Abstract

A Digital Image Correlation (DIC) technique has been adapted to polycrystalline ice specimens in order to characterize the development of strain heterogeneities at an intragranular scale during transient creep deformation. These heterogeneities are due to the strong viscoplastic anisotropy of the ice single crystal (with only one easy glide plane for dislocations), inducing strong mechanical interactions between adjacent grains during deformation, and the establishment of strong internal stresses. Specimens exhibit a columnar microstructure so that plastic deformation is essentially 2-D with few in-depth gradients, and therefore surface DIC analyses are representative for the whole specimen volume. Local misorientations at the intragranular scale were also extracted from microstructure analyses carried out with an automatic texture analyzer before and after deformation. Highly localized strain patterns are evidenced by the DIC technique. Local equivalent strain can reach values as high as one order of magnitude larger than the macroscopic average. The structure of the strain pattern does not evolve significantly with strain during the transient creep regime. Almost no correlation was measured between the local strain and the Schmid factor of the slip plane of the underlying grain ; this highlights the importance of the mechanical interactions between neighboring grains. At the grain scale, the strong lattice misorientations have been associated to the local components of the displacement. In particular, kink band distortions could be correlated to a displacement along the c-axis measured by DIC. The experimental microstructures were introduced into a full-field FFT model that simulates the behaviour of elasto-viscoplastic polycrystals (CraFT code). The simulated deformation fields present globally the same characteristics as the experimental ones. Most of the localization bands are well reproduced, spatially and quantitatively. However, we could not reproduce the macroscopic behaviour of the specimens upon unloading. The predicted recovery effective strain is one order of magnitude lower than the measured one. This limitation might be linked with the internal stress field induced by the dislocation structure, which is not explicitly taken into account in the local constitutive relation.