Qualification tests consist in verifying the module integrity by visual inspection, measurement of the electrical performance at STC and of the electrical isolation before and after treatments that simulate, in an accelerated manner, real operation conditions. For instance, the IEC Standard 61 215 [143] specifies the following:

- Ultraviolet exposure using xenon lamps.
- Thermal cycling (-40°C to 50°C, 50 cycles) in climatization chamber.
- Humidity freeze cycling (thermal cycling with 85% relative humidity).
- Damp heat (1000 h at 85°C and 90% relative humidity).
- Twist test for testing resistance to torques.
- Pressure is applied to the module to test resistance to static mechanical loads.
- Hail impact test, where the module is stricken by 25 mm diameter ice balls at 23 m seg^{-1}.
- Outdoor exposure.
- Hot spot tests, where the module is selectively shaded.

Different test combinations are applied to a sample of a few modules. The modules will qualify if no major failures are found and the visual inspection reveals no damage, the electrical power is within 90% of specifications, and isolation is maintained.

7.11 CONCLUSIONS

This chapter has reviewed current state of crystalline silicon solar cells and modules. The main lines defining the structure of the described situation can be summarized as follows:

- *Changing scale*: The current booming of the markets enables and fosters technological and processing improvements.
- *Laboratory-industry gap*: There is a mature technology at the laboratory that has led to impressive performance levels, on the one hand, and a reliable, fast, 30-year-old industrial process producing modest efficiency, on the other hand. Closing this gap is the key to a lower \$ Wp^{-1} figure of merit.
- *Novel silicon materials*: Market growth and the threat of silicon shortage stimulates new materials and very thin substrates that demand new technological solutions.
- *Technology diversification*: These two challenges are to be faced by solar cell production technology in the coming years. Intensive preindustrial research is being conducted and solutions are being developed along several different lines.
- *Quality*: Product reliability and durability and environmental and aesthetical friendliness are as important as cost for the growth of PV industry and this also influences technology.
- *Long-term scenario*: Alternatives to crystalline silicon technology are being researched thoroughly and presumably some of them will succeed in reducing photovoltaic costs to competitive ones. Nevertheless, for these so-called "leapfrogs" to take place, a mature PV market should consolidate, for which silicon technology is essential at least for the next decade.