Insights into Diffusion in Solids from Inside

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Diffusion in solids, as compared to that in liquids, is relatively slow due to the fact that elementary atomic jumps in solids depend on the presence of defects, e.g. vacant lattice sites, being formed in thermal equilibrium concentrations or induced extrinsically. While the overall atom displacement ('diffusion length') in a solid is typically only 1 mm per year at room temperature, the order of magnitude of the corresponding jump rate, however, is as high as 10^6 per second.

The most versatile experimental method to gain detailed insights into the microdynamics of the moving atoms or ions and their structural environment is nuclear magnetic resonance (NMR) spectroscopy which utilizes spin bearing nuclei inherent in the solid as 'internal spies'. A variety of NMR techniques, which includes measurements of spin-lattice relaxations in laboratory and rotating reference frames, lineshape narrowing, exchange NMR and spin-alignment echoes, give access to jump rates over more than ten decades and the corresponding energy barriers. In certain cases information on the jump geometry may be obtained as well. Combining the NMR results with those of other microscopic and macroscopic diffusion methods such as ac and dc ionic conductivity and mass tracer measurements and comparing solids in different structural forms gives additional insights, e.g., into diffusion mechanisms. Recent examples of diffusion studies in different classes of materials include in particular Li ion conductors in crystalline, nanocrystalline, nanoglassy and glassy forms [1- 4].

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