Gallium Nitride's Behavior under Strongly Ionising Irradiation: from Bulk to Surface

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Understanding the response of Gallium Nitride (GaN) to strongly ionising radiation is pivotal for developing the new generation of radiation-hard semiconductor devices. While GaN is renowned for its high radiation resistance, accurately predicting the effects of ionising radiation remains challenging due to the complex phase-transition diagram and defect creation-annihilation dynamics inherent in group-III nitrides. Here, we employ a combination of the Two-Temperature Model, Molecular Dynamics simulations, and Transmission Electron Microscopy to investigate the response of GaN to Swift Heavy Ions (SHI) at the atomic level.

Our findings highlight the remarkable tendency of GaN to recrystallise the regions melted by impinging ions. Deep in the crystal, the crystalline lattice keeps the molten track well confined, which improves the recrystallisation efficiency [1] and leads to a relatively high energy threshold for permanent ion track formation. In contrast, such confinement is disrupted by the surface, hindering the recrystallisation process and consequently reducing the track formation threshold [2].

The presence of the surface induces yet another change in the ion-solid interaction. While, upon ion impact, the lattice in the bulk primarily expands radially, the surface introduces an additional degree of freedom, allowing the lattice to expand upwards. This surface-induced pressure gradient gives rise to substantial sputtering during the initial stages of ion interaction. Due to this, the ion track morphology near the surface typically contains pits, shallow voids and nanohills.

Overall, our study offers insights into the effects of strongly ionising radiation on GaN, underscoring the paramount importance of accounting for surface effects when studying the radiation damage in this material.

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[2] M.C. Sequeira *et al.*, Small, **18**, 2102235 (2022)