Multicomponent diffusion in industrial glasses and thin films

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Abstract

Chemical diffusion is an essential transport mechanism in silicate melts and glasses. In magmatic processes, as well as in the glass industry, chemical diffusion at high temperature plays an important role for crystal nucleation and growth, for mineral dissolution and for phase separation. Closer to the glass transition, diffusion controls ionic exchanges for strengthened glasses, and exchanges between glass substrates and thin films.

Multicomponent diffusion models the cooperative nature of species mobility, using a diffusion matrix. The diffusion matrix approach is necessary to account for phenomena such as uphill diffusion, in which a gradient of an initially-constant species arises because of couplings with other species. Diffusion coefficients are obtained as the eigenvalues of the diffusion matrix, while eigenvectors describe couplings between species, in the form of exchange reactions.

In this talk I will focus on multicomponent diffusion in several compositions of industrial interest. I will first explain how to obtain
diffusion matrices from experiments. Then I will describe the reaction exchanges evidenced by diffusion eigenvectors and their energetics. Finally I will discuss the consequences of multidiffusion for several situations of industrial importance such as homogenization of melts in furnaces, dissolution of raw materials, refractories corrosion or interaction between glass substrate and thin films.

Keywords: chemical diffusion, diffusion matrix, dissolution, thin films

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