better surface passivation is achieved. On the other hand, bulk passivation is reduced. This technique has been developed at the laboratory level in the last decade, and is currently being introduced into the industry. Figure 7.11(b) shows a sketch of an industrial remote PECVD. It implements a continuous feed of wafers, an advantage that should be compared to the batch-type direct PECVD.

7.6.3 Optical Confinement

Anisotropic texture with alkaline solutions (NaOH or KOH), standard in single crystal solar cells, is also applied to multicrystalline wafers, but with much poorer results, which is one of the reasons for their reduced performance. Reflectance of the textured wafers is relatively high because for randomly oriented grains the etch rate is not the same as that of (100) crystals. Another drawback is the existence of steps between grains, which may cause interruption in the screen-printed metal contacts.

That is why new alternatives are being considered. Their evaluation should take into account not only gains in reflectivity, but also surface damage and compatibility with metallization. In any case, the potential of some of these have been proved, and they are now being developed for industrial applications. Others need more research. The surface features produced by some of these are comparable in size or smaller than the wavelength, and geometrical optics is no longer applicable. They act as diffraction gratings, as scattering media or, in the limit of very small feature size, as graded index layers.

7.6.3.1 Chemical texturing

Several chemical techniques have been proposed. Some of them result in an inverted pyramid structure, but need photolithography patterning, which is a serious drawback for compatibility with the industry [103]. The result of nearly 20% for a mc-Si solar cell relies on an oxide-forced acidic texturing scheme [104]. A simpler approach is based on isotropic etching with an acidic solution containing nitric acid, hydrofluoric acid and some additives. The resulting etch pits of 1–10 μm in diameter are uniformly distributed, giving a homogeneous reflectance over the surface of the wafer and the absence of steps between grains (see Figure 7.12). An increase of short-circuit current of about 1 $mA{\cdot}cm^{-2}$ is reported for solar cells processed on isotropic textured wafers when compared to cells processed on anisotropic textured wafers [105]. Some technical difficulties, such as depletion of the solution and exothermic effects, can be encountered to come to an industrially compatible processing step. An automatic wet-bench, with temperature control of the etching solution and automatic replenishment of chemicals, has been designed recently.

Reduction in reflection, by forming porous silicon, is also being developed [106]. A detailed analysis taking into account the sum of reflectance and absorption within the porous Si layer shows an optimum of about 5 to 6% total optical loss. Besides its potential, the compatibility of the porous Si formation with screen-printed contacts still needs to be addressed.

7.6.3.2 Mechanical texturing

V-grooves about 50-μm deep can be formed in Si wafers by mechanical abrasion using conventional dicing saws and beveled blades, followed by an alkaline etching to reduce