Percolation of cracks in annealed alumina polycrystalline aggregates

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Transport properties in rocks are controlled by the connectivity of pores. Grain boundary cracks (open grain boundary) are pervasive particularly in rocks containing quartz grains. What fraction of open grain boundaries are required to form an interconnected network? Numerical experiments on an array of cubic grains have shown that the percolation threshold is 20%. The aim of this study is to determine experimentally percolation threshold of grain boundary cracks in polycrystalline aggregates.

A crack-free alumina polycrystalline aggregate (Coors Tek Co., Ltd., SPHALL, d˜25 μm) was used as a starting material. Thermal cracks are introduced by annealing. Though corundum is anisotropic in linear thermal expansivity, it is difficult to introduce thermal cracks in a very fine grained aggregate by annealing at temperatures lower than 1000 ℃. Cylindrical samples (D=10 mm, L=10 mm) were, thus annealed at 1800-1900 ℃ to accelerate the grain growth. Thermal cracking is facilitated in a sample with larger grains. The average grain size was increased to 120 μm by annealing at 1850 ℃ for 30 hours. SEM observations have shown that there are open grain boundaries in annealed samples. The amount of cracks was characterized by the crack density parameter (O’Connell and Budiansky, 1974), which can be evaluated from measured compressional and shear wave velocities. More cracks were created in a sample with larger grains. The crack density parameter was increased to 0.039. However, impedance measurements on samples filled with brine (0.1 M KCl aqueous solution) suggest that connected paths are not formed. More cracks are required to form an interconnected network of cracks.

Keywords: Percolation, Electrical conductivity, Grain boundary cracks

