velocity of grain enhancement, either by introducing some kind of seeds or by activating the grain-boundary movement.

(b) Metal-induced crystallization (MIC)

MIC of a-Si can be used to produce μc-Si with grains larger than those achievable either by thermal annealing of a-Si or by direct deposition of μc-Si by plasma or HW processes. If a-Si is deposited at low temperatures on substrates coated with certain metals, and then heated to a temperature >300°C, the a-Si film can be converted to μc-Si. Alternatively, if the deposition of a-Si can be carried out at such higher temperatures on these metals, one can obtain large-grain μc-Si films directly. Here the metal acts as a catalyst to induce crystallization. The effects of several kinds of metals, such as Sb, Au, Al, and In (which form eutectics with Si), and those of Pd, Ti, and Ni (which form silicides with Si), have been studied. Al is a particularly interesting metal for solar cell because it can offer other advantages, as described in this chapter. Earlier studies on very thin (<1 μm) a-Si films found that Al-induced crystallization of a-Si could occur as low as 167°C [76]. However, the grain size of the crystallized films was very small and the annealing time required was between 10 and 60 min. This led to a conclusion that MIC involves intermixing of metal with Si and the formation of a high concentration of metal alloy in the amorphous/crystalline interface. Furthermore, it was found that the growth of the crystalline phase would stop when no more metal is available.

Although the mechanism(s) involved in MIC are not well understood, it is generally believed that nucleation requires a strong interaction between metal and Si [77–79]. These interactions may involve a solid-phase diffusion or formation of an alloy or eutectic. For solar cell applications, each of these mechanisms must be highly controlled. Incorporation of high metal concentrations into the crystallized Si film poses a major limitation on MIC technique. Typically, MIC-formed Si films have very low minority-carrier lifetime. Solar cells fabricated on them can have severe shunting effects because some of the metal segregates at the GBs. Two approaches have been attempted to overcome these drawbacks in MIC films. One, use of metal-induced lateral crystallization (MILC), in which crystallization is started from a metallized region and then extended laterally into a metal-free area. Typically, Pd and Ni, have been used for MILC which yielded films with a grain size up to several microns [80]. However, it is found that crystallized regions away from the initial metal also have large concentration of metal.

The second approach is to use optical excitation instead of furnace annealing to crystallize an a-Si film deposited on a metallic layer. Because the absorption of optical energy within a Si film is not uniform, optical excitation can be tailored to produce an absorption profile favorable for MIC. In particular, infrared excitation of an a-Si film, deposited on an Al layer, will result in a peak in the energy dissipation near the a-Si-metal interface. Thus, optical processing can initiate nucleation at the interface followed by a grain-enhancement process. Initial work comparing thermal processing and optical processing to achieve MIC of a thin layer of a-Si [81] showed that crystallization by optical excitation occurs very rapidly and at temperatures as low as 200°C – features important for TF-Si solar cell fabrication. Optical excitation can initiate nucleation at the interface and the crystallization propagates into the a-Si film. This process is also accompanied by injection of point defects that promotes grain enhancement. Thus, optical processing is a two-step process – a higher-temperature alloying to produce nucleation,