Analysis of Root Mean Square Roughness of Microcrystalline Silicon Thin Films Using Scanning Probe Image Processor software

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Abstract

We have done an analysis of the root mean square roughness (RMS) of microcrystalline silicon (µ-Si) thin films grown by aluminium induced crystallisation (AIC) using Scanning Probe Image Processor software. Surface roughness profiles from Atomic Force Microscope (AFM) topography images were loaded into SPIP Software. These profiles and images were from films grown at different annealing temperatures. Microcrystalline silicon by aluminium induced crystallisation (AIC) is usually used as a seed layer for further epitaxial thickening using methods such as hot wire chemical vapour deposition and subsequent ion assisted deposition. The seed layer surface should be smooth so that its material properties can be transferred to the epitaxial layer. Films were found to have the largest root mean square roughness at about 470°C in both measurements. A temperature range of 340-420 °C has been suggested for the growth of AIC seed layers that can give intermediate root mean square roughness and significant crystallisation for use in solar cell applications.

Figure 1: Particles as detected by SPIP and the corresponding X and Y profiles for films annealed at 470°C and at 520°C

Figure 2: Step profiler surface roughness raw profile for films annealed at 420°C (a) and the corresponding extracted profile (b)

Figure 3: Extracted step profiler low root mean square surface roughness profile for films annealed at 250°C (a) and the largest extracted root mean square surface roughness profile for films annealed at 520°C (b)

Figure 5: Variation of root mean square surface roughness and Raman crystalline volume fractions of µ-Si from annealed Glass/Al/µSi and Glass/Al/µSi/AIC layers on glass substrates

Figure 4: Root mean square surface roughness histogram distributions of the extracted profiles at temperatures between 250°C and 520°C

Conclusion

Films annealed below 300°C had gaussian histogram distribution of the heights implying relatively smooth films. Films annealed over 420°C had asymmetrical distributions towards large heights, an indication of increasing roughness. Atomic force microscope images root mean square roughness (q RMS) at 450°C and at 520°C had average values of 128 nm and 117 nm respectively for values found by averaging (q RMS) plus mean plane correction and first order plane correction. A temperature range of 340-420°C has been suggested for the growth of AIC layers, the range in which appreciable crystallization occurs.

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References


