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Swift heavy ion irradiation effects on tailored nanostructures

Understanding how nanomaterials respond to radiation is essential for their reliable use in high-dose environments. At the nanoscale, size effects play a critical role, fundamentally altering energy dissipation mechanisms and influencing both intrinsic material properties and device performance. To deepen our understanding of ion–matter interactions in confined geometries, systematic studies are indispensable.
In this presentation, we will give an overview of our current activities on the study of swift heavy ion irradiation effects on Bi nanowires. We have synthesized Bi nanowires with diameters ranging from 20 nm to 600 nm by electrodeposition into ion track-etched polymer templates. These wires were exposed to swift heavy ions (1–2 GeV) at the GSI UNILAC linear accelerator, with fluences from 5x10^10 to 10^12 ions/cm^2 to study size-dependent structural changes under ion irradiation. Bismuth is particularly well-suited for such studies due to its long characteristic electronic length scales, such as the Fermi wavelength and electron mean free path, which make size effects prominent even at relatively large dimensions. Furthermore, its semi-metallic nature, low electrical conductivity, and low melting point contribute to formation of ion tracks of significant size. SEM and TEM analyses reveal distinct, diameter-dependent morphological changes, including crater formation, empty cavities, and perforations. Atomistic simulations using a thermal spike model support our experimental results and also show a variety of damage topologies, depending on initial track size and stopping power.

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