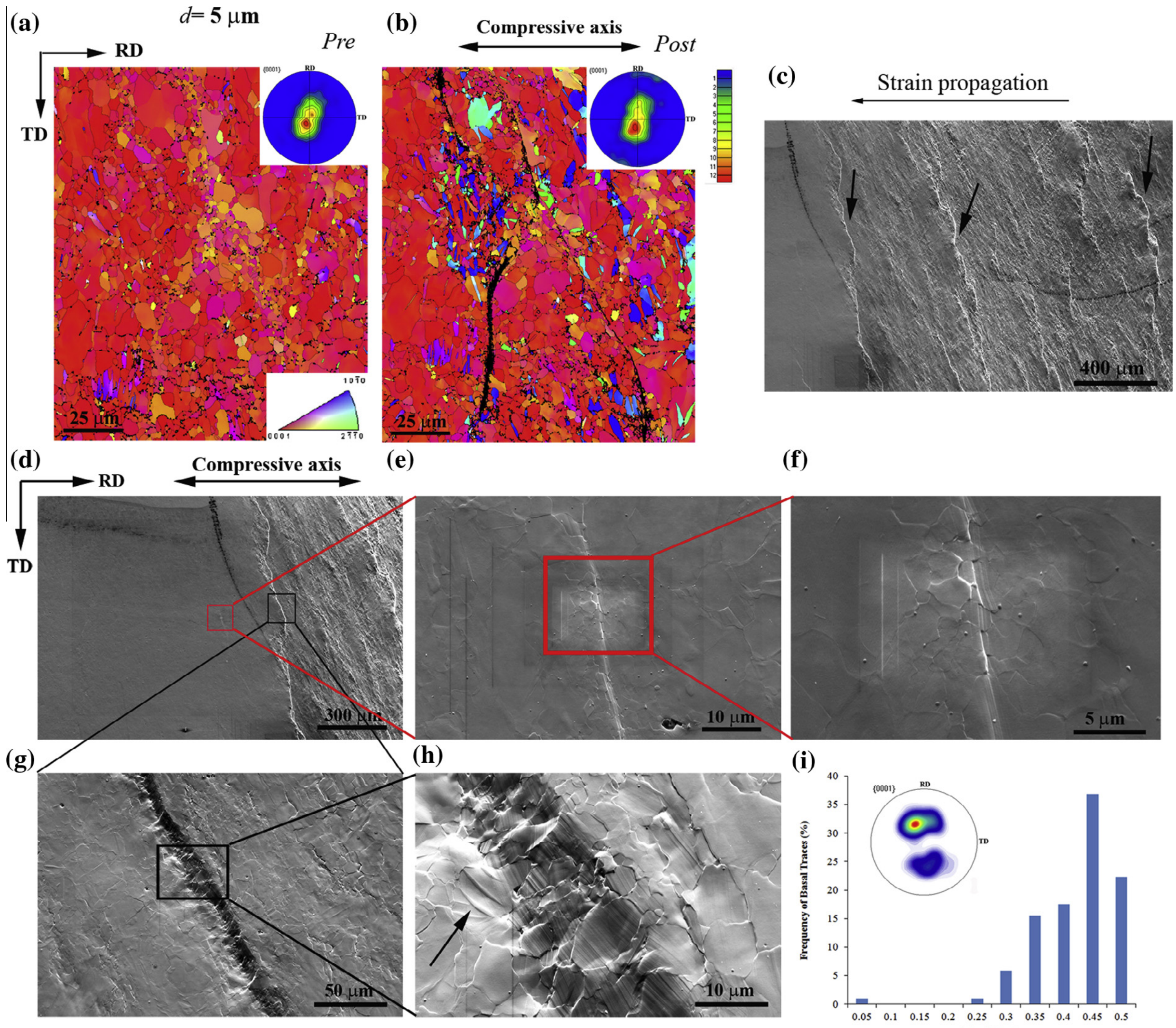

Fig. 3. (a and b) EBSD IPF maps in the ND and {0001} pole figures for the polycrystal with $d = 5$ μm (a) before testing and (b) after a strain of ~10% at 50 °C and 10^{-3} s^{-1}; (c–h) SEM micrographs at different magnifications showing the microstructure within the bands; (i) SF_{basal} distribution of the grains within the bands in which basal slip was observed and the corresponding {0001} pole figure.

corresponding to the grains contained within the bands are very high, indicating that this mechanism becomes active in response to the applied stress. Summarizing, basal slip, localized along well-defined bands, is the dominant deformation mechanism in the polycrystal with an average grain size of 5 μm at 50 °C and 10^{-3} s^{-1}. Altogether, and in agreement with the macroscopic mechanical stress–strain curves of Fig. 1, our microstructural study supports the occurrence of a twinning to basal slip dominated flow transition with decreasing grain size upon yielding.

The high activity of basal slip observed would not be expected due to the low average SF_{basal} that is characteristic of rolled Mg alloys. In a previous publication on the tensile behavior at 50 °C of these same polycrystals [38], the average SF_{basal} were calculated using X-ray diffraction (XRD) and electron backscattered diffraction (EBSD). The corresponding XRD values were 0.230 ($d = 19$ μm), and 0.240 ($d = 5$ μm), and the EBSD values were 0.180 ($d = 19$ μm), and 0.188 ($d = 5$ μm). Therefore, both techniques confirm the resemblance of the macro and micro-texture as well as the presence of relatively poorly oriented grains for basal slip in the two pure Mg polycrystals investigated.

Accordingly, the formation of basal slip deformation bands in the fine-grained polycrystal can be rationalized as follows. Fig. 4 illustrates the misorientation angles (θ) of the GBs across which basal slip transfer could take place (blue bars) and of those at which slip traces were arrested (red bars). It can be clearly seen that $\theta_{th} \sim 30°$ is the upper limit for basal slip transfer. It appears, therefore, that even though the fraction of grains that are favorably oriented for basal slip in the rolled pure Mg polycrystals under study is small, when those grains are connected by boundaries with misorientation angles smaller than 30°, slip transfer takes place easily and, thus, basal slip prevails.

It is, therefore, at this point reasonable to hypothesize that the transition from twinning to basal slip-dominated flow with decreasing grain size could be caused by a change in the "connectivity" between grains that are favorably oriented for basal slip emerging from the processing. Indeed, some properties of polycrystals are known to depend on the topology of the GB networks and this dependence has been modeled using percolation theory concepts [48]. In order to test the validity of the above hypothesis a thorough study of the connectivity between grains that are