

Mechanisms of Na- and K- diffusion in alkali feldspar

**E. Petrishcheva¹, L. Baldwin¹, H. Hutter²
R. Abart¹**

¹ University of Vienna, Vienna, Austria
(elena.petrishcheva@univie.ac.at)

² Vienna University of Technology,
Vienna, Austria

The intracrystalline diffusion of Na⁺ and K⁺ in alkali feldspar is a key control on the rates of composition change and re-equilibration during cooling-induced exsolution. We performed combined inter- and tracer diffusion experiments using gem-quality Eifel sanidine and 41K-doped KCl as diffusion couples. The sanidine is homogeneous down to the nm scale with a potassium site fraction of 0.85 and was machined to cuboid plates with polished (001) and (010) faces. The salt with 95 at.% 41KCl and 5 at.% 39KCl was applied to the polished surfaces as KCl solution, which was gently dried before the diffusion anneal. The crystal-salt diffusion assembly was annealed at 700°C to 950°C for 1 to 336 hours, depending on temperature. After annealing the salt was removed and the ²³Na, ³⁹K, and ⁴¹K concentrations were analysed using TOF-SIMS in depth profiling mode. The profiles testify to the out-diffusion of Na and in-diffusion of K. At the same time, ³⁹K (94 at.% of natural K) was exchanged with ⁴¹K from the salt. The different rates of Na- and K-diffusion lead to a peculiar maximum of the ³⁹K content in an interval, where Na has already been lost and ⁴¹K has not yet arrived.

We derive a model for describing multicomponent diffusion in ionic solids. The model accounts for both, vacancy-mediated self-diffusion of ions and binary exchange between ions. The model equations are derived in the most general form following the Cahn-Hilliard approach. To this end, we utilize system's free energy and Onsager's reciprocal relations. The resulting diffusion equations for the individual components are essentially nonlinear. In our approach the concentration-dependence of the diffusivities is derived analytically from basic principles. The derived equations are solved numerically and the results are verified with the experimental data for the Na-³⁹K-⁴¹K three-component system. This allows us to quantify both the Na- and K-self-diffusion coefficients and diffusivities resulting from the binary exchanges. The resulting coefficients agree with those published by other authors and have clear physical meaning.