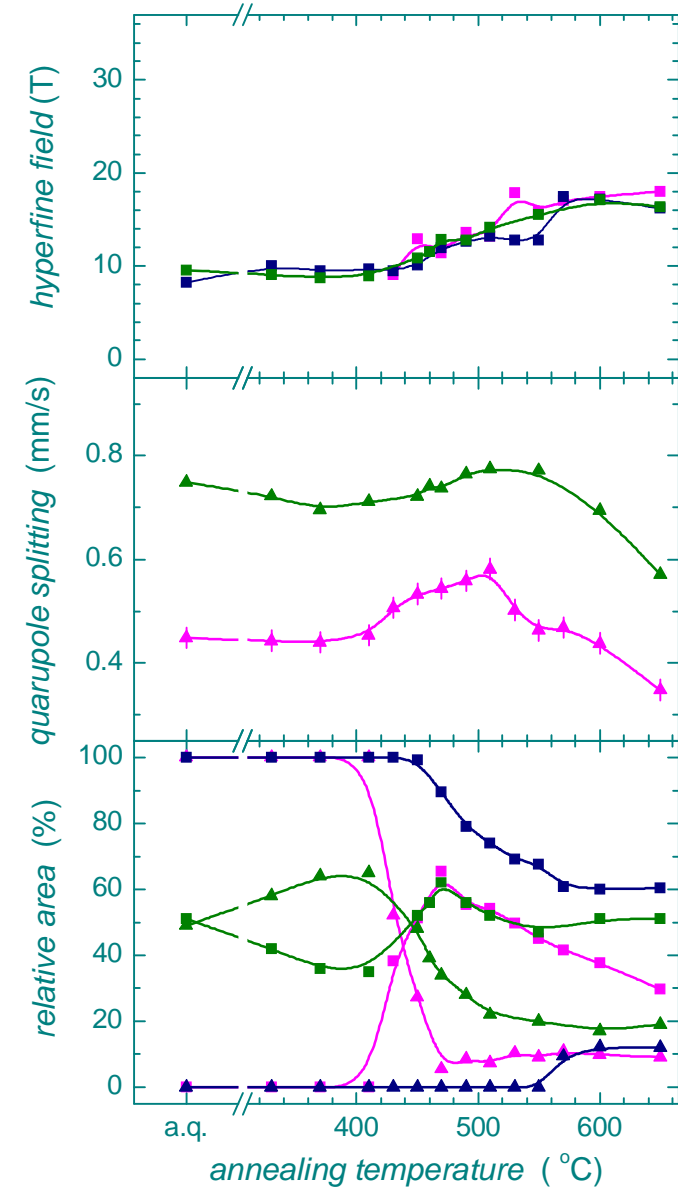
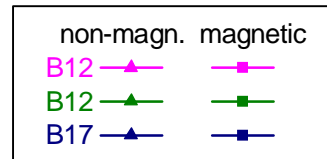
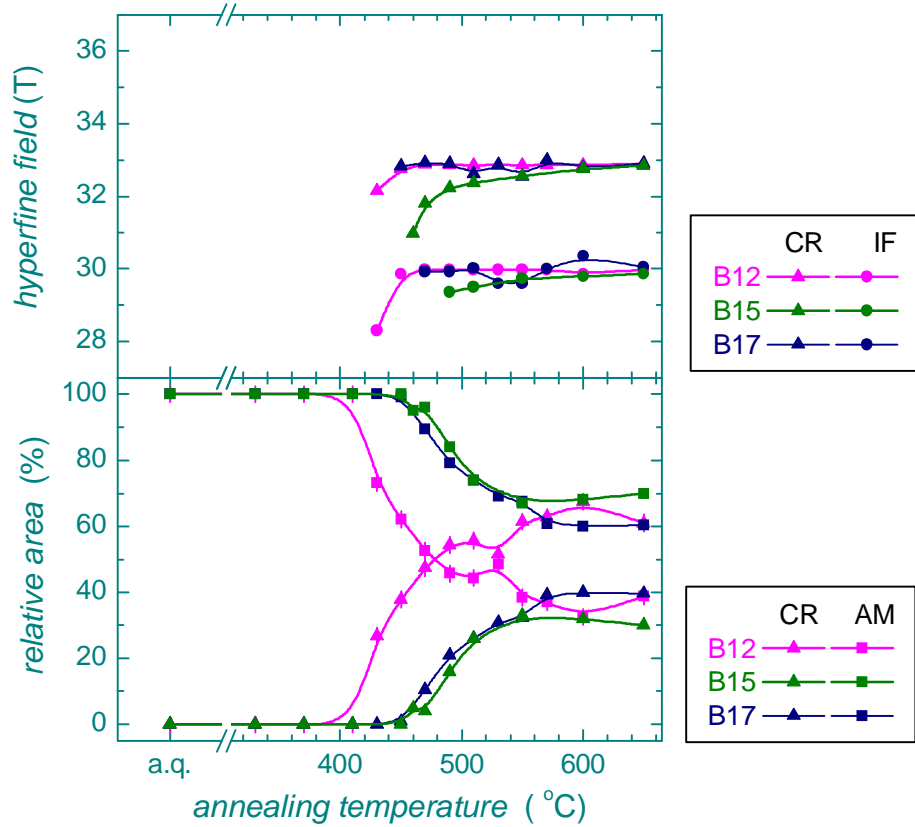
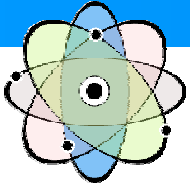
HREM



- amorphous (AM)
 - non-magnetic regions
 - magnetic regions
- crystalline phase (CR)
- interface regions (IF)

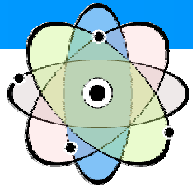


Parameters TMS

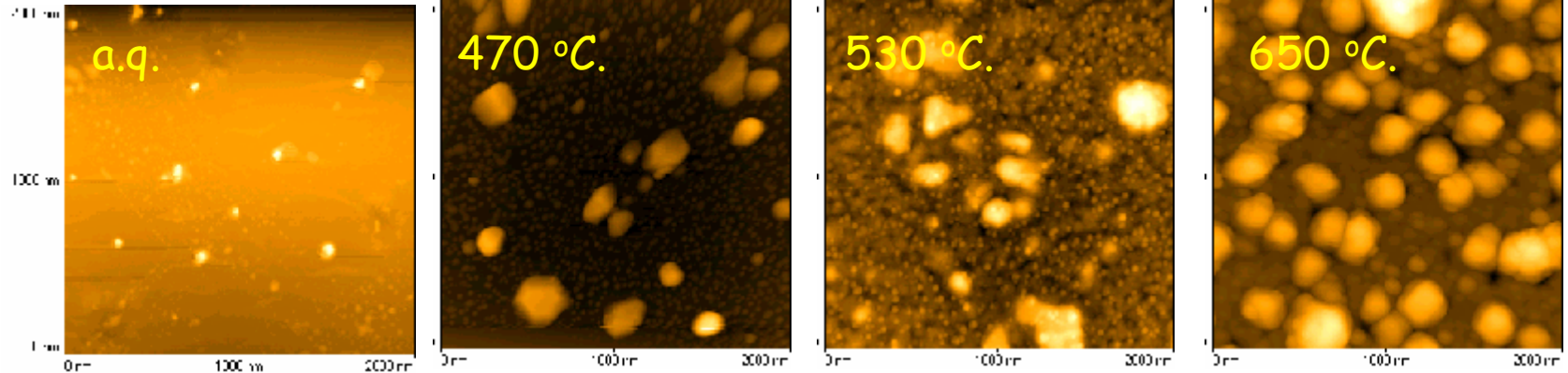




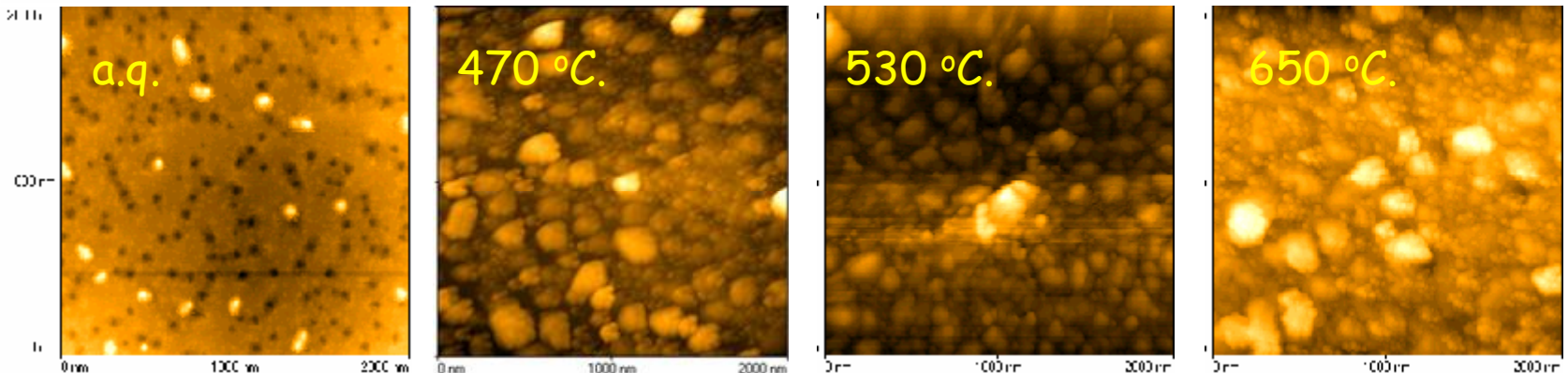
AFM



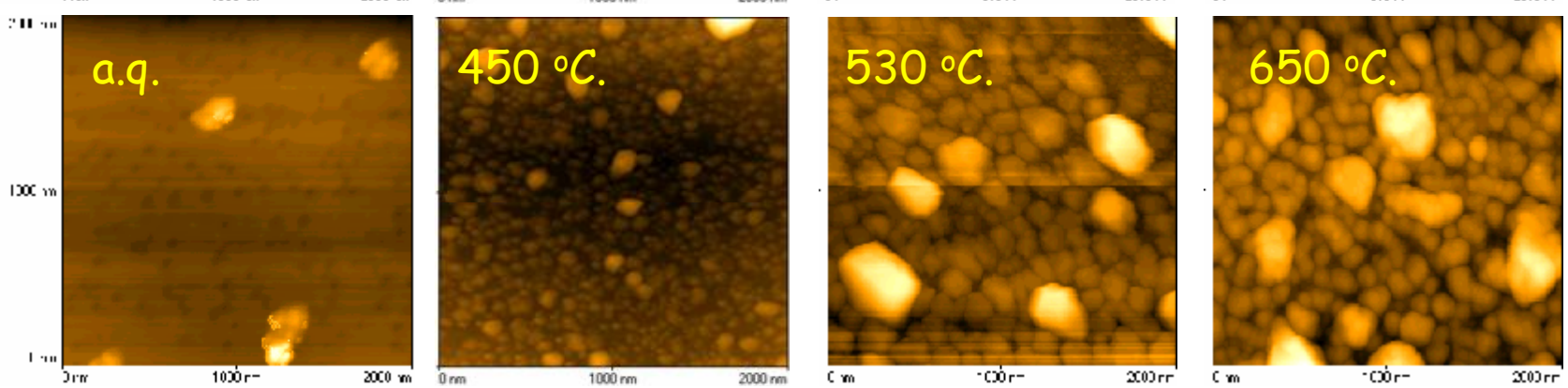
x = 12

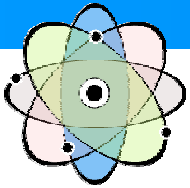


x = 15

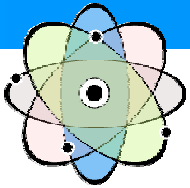


x = 17

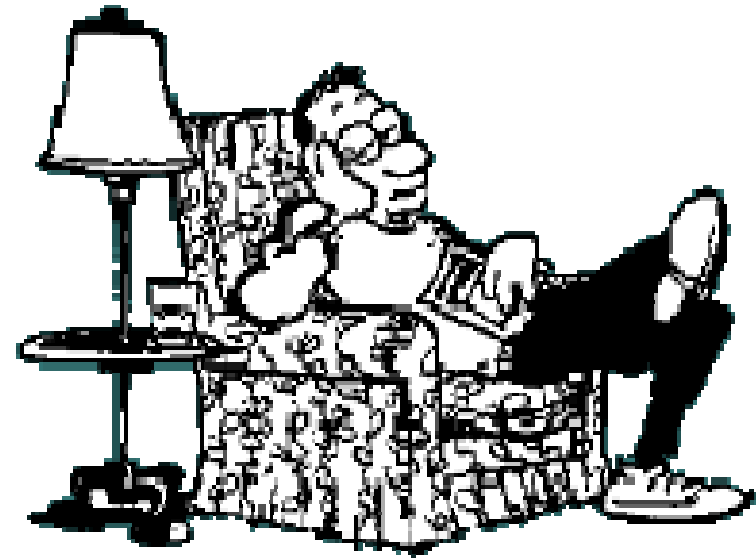




- Fe/B ratio affects the hyperfine interactions
 - increase in T_C with x (270, 316, 346, and 379 K)
 - changes in amorphous rest after onset of crystallization
 - polarization
 - topological and/or chemical SRO
- identification of structural arrangement
 - as-quenched state
 - traces of bcc-Fe in $x = 12$
 - wheel and air side of the ribbon (TEM, XRD, CEMS, AFM)
 - structural relaxation (DSC, MS)
 - nanocrystalline state
 - evolution of hyperfine interaction in the amorphous rest (MS)
 - identification of crystalline phases (MS, XRD, AFM, TEM + DSC)
 - size (~10 nm), relative contents, T_{x1} , bcc-Fe + $Fe_{0.875}Mo_{0.125}$, $Fe_{23}B_6$, Fe_2O_3 , Fe_3B , FeO, Mo_2FeB_2 (P4/mbm, tetragonal but fcc-like)



- E. Illeková (Bratislava) - DSC
- Y. Jirásková (Brno) - CEMS



- Grants: VEGA 1/1014/04, FR/SL/FEISTU/04, MSM6198959218