Experiments were conducted to investigate deformation-induced processes during in-situ tensile test at elevated temperature. The billets of coarse-grained copper were processed by equal-channel angular pressing (ECAP) at room temperature using a die that had an internal angle of 90° between the two parts of the channel and an outer arc of curvature of ~ 20°, where these two parts intersect [1]. The pressing speed was 10 mm/min. To obtain an ultrafine-grained (UFG) material, the billets were subsequently pressed by route B. by 8 ECAP passes to give the mean grain size ~ 0.7 µm (Fig. 1a).

The constant strain-rate test in tension was performed at 473 K using testing GATAN stage Microtest 2000EW with EH 2000 heated grips which is configured for in-situ electron back scatter diffraction (EBSD) observations. Microstructure was examined by SEM-FEG TESCAN MIRA 3 XM equipped by EBSD detector HKL NordlysMax. The tension test was interrupted by fast stress reductions after different deformation step and observation of microstructure changes was performed.

Despite of a considerable interest in ECAP processing method, there are not many works documenting microstructure evolution and changes during creep testing and determining creep mechanisms of ultrafine-grained materials processed by ECAP. It was found that creep resistance of UFG pure Al and Cu is considerably improved after one ECAP pass in comparison with coarse grained material, however, further repetitive pressing leads to a noticeable deterioration in creep properties of ECAP material [2,3] Recently it was observed the coarsening of the grains in microstructure of ECAP copper during creep at elevated temperature [4]. It was suggested that creep behaviour is controlled by storage and dynamic recovery of dislocations at high-angle boundaries [4,5].

In the present work was found that ultrafine-grained microstructure is instable and significant grain growth has already occurred during heating to the testing temperature (Fig. 1b). Static recrystallization during heating led to the formation of high fraction of special boundaries $\Sigma 3$ and $\Sigma 9$ (Fig. 1d). The tensile deformation at 473 K led to the additional grain growth (Fig. 1c) and during tensile testing (Fig. 2) the nucleation and subsequent growth of cavities were observed.

References:

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Fig. 1: In-situ observation of microstructure after a) 8 ECAP passes, b) subsequent heating to the test temperature, c) $\epsilon \sim 0.1$ at 473 K and d) distribution of misorientation angle

Fig. 2: The dependence of true stress vs. true strain for copper processed by 8 ECAP passes