

On the Effect of the Hydrogen Content and Deposition Type on the Grain Nucleation and Grain Growth during Crystallization of a-Si:H Films

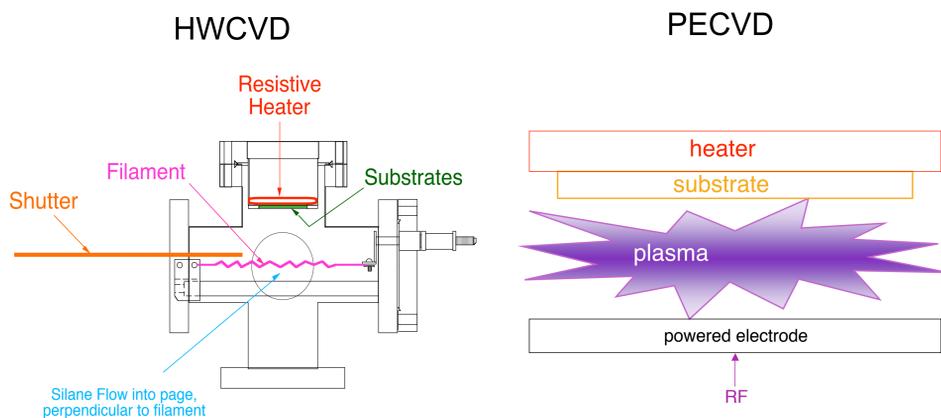
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Object(s) of this Study

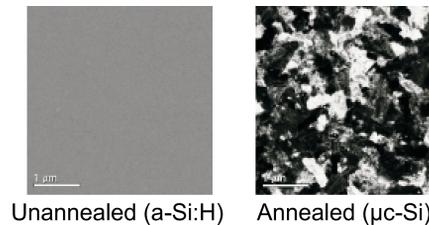
- analyze crystallization kinetics for 600°C anneal temp.
(1) nucleation rate, (2) grain growth velocity
- determine influence of initial film C_H for HWCVD films
- determine influence of deposition type for same film C_H

a-Si:H Film Growth

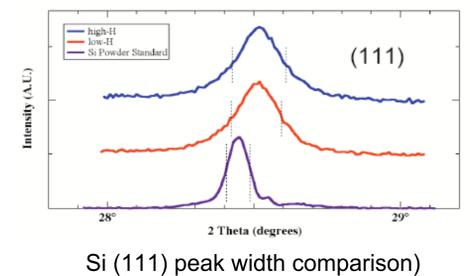


Characterization Methods

(1) TEM



(2) X-ray Diffraction (XRD)



(3) Raman Spectroscopy

(partially annealed, but still amorphous films)

Measure vs. Anneal Time

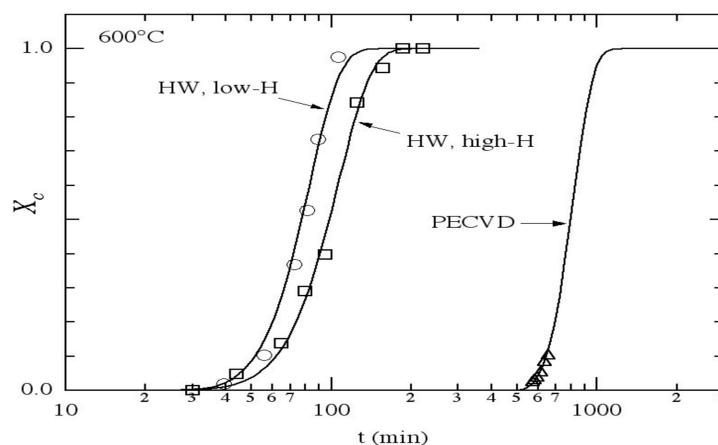
- Cryst. Volume fraction
- Grain number density
- XRD (111) peak width
- Raman TO HWHM (a-Si:H)

Calculate

- nucleation, grain growth rates
- final grain size (TEM)
- XRD 'grain size' (Scherrer formula)

Results

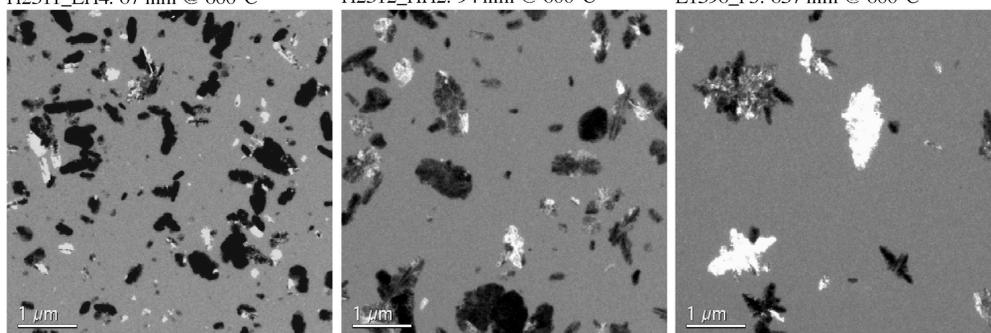
incubation times longer for high C_H films, much longer for same H content PECVD vs. HWCVD films



grain growth rates ~ similar for all films
- nucleation rates much smaller for PECVD films

Film Type	HWCVD (3 at.% H)	HWCVD (12 at.% H)	PECVD (10 at.% H)
t_c (min)	62	88	366
s_g (nm/min)	4.1	3.1	2.7
r_n (min. μm^3) ⁻¹	2.3	1.4	0.027

H2511_LH4: 67 min @ 600°C H2512_HH2: 94 min @ 600°C L1596_P3: 657 min @ 600°C



d_g (x) (μm)	low-H HWCVD	high-H HWCVD	PECVD
	0.31	0.34	1.20

Does H Evolution Play Any Role in Crystallization?

- Raman TO HWHM increases as H is evolved from high C_H HWCVD film
- high C_H film also exhibits smaller XRD grain size

Film Type	HWCVD (low C_H)	HWCVD (high C_H)
XRD grain size	800Å	520Å
Raman HWHM (as grown)	28 cm^{-1}	28 cm^{-1}
Raman HWHM (annealed)	28 cm^{-1}	33 cm^{-1}

- XRD line broadening cannot be due to size effects alone
- significant H evolution may result in structural disorder (strain, defects)

Conclusions

- significant difference in incubation times, nucleation rates for HWCVD, PECVD films
- lower PECVD nucleation rates translate into larger grain sizes
- structural disorder caused by H evolution may affect grain growth