RADIATION DAMAGE EFFECT STUDIES WITH ENERGETIC HEAVY ION BEAM

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Primary process of radiation damage in solid materials is an atomic displacement resulting in the production of lattice atom defects, i. e., pair of vacancy and interstitial atoms, and defect clusters. When metallic materials are in high temperature, void formation and swelling are induced as a consequence of agglomeration of vacancy clusters, which is a typical phenomenon in nuclear reactor core structural materials, especially in fast breeder reactors and even in pressurized water reactors. Atomic displacement takes place principally via nuclear elastic interaction of energetic particles like neutrons and ions with materials. On the other hand, it is known that electronic interaction also makes important contribution to radiation damage evolution, e.g., radiation annealing. Furthermore with very high energy heavy ions, special kind of damage called columnar defects with nano-scale diameter are formed along the incident ion path via very strong electronic interaction of the projectiles. The defects with almost amorphous structure are observed in cuprate high temperature superconductors irradiated with GeV-energy heavy ions. Magnetization of the superconductors can be extremely improved through strong pining behavior of the columnar defects for magnetic flux. Another recent topics which is concerned with electronic interaction regime is secondary ion emission and sputtering by highly charged heavy ions. As potential energy of the projectile ions increases remarkably with increasing charge state, the ions can give very high electrostatic energy on the materials surface, and eventually ionic and atomic sputtering is enhanced extremely via Coulomb explosion machanism.

In this presentation, among our experimental experience, void swelling in nuclear reactor materials, columnar defect formation and magnetic property improvement of high temperature superconductors, and novel sputtering induced by highly charged ions are introduced.