Metallic Glasses for Accelerator Applications

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Motivation

Amorphous metallic alloys are good candidates for magnetic shielding as well as for magnetic cores of accelerator RF-cavities. During the machine operation, the magnetic materials of the cavities are exposed to radiation caused by lost beam particles. The lost primary beam particles interact with material of the beam-pipe wall and produce secondary particles like light fragments and neutrons. At high beam-intensities, even low-level beam losses may correspond to high radiation load of the magnetic materials.

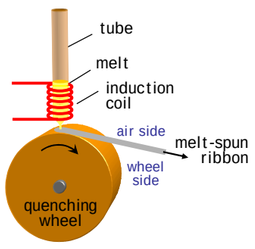
Aim

- Investigation of the radiation damage induced by ion bombardment.
- Study the impact of irradiation on structural and magnetic characteristics of the construction materials.
- Calculation of the radiation damage profiles.
- Application of transmission and conversion electron Mössbauer spectrometry to distinguish between the bulk and surface radiation damage.

Experiment

Samples

- NANOPERM $Fe_{76}Mo_8Cu_1B_{15}$
- FINEMET $Fe_{74}Nb_3Cu_1Si_{16}B_6$
- prepared by the melt-spinning technique
- ribbons about 20 μm thick



^{57}Fe Mössbauer Spectrometry

- transmission Mössbauer spectrometry - TMS
- conversion electron Mössbauer spectrometry - CEMS
- scanning depth of CEMS ~200 nm
- ^{57}Co/Rh source, calibration with α-Fe foil @ 300 K

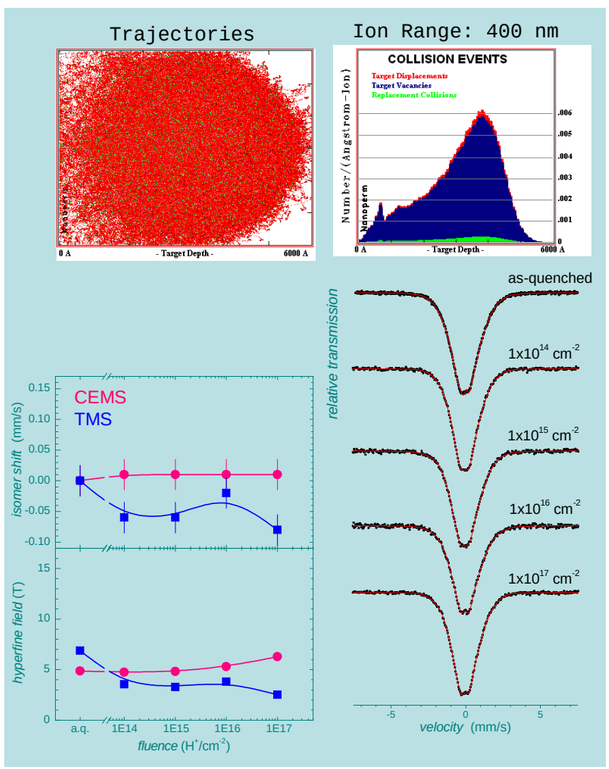
Implantation

- air side of the ribbon
- fluencies up to $1x10^{18}$ ions/cm^2
- range & profile simulations by SRIM

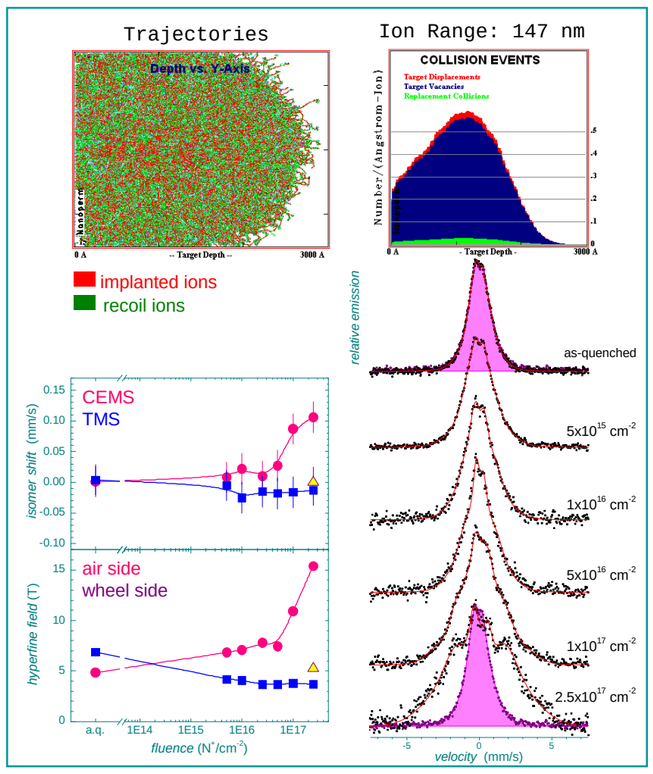
Results

$Fe_{76}Mo_8Cu_1B_{15}$

80 keV H^+

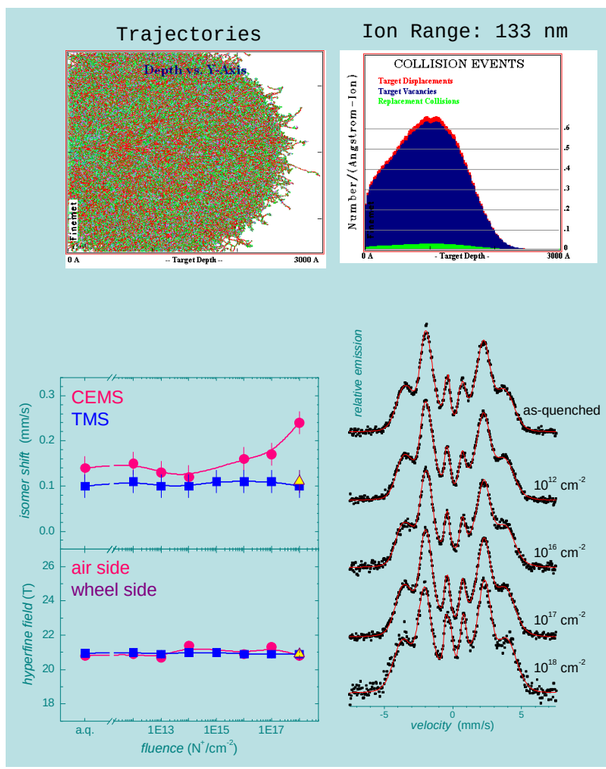


130 keV N^+

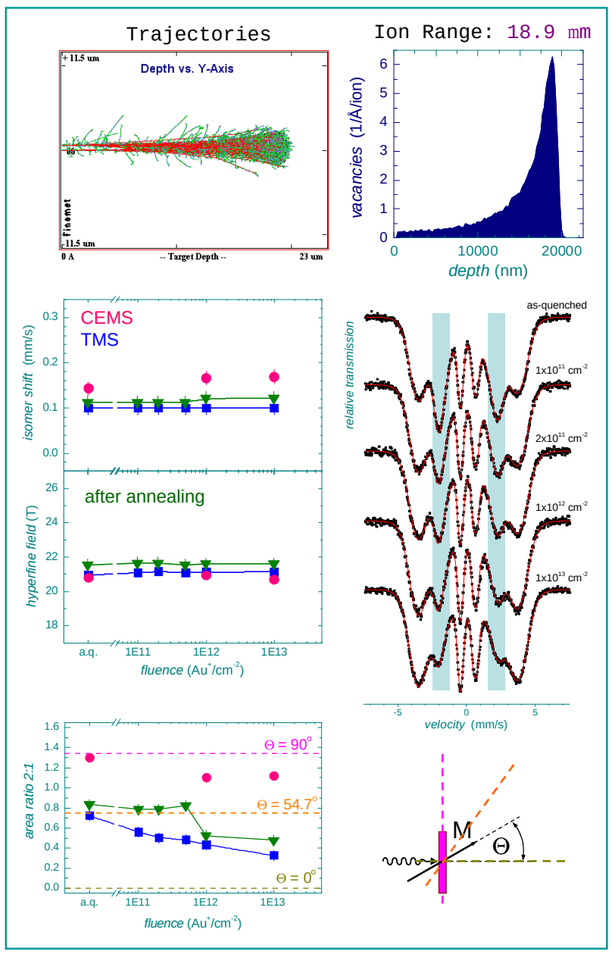


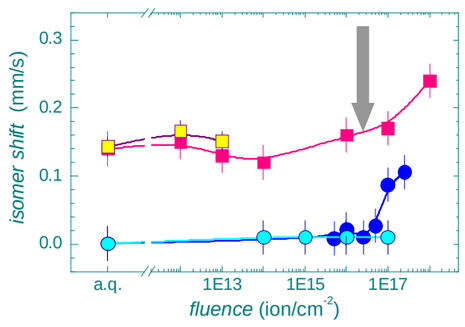
$Fe_{74}Nb_3Cu_1Si_{16}B_6$

110 keV N^+



593 MeV Au^+





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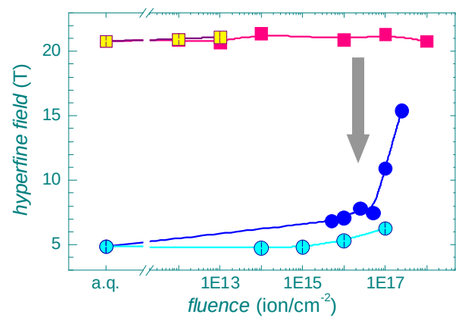
80 keV H^+



Conclusions

- Ion irradiation of metallic glasses introduces structural rearrangements in the amorphous matrix of the investigated alloys associated with changes in chemical and topological short-range order (SRO) which are reflected in isomer shift and hyperfine magnetic fields values, respectively.
- The observed alternation of the hyperfine spectral parameters depends primarily on the total number of displacements of the resonant atoms which is closely related to the total number of incident ions, i. e. fluence as well as their energy and type.
- $Fe_{76}Mo_8Cu_1B_{15}$ alloy is quite sensitive to radiation damage and notable alternations of the hyperfine magnetic fields as well as isomer shifts are observed after bombardment with 130 keV N+. This system is especially suitable for irradiation studies because any structural rearrangement is readily detected.
- $Fe_{74}Nb_3Cu_1Si_{16}B_6$ alloy seems to be resistant to radiation damage and the irradiation-induced structural changes are limited to alternations of chemical SRO. Because this metallic glass exhibits good soft magnetic properties, it might be considered as a good candidate for RF cavities in accelerator technology.

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