EGU21-6928
https://doi.org/10.5194/egusphere-egu21-6928
EGU General Assembly 2021

Development of in situ measurement of solid-state deformation in a large anvil press utilizing a piezoelectric crystal

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In situ measurement of solid-state deformation in a large volume press has historically required use of neutron and x-ray scattering facilities. The lack of widespread availability of these facilities has limited the abilities of researchers to measure in situ deformations on a regular basis. We have developed an assembly that utilizes a piezoelectric crystal within a typical large volume press assembly in a 6-axis press at pressures up to 5 GPa. The basic design of the assembly can be applied to multiple assembly sizes for a wide range of possible pressures. The piezoelectric crystal is a round disk, <1 mm in diameter, that is sputter coated with Au. Copper wires are placed through drilled holes in the side of the assembly, one connected to each side of the disk. The crystal generates a voltage across the two faces when a deviatoric stress is applied that is measured and plotted in real-time during the experiments. The voltage is then used to calculate strain and strain-rate in uniaxial compression. Using the known equation of state of the piezoelectric crystal, such as quartz or gallium orthophosphate, the stresses responsible for the strain can be calculated. Thus, we can measure the stress and strain regime of simple deformation within an assembly in situ in real-time during the deformation. We have measured strain-rates as low as 10^{-7} s^{-1} over a greater than 30-minute timescale. The total strain on the assembly can be measured by the total distance advanced by the press piston, which must be accommodated. Comparing the differences in strain accommodated by the piezoelectric crystal between separate experiments allows us to infer the strain accommodated by the sample under investigation.

Current limitations in measuring lower strain-rates are charge-leakage around the piezoelectric crystal causing a voltage drift during measurements and limitations in high-temperature experiments due to phase transitions during heating in the piezoelectric crystals to phases that are not piezoelectric. Future work will concentrate on finding a suitable, high-resistance material to place around the piezoelectric crystal to limit charge leakage and designing the assembly such that the piezoelectric crystal experiences lower temperature during heating than the sample to avoid phase transitions in the crystal.