But lifetime is important at the end of solar cell fabrication during which it can undergo strong variations. This issue is handled in different ways in a laboratory and a factory environment. In the laboratory, measures are taken to maintain long initial lifetimes by avoiding contamination during high-temperature steps: furnace cleaning, ultra pure chemicals and so on. In a rough, industrial environment and with defect-containing (Cz- and mc-Si) materials, the problem is more complex: in addition to contamination from the surroundings, impurities and defects in the substrate move, interact and transform at high temperature. The solution is to integrate gettering steps [38] in the fabrication flow that reduce the impact of contamination, and to tailor the thermal treatments to the peculiarities of the material. Final substrate lifetimes of industrial cells range from 1 to 10 μs.

Gettering techniques eliminate or reduce contaminant impurities in a wafer, and so neutralize the effect of lifetime reduction. Although gettering processes are not always well understood, it is admitted, in general, that in a gettering process a sink region is formed, which is able to accommodate the lifetime-killing impurities in such a way that they are not harmful to the device being manufactured, or at least they are where they can be easily removed.

In solar cell fabrication, we take advantage of the fact that phosphorus and aluminum diffusions, appropriate candidates for emitter and BSF layers, respectively, produce gettering in certain conditions [39]. Other techniques have been explored [40, 41], but their integration in a solar cell process is not so straightforward.

P gettering effect has been proved for a wide variety of P diffusion techniques (spin-on, $POCl_3$, PH_3 etc), provided diffusion is done in supersaturation conditions (i.e. over its solid solubility in silicon). Unfortunately, this leaves a “dead layer” of electrically inactive phosphorus near the surface, which reduces UV response of the cells in case it is not etched away [42]. Another phenomenon related to this supersaturated P is the injection of silicon self-interstitials to the bulk of the material, which is responsible for an enhancement of the gettering effect [43].

When Al is deposited on Silicon (by different techniques such as sputtering, vacuum evaporation or screen printing) and annealed over the eutectic temperature (577°C), a liquid Al-Si layer is formed, where impurities tend to segregate because of their enhanced solubility [44]. They will remain in this gettering layer while cooling, so that bulk lifetime will improve after the process.

Another approach to improve material quality is “bulk passivation”, a treatment with hydrogen, for example, during SiN_x deposition, to which some defected materials respond very well [45].

7.3.2.2 Doping level and type

Both laboratory record-efficiency and industrial cells use boron-doped substrates. Rather than fundamental advantages [46], there are practical (properties of P diffusion, easiness of Al alloying) and historical reasons for this preference [47]. However, the situation may change once the role of boron in the degradation of Cz-Si cells under illumination has been established [48].