

followed by a lower-temperature vacancy injection to enhance the grain size and continue conversion of amorphous to crystalline phase. Optical processing of the TF-Si samples is done in a quartz furnace, with tungsten-halogen lamps fitted on one side. The sample is illuminated from the a-Si side. The intensity of the light is controlled to provide a predetermined intensity versus time profile including a slow ramp-up and ramp-down of temperature.

Figure 8.26(a) is an XRD (x-ray diffraction) spectrum of a 3- μm film, deposited by HWCVD at $<100^\circ\text{C}$ on a Al/Cr-coated 7059 glass substrate, showing absence of crystalline structure in the Si film. Only Al peaks are seen in the spectrum [82]. It may be pointed out that it is necessary to deposit a thin layer of Cr on glass prior to deposition of Al to improve the adhesion of Al. Figure 8.26(b) is the XRD spectrum of this sample after optical processing at $\sim 480^\circ\text{C}$ for 3 min. An important feature of Figure 8.26(b) is the presence of two preferred orientations – (220) and (111). One can also notice the existence of a large Al peak due to unused Al. The initial Al thickness was 2 μm . Longer times can also help increase grain size, however, because optical processing is a transient process, its advantages diminish (approaching a thermal process), if the process times are too long. This indicates that the crystallization of a-Si can happen very rapidly with optical excitation processing technique.

If the deposition of a-Si on Al/Cr-coated substrates is carried out at temperatures in excess of 300°C , some crystallization and some (or total) consumption of Al can occur during the deposition itself. Figure 8.27(a) is an XRD spectrum of a 2- μm , Si film deposited by HWCVD at 500°C showing the crystallization was strongly textured in (220) direction. However, optical processing can further enhance crystallization. Figure 8.27(b) shows an XRD spectrum of the same sample after optical processing at 480°C for 3 min. The intensity of the (111) peak becomes much stronger, and the intensity of (220) peak increases more than 200%. The increase in (111) and (220) peaks could result from formation of new grains of the preferred orientations, and/or (more likely) by enlargement of the original grains during processing.

Additional results show that an increase in process time and/or temperature leads to enhancement of grain size, while crystallization spreads over the entire thickness of the a-Si film with two preferred orientations. However, there appears to be an “incubation temperature” at which the grain enhancement begins. We have carried out studies to investigate crystallization at different temperatures. The samples were optically processed to change the maximum light intensity while keeping the process time constant. Figures 8.28(a) and 8.28(b) show the intensity of XRD peaks for (111) and (220) orientations as a function of process temperature. These results are shown for three (3 μm , 6 μm , and 10 μm) thicknesses of a-Si films deposited by HWCVD. The deposition temperatures for these films are as follows: 3 μm at $<100^\circ\text{C}$, 6 μm at $<250^\circ\text{C}$, and 10 μm at $\sim 500^\circ\text{C}$. Each of the XRD measurements was made after calibrating the system with standard reference samples. Hence, the intensities of the XRD peaks are representative of the extent of crystallization in those specific orientations. From these plots, one may also infer that thinner films can be crystallized more readily than thicker ones. Despite the fact that the 6 and 10 μm films had some crystallization occurring during the deposition itself, the incubation temperature is lower for thinner films. This conclusion is also supported by TEM (transmission electron microscope) results, which show that the initial part of the optical process leads to a nucleation occurring over the entire interface. Then a