

TEM OBSERVATIONS OF SYNTHESIZED FORSTERITE CRYSTALS AFTER SHOCK EXPERIMENTS

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Introduction: The apparent strains of olivine crystals can be estimated from XRD analyses and known to be proportionally correlated to the shock pressures loaded on them [1]. In this study, microstructures of experimentally shocked forsterite crystals were observed by TEM after determining apparent strains by XRD analyses using a Gandolfi camera.

Experiments: Shock recovery experiments on synthesized forsterites crystals were carried out at the shock pressures 11.7, 20.8, 34.5 and 46.2GPa. Double polished thin sections (PTSs) of each sample were prepared and observed under a polarizing microscope. Two or three crystals of less than 100 μm in size for each shock-recovered sample were taken out from the center of each PTS and analyzed by an XRD method using a Gandolfi camera to determine the apparent strain of crystals. One crystal for each recovered sample was fabricated to thin film by an FIB method and observed by TEM. TEM observations were carried out by using JEM-200CX at 200kV of accelerating voltage. The shapes and densities of dislocations were observed under the bright field (BF) and dark field (DF) conditions. The Burgers vectors of dislocations were determined under two DF conditions in which dislocations are out of contrast.

Results and Conclusions: The apparent strains of forsterite crystals increase with the shock pressures loaded on them. The apparent strains of selected crystals for TEM observations are 0.031(2), 0.048(4), 0.164(9) and 0.194(7)% for samples shocked to 11.7, 20.8, 34.5 and 46.2GPa, respectively.

By TEM observations, following textures were observed:

For 11.7GPa crystal. The curved dislocations are locally concentrated, while the majority of this sample shows homogeneous contrast in a BF image along [100] zone axis. This texture is thought to be a nucleation source of dislocations [2]. The Burgers vector of dislocations is \mathbf{c} .

For 20.8GPa crystal. Straight dislocations are dominant. Many of them are directed nearly [100], while a few directed [001]. All have the same Burgers vector \mathbf{c} . Most dislocations lie on a crystallographic a-c plane showing that the activated glide plane is (010). The dislocation density is $6.7 \times 10^8 \text{cm}^{-2}$. The dominance of [100] edge dislocations will show the early stage of diffusion of dislocations by the fact that the velocity of edge segments is larger than the screw segments.

For 34.5 GPa crystal. Dislocations are straight and mainly directed [001]. A few dislocations are directed [100]. All have the same Burgers vector \mathbf{c} . The distribution of dislocations is heterogeneous compared with the other samples. The sub-grain boundaries (dislocation array) and cracks also exist. The density of free dislocations is up to $1.3 \times 10^9 \text{cm}^{-2}$.

For 46.2GPa crystal. The straight dislocations are homogeneously distributed and directed [001]. All have the same Burgers vector \mathbf{c} . The sub-grain boundaries and cracks also exist. The density of free dislocations is $1.3 \times 10^9 \text{cm}^{-2}$.

References: [1] Uchizono *et al.* 1999. *Mineralogical Journal* 21:15-23. [2] Leroux H. 2001. *European Journal of Mineralogy* 13:253-272.