X-RAY DETERMINATION OF THE INFLUENCE OF CRYODEFORMATION ON THE MICROSTRUCTURE OF ULTRAFINE-GRAINED/NANOCRYSTALLINE TITANIUM

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Investigation of the deformation microstructure of nanocrystalline (NC) and ultrafine-grained (UFG) materials is of great interest for optimizing their unique physical and mechanical properties. In most cases, to obtain materials of this class large plastic deformation modes [1]. Given the coexistence of anisotropy of physico-mechanical properties and crystallographic texture of hcp titanium, it is important to study the directional microstructural inhomogeneity or morphological anisotropy of structural elements.

Material and experimental procedures

The initial x-ray data were obtained by scanning two surfaces of a sample, namely the rolling plane (∥) and the plane perpendicular to the rolling direction (⊥). In order to ascertain the anisotropy of the microstructure, a comparative analysis of diffraction patterns, relative integral intensities *I*, dimensions of crystallites (coherent scattering regions) *L* and microdeformation values $<\varepsilon^2>^{1/2}$ in the rolling plane and in the plane perpendicular to the rolling direction (RD) was performed by comparison. The values of relative integral intensities Ī were obtained as the ratio of the absolute integral intensity of the reflection I to the absolute integral intensity of the diffraction peak (1011).

The microstructural elements of the emerging structural states and their parameters were determined by the activity of deformation modes - slip and twinning. Their activity depended on the degree of cryorolling [2].

Results

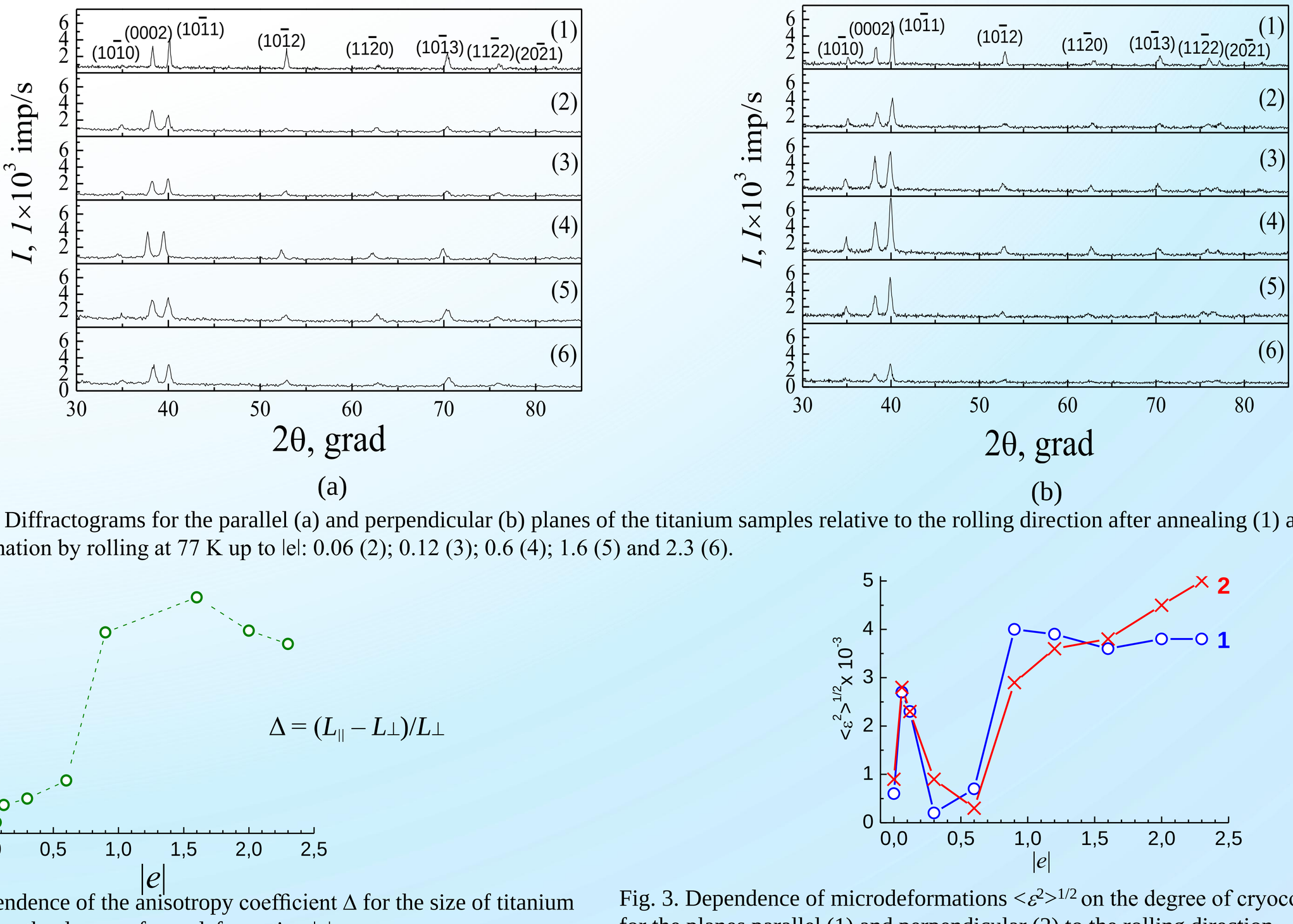

Fig. 1. Diffractograms for the parallel (a) and perpendicular (b) planes of the titanium samples relative to the rolling direction after annealing (1) and after deformation by rolling at 77 K up to |e|: 0.06 (2); 0.12 (3); 0.6 (4); 1.6 (5) and 2.3 (6).

Fig. 2. Dependence of the anisotropy coefficient Δ for the size of titanium crystallites on the degree of cryodeformation |e|.

Fig. 3. Dependence of microdeformations $<\varepsilon^2>^{1/2}$ on the degree of cryocompression |e| for the planes parallel (1) and perpendicular (2) to the rolling direction.

Conclusions

The complex nature of the observed change in the height and width of the diffraction profiles reflects the evolution of microstructure which is associated with the generation of a nanocrystalline state and determined by the level of defectiveness and by a decrease in the CSR size. The difference in intensity distribution is determined by crystallographic randomization of microstructural elements.

Dependencies of crystallite sizes on a degree of cryocompression for two mutually perpendicular surfaces are similar and correlate with the stage character of the change in grain size.

The effect of morphological anisotropy of crystallites/grains is most pronounced for the nanocrystalline state.

The observed complex variation in the microdeformation with compression deformation is well correlated with relative slip and twinning activity, which affect the level of local internal stresses and the possibility of their relaxation.

Literature

1. M.A. Meyers, A. Mishra, D.J. Benson, Progr. Mat. Sci. **51**, 427 (2006).
2. V.A. Moskalenko, A.R. Smirnov, A.V. Moskalenko, Low Temp. Phys. **35**, 905 (2009).