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Impact of He+ ion irradiation on CuO nanostructures: defect formation and structural analysis

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Copper (II) oxide (CuO), a stable, abundant and environmentally friendly p-type semiconductor with a narrow bandgap ranging from 1.21 to 1.55 eV, is increasingly investigated for advanced optoelectronic devices. Among the various approaches to tailor the properties of materials, defect engineering stands out, including thermal treatments, doping and irradiation, as key techniques to control and modify defects within the materials. This work explores the structural evolution and defect dynamics of nanostructured CuO under He+ ion irradiation with doses up to 3.38×10^16 particles/cm². Scanning electron microscopy (SEM), X ray diffraction (XRD) and positron annihilation spectroscopy (PAS) were used to study the irradiated CuO nanostructured layers. The results revealed competition between different mechanisms: lattice recovery and defect formation processes. Besides, the width of a defective surface layer dominated by a high concentration of complex defects was quantified. This corresponds to significantly high positron lifetimes, attributed to positron trapping at defects on the spatially separated nanorod surfaces. Irradiation induces initial defect creation followed by lattice recovery at short irradiation dosis, and the competition of three radiation induced processes at longer irradiation times (i.e. vacancies creation, complex defects creation and its reduction). These findings deepen understanding of defect engineering in nanostructured CuO and its applications in radiation-exposed environments.

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