MICROMECHANICAL INTERPRETATION OF MICROPIPES MORPHOLOGY IN BULK SIC CRYSTALS

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Due to the improvement of the production technologies, SiC single crystals are gradually becoming one of the main materials for high current - high power electronics. Diameter of commercial SiC ingots has recently grown from 50 to 100 - 150 mm. The density of defects therein decreased by several orders. In particular, the density of micro-pores threading along the entire length of ingot, i.e. dislocated micropipes, has become less than 1 cm^{-2}. However, not all the features of their formation explained and further study is required to eliminate these defects.

We report on theoretical and experimental investigations of micropipe morphology in SiC single crystals grown by the sublimation technique [1]. Micropipes were imaged by means of phase contrast technique in Synchrotron radiation (SR) with photon energy greater than 10 keV. Unmonochromated x-rays had the spatial coherence of $L_s = 42$ μm. The computer simulation of phase contrast images [2] allowed the determination of 3D micropipe morphology from only one 2D projection. We measured the micropipe parameters in the three directions: parallel and normal to the x-ray beam and along their axis. Remarkable effectiveness of the simulation approach made it possible to detect instabilities in their shapes and sizes.

A theoretical model of transformation of threading lattice dislocations into micropipes through the nonequilibrium processes of pipe diffusion and coagulation of vacancies is suggested. The model includes the following main stages: (1) heterogeneous formation of dislocations elongated along the *c* axis and reaching the front of the crystal growth; (2) pipe diffusion of vacancies from the surface into the crystal bulk through the cores of these dislocations; (3) coagulation of these vacancies around the dislocation lines; (4) forming a continuous cavity (micropipe) around dislocations and leveling its surface by surface diffusion of vacancies. Under this scenario of micropipe formation, the formation of oblate micropipes can be explained by their trend to comprise some dislocations (dislocation bundle) at once with minimizing the micropipe surface. The largest size of the micropipe cross section is then approximately equal to the distance between the farthest dislocations in the bundle. If the dislocation bundle is a self-screened ensemble of dislocations, from a dipole to an arbitrary multipole, then the driving force of the dislocation agglomeration inside one micropipe is total annihilation of dislocations there, while the main limitation of such agglomeration is that the bundle size cannot be larger than its critical size d_c. If the dislocation bundle consists of dislocations of the same sign (or of opposite signs but when the number of dislocations of one sign differs from the number of dislocations of the opposite sign), then the driving force of the dislocation agglomeration within one micropipe is a decrease in the strain energy density near the bundle. The main limitations in this case are that (1) the Burgers vector magnitudes of the residual dislocations must be larger than a critical value b_c and (2) the transverse size of the bundle of residual dislocations (the largest distance between them) must be in the range between two critical values d_{c1} and d_{c2}, which is determined by the value of b. Our numerical estimates of critical values d_c, d_{c1} and d_{c2} are in good accordance with the sizes of oblate micropipes observed in our experiments.

References

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DAMAGE AND FRACTURE OF AGED ELASTIC-VISCOUS MEDIA

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Structural polymeric materials and composites based on them are widely used in various fields of modern engineering practice. In actual operating conditions they are subjected to the influence of complex mechanical, physical and chemical factors. Internal physical and chemical processes occurring as a result of these actions lead eventually to a change in there rheological properties. Together, these processes determine the aging of the material. It is possible to distinguish two types of aging: climatic and deformation. In the case of there combinations there are significant changes in the mechanical characteristics that are observed in our experiments performed on alternating active and cyclic loading and aging on specimens of polyurethane at different times of climatic and strain aging. In particular, in experiments with strain aging it is observed that material is hardened considerably, as compared with the specimens tested after climatic aging. To describe them the elastic viscous models of Maxwell and Voight, expressed in the scale of the effective time, are used. These equations are supplemented by a kinetic equation that determines the evolution of the damage state of the