Observation of shear bands in metallic glasses

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The possible deformation mechanisms of metallic glasses have received appreciable attention because of their potential application as high strength materials. Under a tensile loading condition, metallic glasses fail catastrophically on one dominant shear plane and show little global plasticity. Conversely, metallic glasses deform in an elastic-perfect plastic manner under a compressive or geometrically constrained loading state. Therefore, multiple shear bands can be observed when the catastrophic failure is delayed by a geometrical constraint, for examplecompression, bending, rolling and local indentation

Examination by SEM reveals a high density of shear bands on the surface of the fractured sample. These shear bands are imaged as almost straight lines on the surface and are oriented roughly at 45 to the loading direction. Vein patterns, a typical fracture characteristic of amorphous alloys, were clearly observed on the fracture surfaces. In the case of BMG matrix composite samples, almost randomly distributed crystalline ductile phase provided the initiation and confinement of shear bands distributed throughout the sample due to the spatial variation in elastic properties as well as the conditions of yielding in the two-phase microstructure system. In the TEM micrograph the shear band appears lighter in contrast than the rest of the micrograph. Depending on the loading condition the shear band remains as an amorphous state or nanometer-size crystalline phase precipitates inside the shear band. Regions outside the shear band are completely amorphous.

Since deformation energy is concentrated in the shear bands, it can lead to the formation of nanocrystals either by directly imposing large permanent strain for atomic rearrangement or by inducing heat adiabatically enabling the long-range atomic diffusion. However, the microscopic mechanism for the deformation-induced crystallization is not yet clearly resolved. In the present study, the nanocrystallization in the shear band has been observed in detail and the possible origin has been discussed.

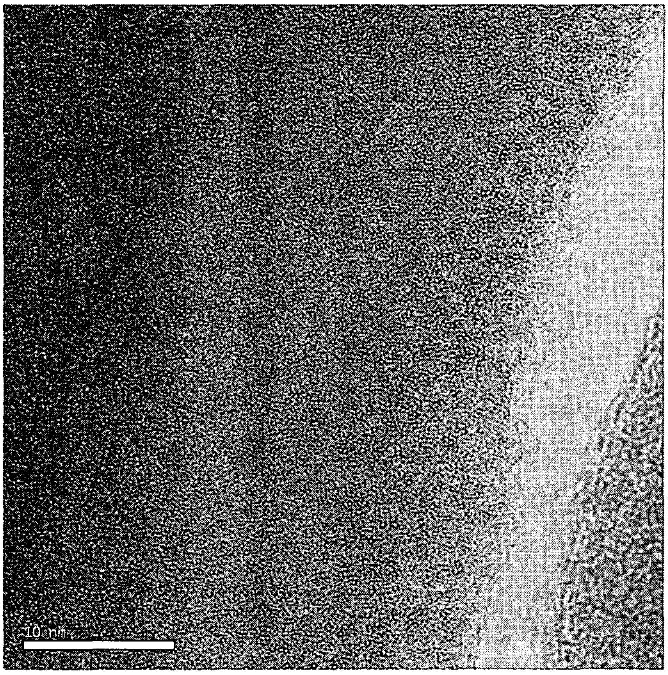

Fig. 1. Ti-based metallic glass에서 in situ straining 시 관찰된 shear band