(c) Zone-melting recrystallization (ZMR)

In zone-melting recrystallization, a narrow zone on the surface of the sample is melted with heating. The film is recrystallized by moving this melted zone around the surface. A range of energy sources, including strip heaters, electron beams, and radio-frequency (RF) heaters, have been used. Because the thin film is heated to the temperature around the melting point of silicon ($\sim$1200°C), this method is not suitable for the crystallization of an a-Si film on a normal glass substrate. For the other kinds of low-cost substrate (such as metallurgical Si and carbon), preventing the impurity diffusion from the substrate to the film is also a major issue. Ishihara *et al.* reported impressive results for solar cells fabricated on poly-Si thin films obtained by ZMR technology [84].

(d) Laser-induced recrystallization

XeCl excimer laser recrystallization (ELR) and annealing (ELA) of a-Si has been studied extensively in recent years. Although most works are concentrated on the use of this method for thin-film transistor (TFT), it is also used for solar cells. The focused short-pulsed laser beam is scanned over the a-Si or μc-Si thin film to heat the sample. In laser recrystallization, depending on the power of the incident light, the part of the thin film under illumination can be either in liquid phase (melted totally) or in liquid + solid phase (partly melted), which will result in different grain sizes. It is interesting that the grain size does not increase even though the temperature in the thin film is around the melting point of Si. Because short-pulse laser is used, the temperature of the substrate can be much lower than that of the film; this is a major difference between ZMR and ELR. By placing a thin oxide and/or nitride layer between the substrate and a-Si, both heat transfer from the thin film to the substrate and impurity diffusion from the substrate to the thin film can be dramatically reduced. Other alternatives such as using prepatterned a-Si and multiple-step laser processing can improve the quality of the film. TFTs fabricated on ELR films have yielded excellent overall performance [85]. At present, solar cells fabricated on laser-crystallized Si have achieved conversion efficiencies close to 9%.

Solid-phase crystallization processing using ELA combined with RTP is also reported [86]. The ELA treatment can be at a temperature of 550°C. Poly-Si thin films with a grain size as large as several microns have been obtained.

8.3.6 Processing Considerations for TF-Si Solar Cell Fabrication

The performance of crystalline Si solar cells is strongly controlled by impurities and defects in the material [87]. Although the quality of the starting material used for wafer-based commercial Si solar cells is quite poor, the PV industry has developed solar cell fabrication methods that improve the material quality during the cell fabrication. As explained in the previous sections, one of the advantages of the TF-Si solar cell is its partial immunity to the quality of the material. However, high-efficiency device fabrication does require material quality and processing procedures that may not be compatible with low cell costs unless careful consideration is given to minimizing impurities and defects. It is prudent to include a brief discussion of the processing approaches used to ameliorate deleterious effects of impurities and defects in the design and processing of TF-Si cells.