

Ion-induced Collective Rotation of Nanocrystallites Observed With X-ray Diffraction

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Systematic changes of grain orientation in nanocrystalline materials after irradiation with swift heavy ions were studied in case of Ti, TiN and NiO. A few micrometer thick layers of Ti and TiN were deposited on Si substrates and irradiated with 350 MeV Au ions up to $3E^{15}$ ions/cm² at 80 and 300 K. Beam and surface normal subtended an angle θ of 30°. Single crystals of NiO (~1mm thick, orientation (100) and (111)) were irradiated with 600 MeV Au at 300 K and $\theta=0$ and 45°. All irradiations were performed the ISL facility at HMI Berlin. Crystallite orientation was measured as a function of ion fluence using x-ray diffraction at the KMC2 beamline at BESSY synchrotron light source or conventional x-ray diffractometer on-line at the accelerator.

Orientation distribution in unirradiated Ti and TiN layers was cylindrical symmetrical around the normal to the sample surface. During irradiation two concurrent effects were observed:

- 1) The cylindrical symmetry was broken and new texture appeared with narrow distribution around a preferred orientation, the so called mosaic texture, and
- 2) the orientation distribution (texture) rotated as a whole. The vector characterizing the rotation depended on the direction of the impinging ion beam. Before the other effects destroyed the cylindrical symmetry the texture rotated through more than 80°. Moreover, for small fluences, this rotation was reversible, i.e., changing the sign of θ changed the sign of the rotation. NiO single crystals remained single crystalline when irradiated with 600 MeV Au at $\theta = 0^\circ$. Changing to $\theta=45^\circ$, however, the crystals fragmented rapidly ($\sim 1E^{13}$ Au/cm²) into small (~30nm diameter) well-aligned nanocrystals and exhibited crystallite rotation like in Ti and TiN.

The crystallite rotation is described qualitatively by the assumption that the ion beam provokes ion hammering in the non-crystalline parts of the sample, i.e. the disordered grain boundaries, The crystalline grains rotate because they are carried embedded in the shearing matrix. This shear motion is evidenced experimentally by measuring the motion of the irradiated surface similar to previous work [1].

[1] A. Gutzmann and S. Klaumünzer, *Nucl. Instr. Meth.* **B 127/128** (1997) 12.