1.6 Chemical equilibrium and reactions in solids

"Chemical reactions" in solids often occur (only) at high temperatures and sometimes it is not obvious that the concepts of chemical equilibrium reactions can be applied for their description because they run under completely different names, e.g. defects and defect formation in Si (mono- and multi-crystalline) at high temperatures (while e.g. block casting or at device processing) show many similarities to chemical reactions. Electrochemical reactions (Butler-Volmer-kinetics) are described nearly identical to the standard diode equation. Charging and discharging of (e.g. Li ion battery) anodes and cathodes are examples for chemical reactions within solids at room temperature. Recent silicon solar cell efficiencies are limited by two meanwhile famous recombination active defect types (Iron-Boron pairs, Oxygen-Boron complex). Both defect types can change their state (and correspondingly their recombination activity) by inducing light and/or applying moderate temperatures. Especially the up to now not (well) understood Oxygen-Boron complex is the obstacle for using standard (quite cheap) p-type (Boron doped) CZ silicon for high efficiency solar cells. So although in silicon the effective mass of electrons is by more than a factor of three smaller than the effective mass of holes and thus allowing for a much more efficient diffusion of electrons (as minority carriers) through the bulk of a p-type Si solar cell, there is a clear trend to use n-type Si for high efficient silicon solar cells.

Essentials:

- Chemical reactions are very important in solids as well, but often only at high temperatures
- It is close to useless to learn the concepts of equilibrium chemical reactions using solid state examples, since nearly always "slight" adaptations due to "transport limitations" are necessary
- The relevant transport mechanisms like diffusion and Brownian motion (i.e. Maxwell distribution of speeds) must first be discussed fundamentally before they can reasonably be used to describe, e.g. non equilibrium, steady state, and relaxation time constants.