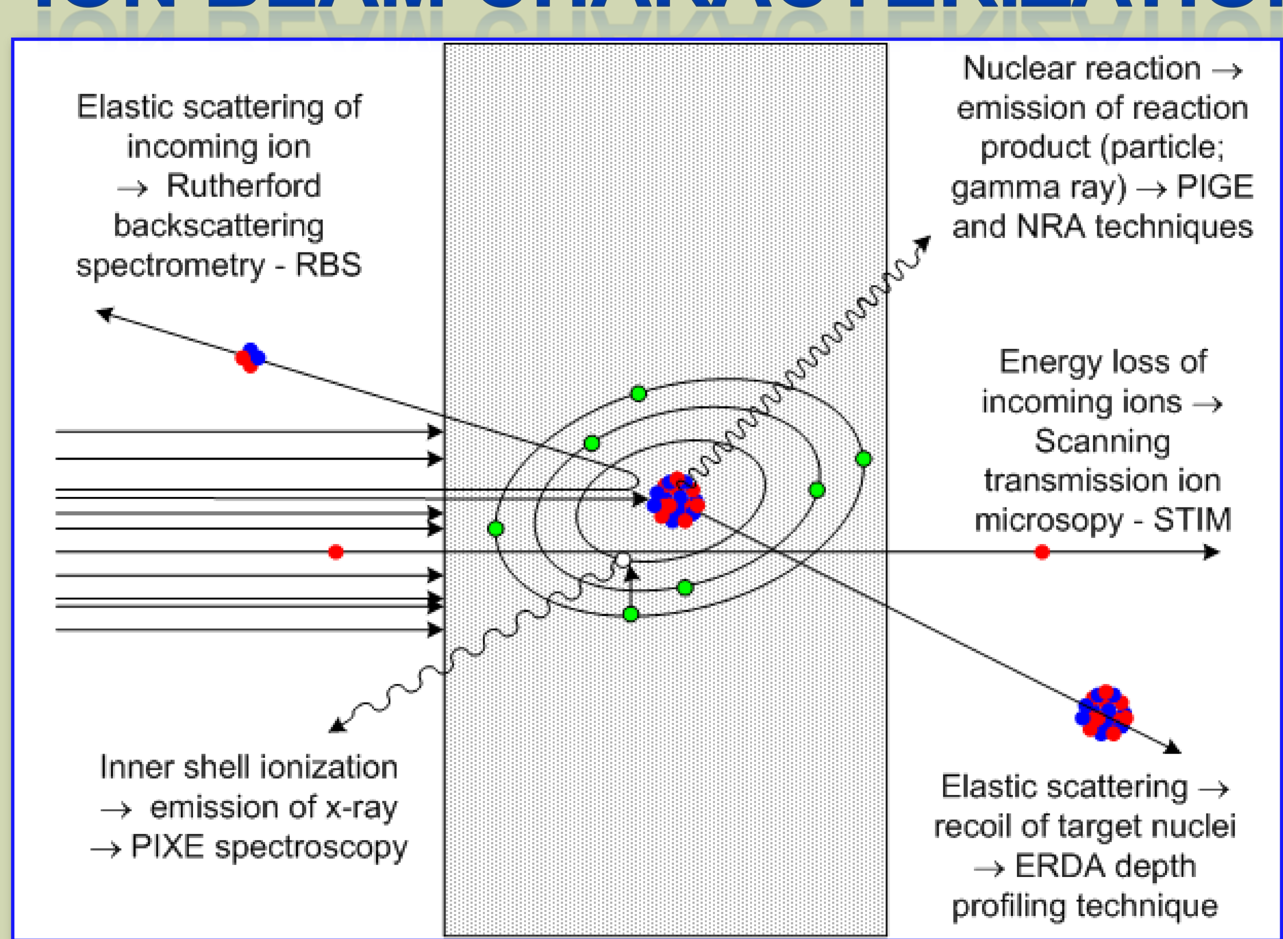
WHEN MeV IONS MEET MATTER

M. Karlušić[1], I. Božičević[1], V. Grilj[1], M. Buljan[2], I. Bogdanović Radović[1], S. Fazinić[1], M. Jakšić[1]

[1]Zavod za eksperimentalnu fiziku, Laboratorij za interakcije ionskih snopova
[2]Zavod za fiziku materijala, Laboratorij za poluvodiče

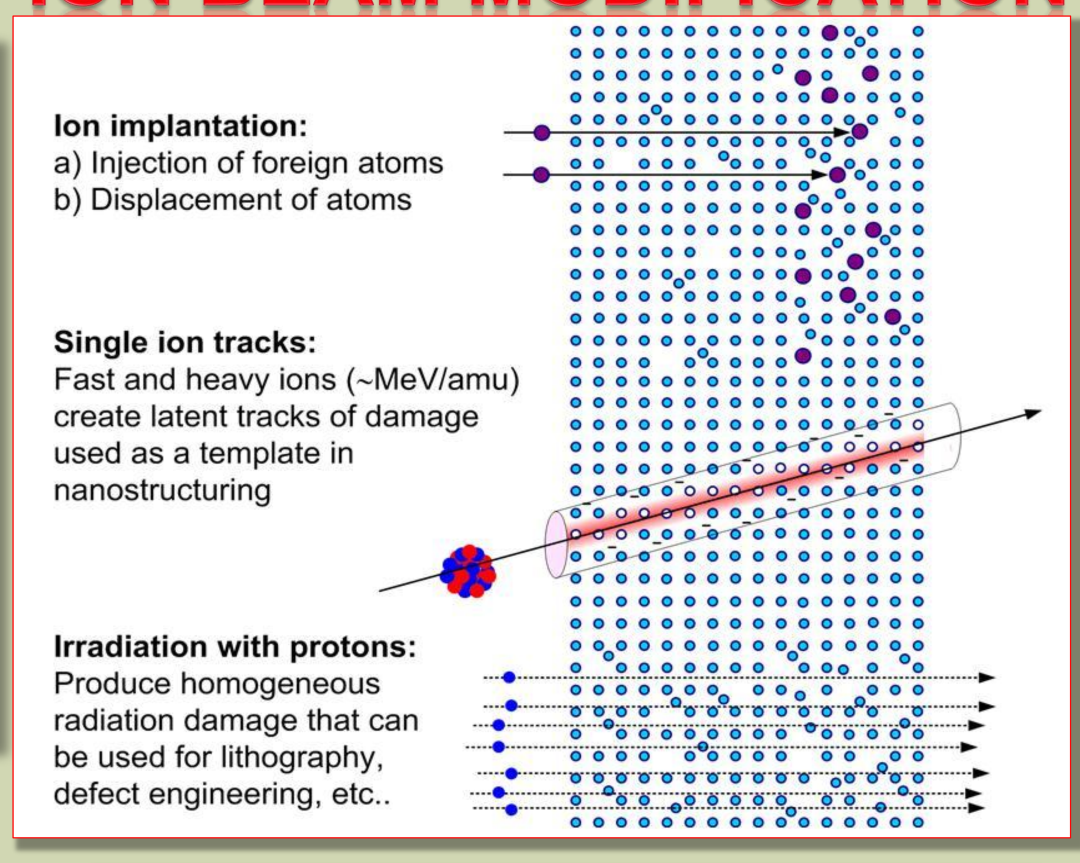
NANOZNANOST

ION BEAM CHARACTERIZATION



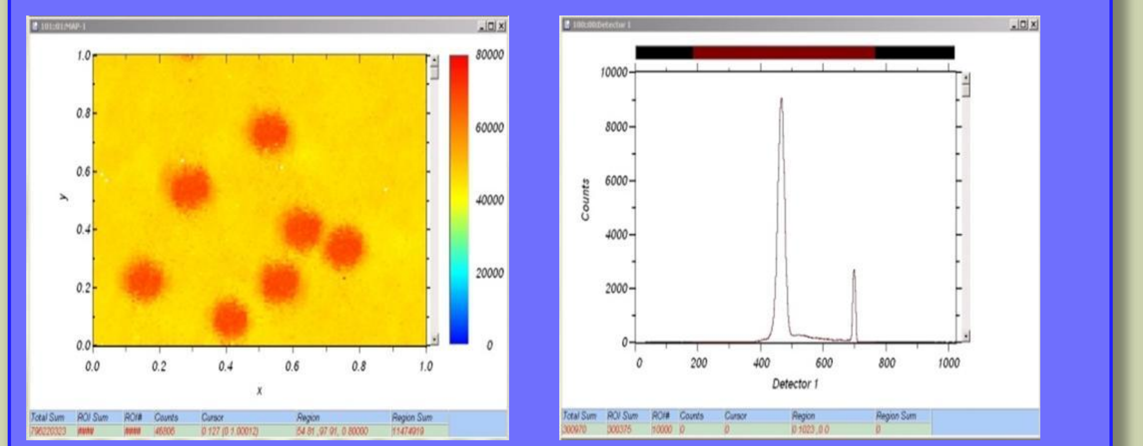
Ion beams in the MeV energy range are versatile tool for both materials analysis and structuring. Violent interaction between MeV heavy ion and target material leads to diverse physical processes, which can be exploited in a number of ways. By adjusting ion beam parameters, interactions at the surface or deep in the bulk can be chosen. Additional opportunities offer an ion microbeam setup, where low beam current or even single ion irradiations are possible. In this contribution, few recent examples of both materials analysis and modifications by MeV heavy ion beams are presented.

ION BEAM MODIFICATION

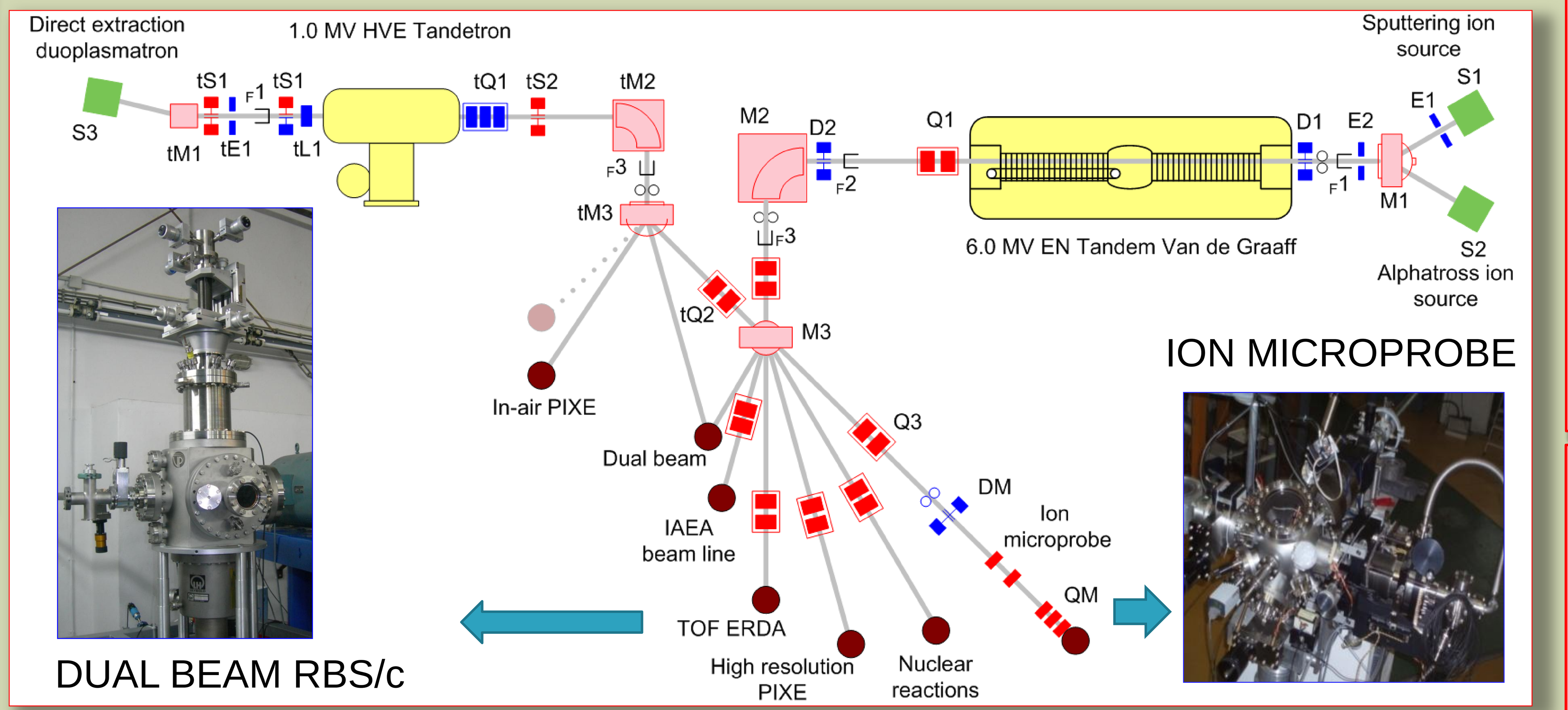


STIM (Scanning Transmission Ion Microscopy)

Whatman etched ion track polycarbonate membrane was scanned with focused He microbeam. Position and energy of transmitted ions were used for 3D profiling (unpublished).



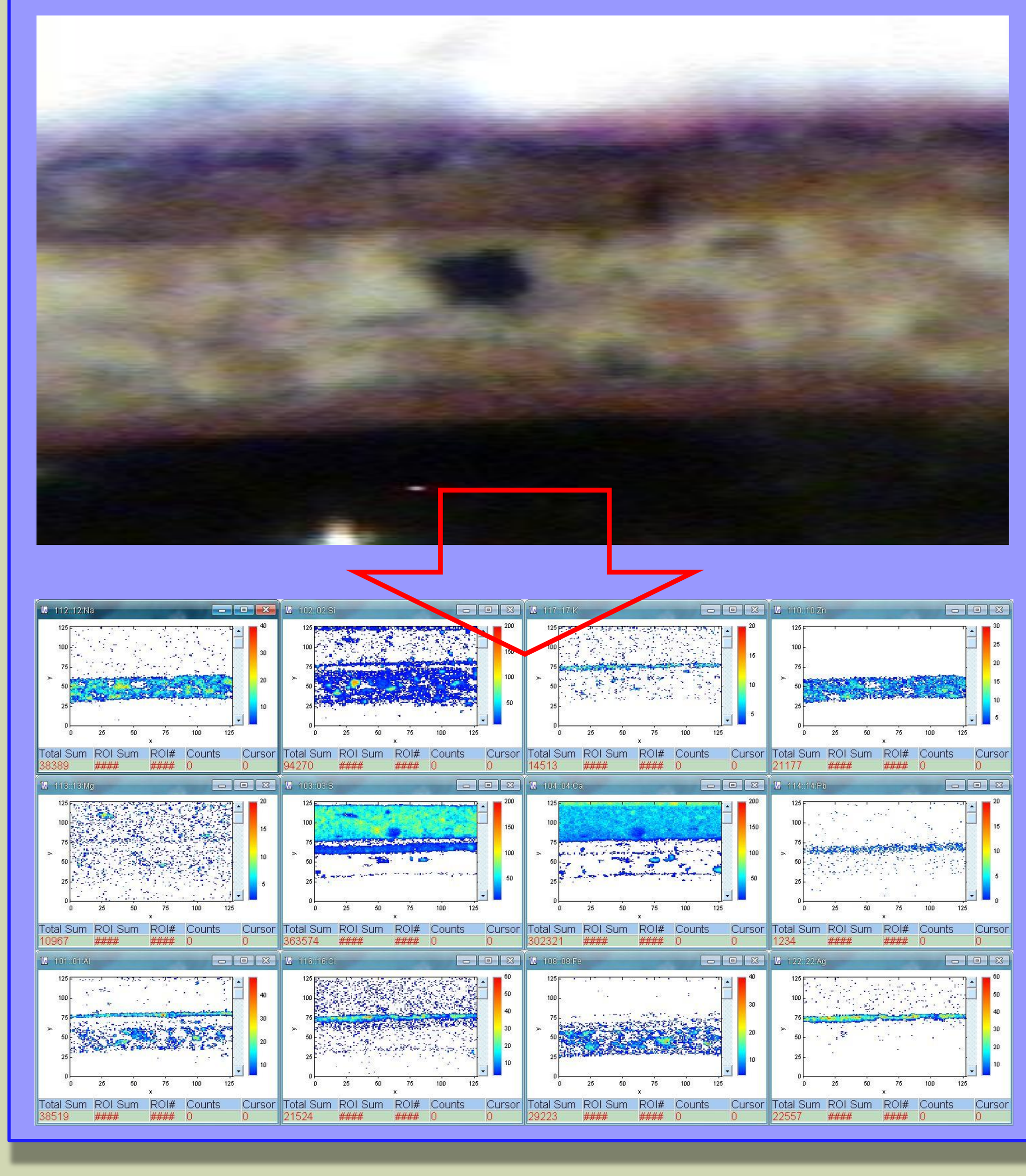
RBI ACCELERATOR FACILITY



Laboratory for ion beam interactions at RBI is equipped with two accelerators: 6.0 MV Tandem Van De Graaff and 1.0 MV HVE Tandetron and several beam lines dedicated to ion beam applications. Dual beam chamber makes possible in-situ RBS/c analysis during MeV heavy ion irradiation or implantation. Ion microprobe with new quintuplet focusing system is able to focus heavy ions down to 300 nm expanding also opportunities for modification of materials.

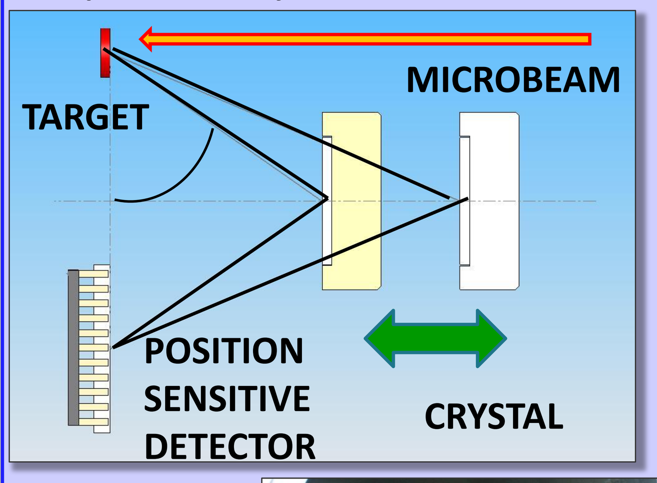
PIXE (Particle induced X-ray Emission)

Proton microbeam was scanned over the lateral cross-section of a painting to investigate elemental composition of used pigments. Energy and intensity of x-rays emitted from the sample for each position of scanning beam were measured. Obtained maps show elemental distribution throughout the cross-section.



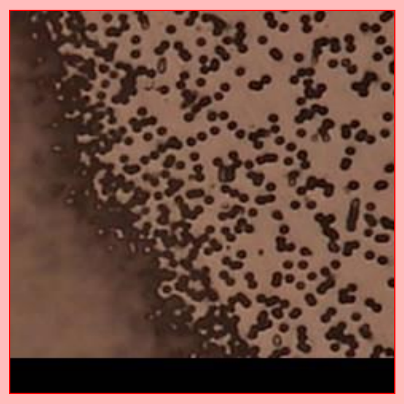
Miniature wavelength dispersive X ray spectrometer

Use of small beam size with ion microprobe and CCD detector as a position sensitive detector, miniature WDX spectrometer was constructed for measuring influence of chemical effects on x-ray spectra and to resolve lines that can not be separated with energy dispersive systems.



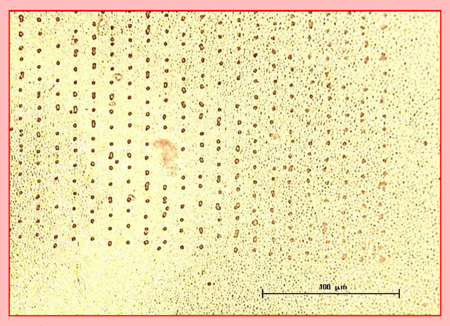
Position of target, CCD detector and crystal in miniature WDX spectrometer

Creating nanometar sized tracks with MeV heavy ions

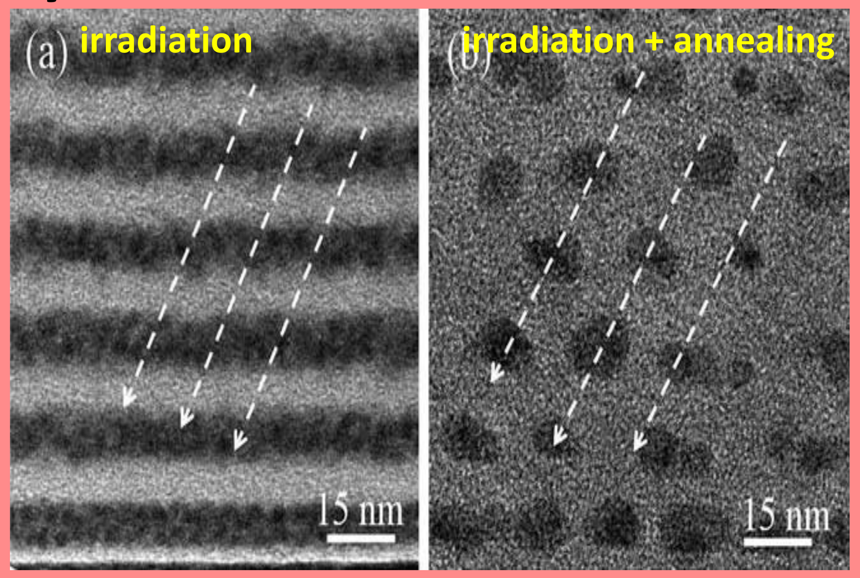


Random tracks created with broad beam of 35 MeV Cl ions in PMMA

Orderd array of etched ion tracks in polycarbonate irradiated with 9.5 MeV Si ions (submitted)



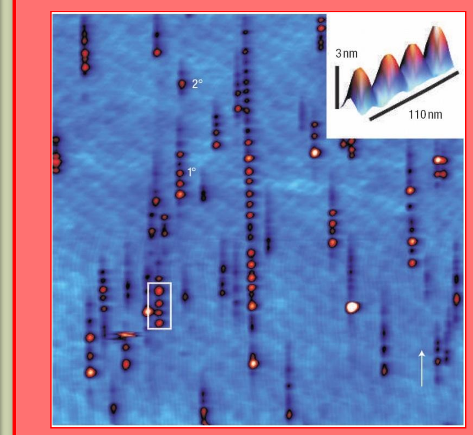
Ordering of quantum dots by ion irradiation



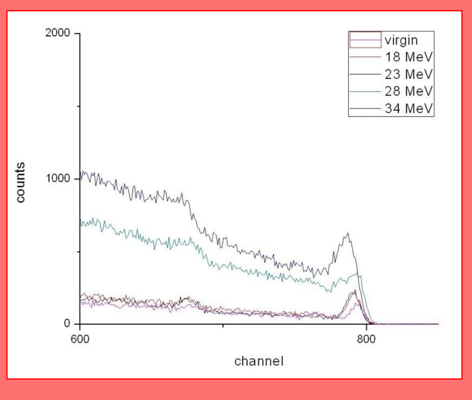
$(Ge+SiO_2)$ / SiO_2 multilayer irradiated with 3 MeV $^{16}O^{3+}$ under angle of 60°, dose 10^{15} ion/cm^2[1], [2]

Creation of ordered nanodots in $SrTiO_3$ by swift heavy ions

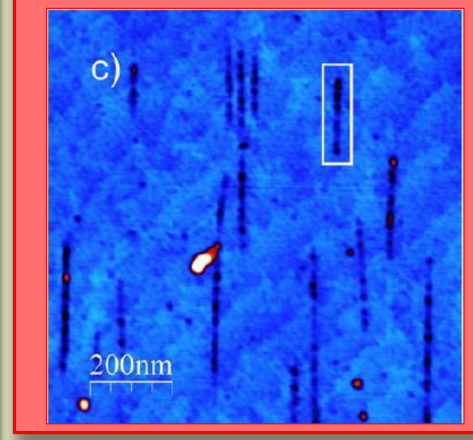
Recent discovery of chainlike-nanodot morphology of surface ion tracks in $SrTiO_3$ [3] generated strong scientific interest in detailed investigations of ion tracks. At RBI, original experiment was successfully repeated at lower energies and threshold for ion track formation was found [4]. We have also investigated ion tracks in the bulk $SrTiO_3$ using RBS/c at HZDR, Dresden, Germany within EU FP7 SPIRIT project. Much higher threshold was established and a novelty - its angular dependence was found. Extension of themal spike model was developed at RBI which explains observed features (unpublished). Recently, in-situ RBS/c setup is constructed and tested at RBI.



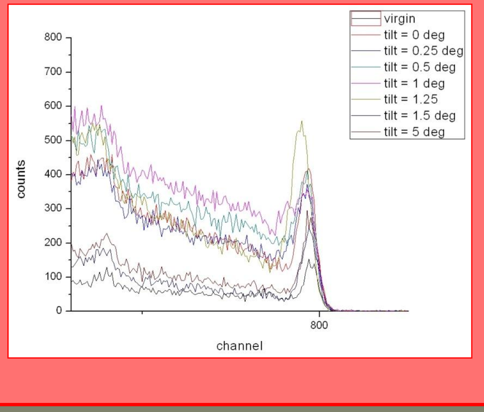
90 MeV Xe, angle 1^0
GANIL, Caen, France
AFM + TS model
Univ. Duisburg, Germany



18-34 MeV I, tilt angle 1^0
RBI, Zagreb
1.7 MeV He RBS/c
HZDR Dresden, Germany
threshold: 9 – 10.5 keV/nm



28 MeV I, angle 1.3^0
RBI, Zagreb
AFM + TS model
Univ. Duisburg, Germany
threshold: 5 - 7 keV/nm



28 MeV I, tilt angle 0^0-5^0
RBI, Zagreb
1.7 MeV He RBS/c
HZDR Dresden, Germany
angle dependent threshold!

References
[1] M. Buljan et al, Appl. Phys. Lett. 95 (2009) 063104
[2] M. Buljan et al., Phys. Rev. B 81 (2010) 085321
[3] E. Akcöltekin et al., Nature Nanotechnology 2 (2007) 290
[4] M. Karlušić et al, New J. Phys. 12 (2010) 043009