Selective emitters are being developed at the laboratory level for screen-printed solar cells. A number of techniques have been proposed [84] that are compatible with the screen-printing process; none of them is at present implemented in production lines:

- Two separate diffusions for metallized and unmetallized regions, the heavy diffusion being restricted to the regions to be metallized by a screen-printed mask.
- A homogeneous and thick emitter is diffused by conventional means; a screen-printed mask is applied to protect the regions to be metallized from the plasma etch that follows. In this way, in the unprotected regions the emitter is thinner and less doped.
- Self-aligned selective emitter by diffusion from a patterned solid dopant source: under the dopant source a highly doped emitter is formed, while a much lighter diffusion from the gas phase takes place at the uncovered regions.
- First a high sheet resistance emitter is formed to which self-doping pastes containing phosphorus as well as silver are applied. Firing is performed above the silver–silicon eutectic temperature, thus leading to the formation of an alloyed layer heavily doped with phosphorus [85].

Except the last one, all the techniques require some kind of pattern aligning to print the front contact fingers on the heavily doped regions. Automatic screen printers feature enough accuracy to perform this task.

Obviously, the unmetallized part of these emitters is sensitive to surface passivation, which must thus be implemented by oxidation or nitride deposition.

7.5.4 Rapid Thermal Processes

In conventional furnaces of the closed-tube or conveyor-belt types, not only are the wafers heated to the process temperature but also the equipment itself: chambers, substrates or boats and so on. This brings about (1) long heating–cooling times, due to the large thermal masses involved, (2) a high potential for contamination, since a lot of parts, some of them metallic, are held at a high temperature and (3) high-energy consumption.

On the other hand, the microelectronic industry has developed in the last years, so-called *rapid thermal processes* (RTP), whereby only the wafers, and not their environment, are heated up to high temperature. Selective heating is accomplished by intense UV illumination of the semiconductor. The interest of RTP for solar cell fabrication comes from very short thermal cycles down to a few minutes including heating and cooling, so that throughput can be boosted. Besides, the absence of hot parts in the equipment diminishes potential contamination and energy consumption.

At the laboratory scale rapid thermal diffusion of very thin emitters (which is beneficial from the electrical point of view) has been demonstrated. Rapid thermal firing of screen-printed contacts and aluminum alloying have also been successfully implemented, along with other promising techniques such as rapid thermal nitridation and oxidation of the surfaces for passivation purposes [86, 87]. It can be said that every thermal step in the solar cell process can be made by RTP.

A possible drawback of the technique is a degradation of substrate lifetime as compared to conventional processing of some materials, due to the formation and quenching-in