Detailed study of the ion emission from a germanium crystal surface under impact of fast heavy ions in channeling conditions

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When a swift ion beam is sent parallel to a major axial direction of a single crystal, the energy deposition close to the surface varies typically by one order of magnitude depending on the impact parameter at entrance (which defines its transverse energy): ions entering at the largest distance from the atomic strings experience very low electron densities, and they will transfer most of their energy by distant collisions only. On the opposite, ions penetrating the crystal very close to an atomic row undergo close collisions with core electrons, the density of which is very high. Such ions induce many ionizations of the neighboring aligned atoms, which might provide a test for Coulomb explosion.

Ion emission from the entrance surface of a thin Ge crystal aligned along the <110> axial direction was measured. The projectiles, delivered by the GANIL accelerator (France), were Pb²⁺ ions at 6.5 MeV/u, Pb⁶⁺ and Pb⁷⁺ ions at 29 MeV/u. Secondary ion yields, together with the mass identification of the detected species, were measured by means of a multi-anode time of flight mass spectrometer. Transmitted projectiles were charge- and energy-analyzed using the high resolution SPEG spectrometer. Thus the detailed ion emission was measured event-by-event as a function of the transverse energy of channeled projectiles.

Although the experience was performed under secondary vacuum conditions, we observed a strong dependence of the secondary ion yield from the amorphous surface layer upon the projectile distance of approach to the <110> Ge strings of the underlying crystal. We discuss this dependence as a function of the incident charge and velocity, i.e. on the local density of the deposited energy.