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Materials research with energetic ion beams: Basic aspects and nanotechnology

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When solids are exposed to energetic ions (MeV-GeV), their physical and chemical structure can severely be modified. The change is governed by ultrafast dynamical processes starting from the deposition of large energy densities, electronic excitation and ionization processes, and finally damage creation in the atomic lattice system. Each projectile creates a cylindrical track with a few nanometers in diameter and up to many μm in length. Of particular interest are material degradation and modification processes under multiple extreme conditions. The coupling of extreme energy depositions with high pressure and high temperature can dramatically modify phase transformation pathways leading to interesting insights and applications in the field of materials- and geosciences.
At present, a dedicated irradiation facility at UNILAC provides different in-situ and on-line techniques to monitor damage formation. This includes sophisticated analytical methods such as high resolution microscopy and X-ray diffraction for the investigation of beam-induced surface and bulk modifications. In addition, optical spectroscopy, thermal imaging and residual gas analysis are applied. The irradiation experiments can be performed under various gas atmospheres and under cryogenic to elevated temperature.

Primary author: BENDER, Markus (GSI, Darmstadt)

Presenter: BENDER, Markus (GSI, Darmstadt)

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