

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

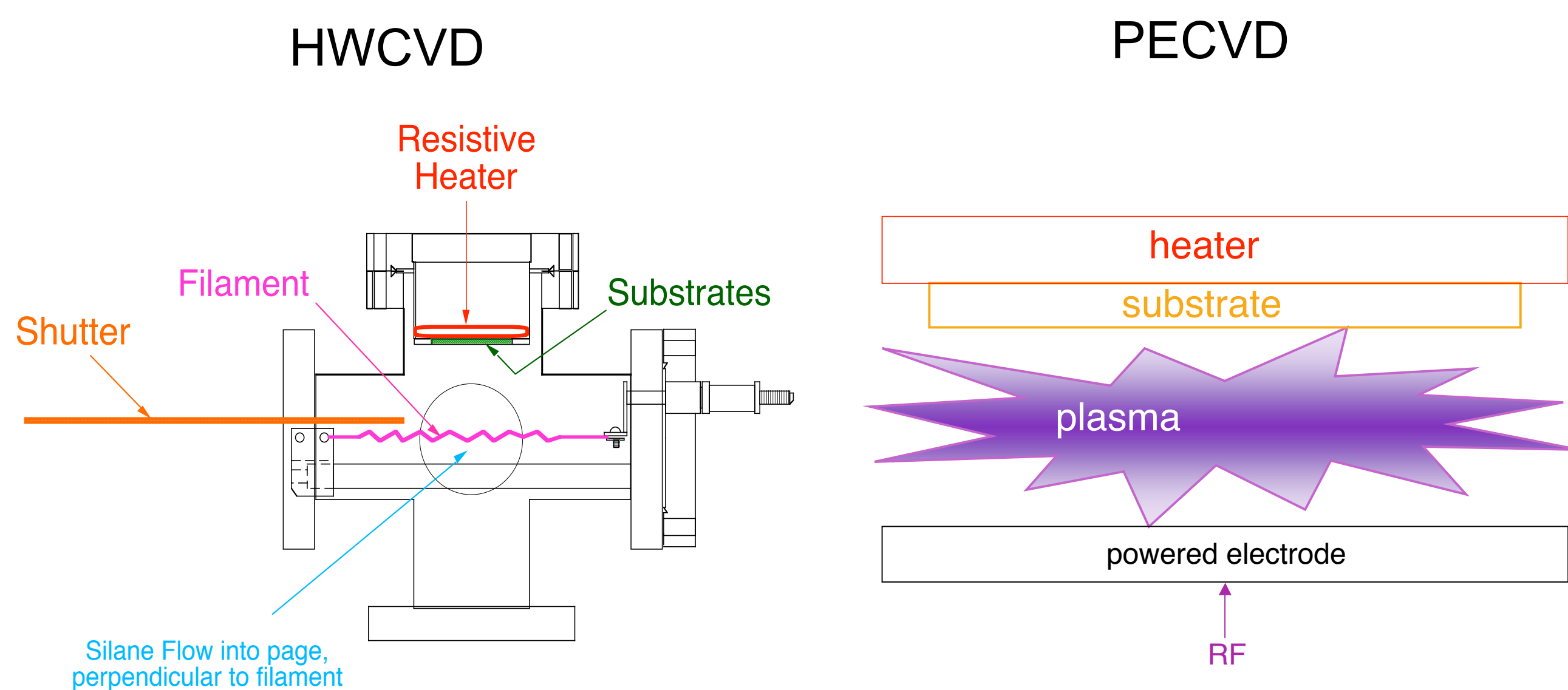
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## Object(s) of this Study

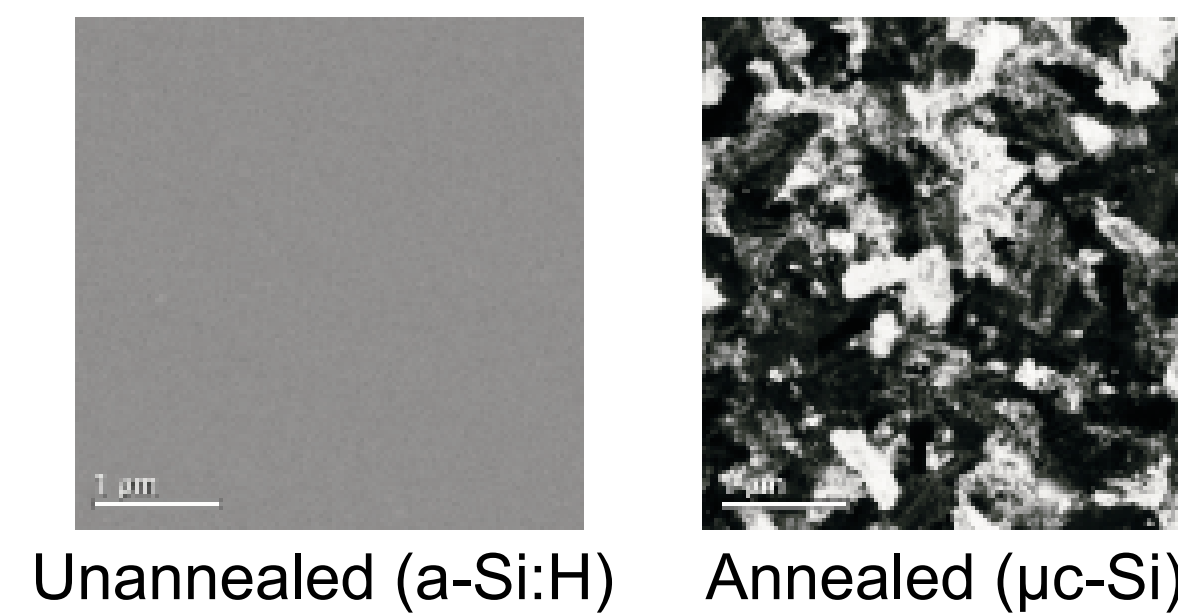
- analyze crystallization kinetics for 600°C anneal temp.  
(1) nucleation rate, (2) grain growth velocity
- determine influence of initial film  $C_H$  for HWCVD films
- determine influence of deposition type for same film  $C_H$

## a-Si:H Film Growth

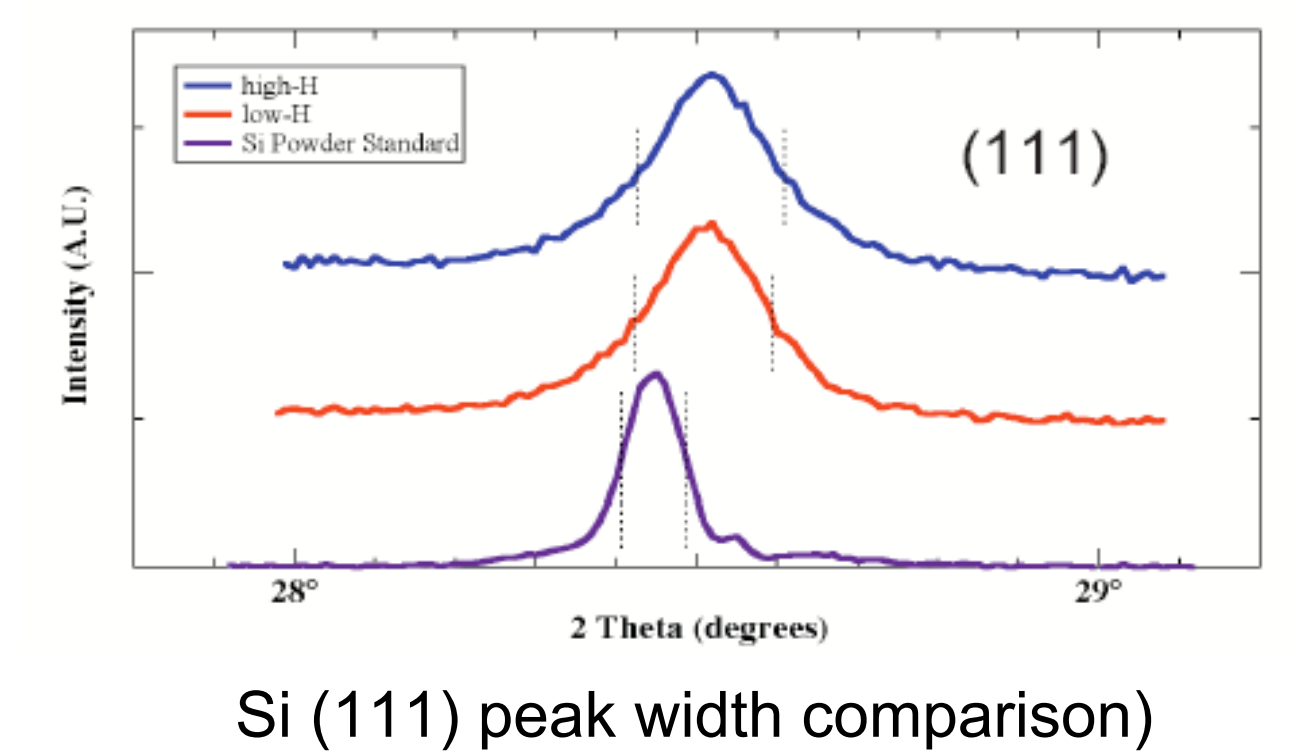


## Characterization Methods

### (1) TEM



### (2) X-ray Diffraction (XRD)



### (3) Raman Spectroscopy

(partially annealed, but still amorphous films)

#### Measure vs. Anneal Time

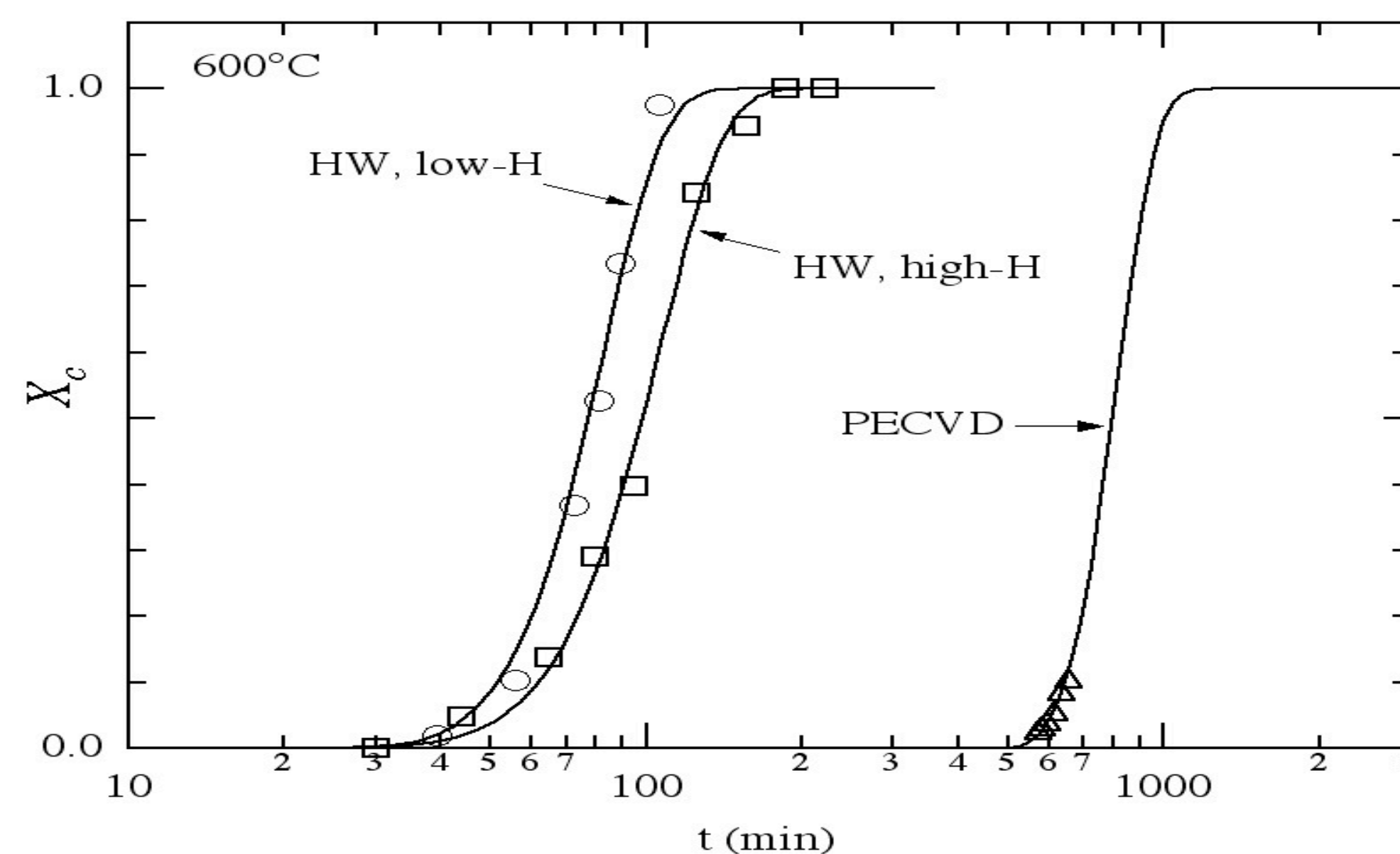
- Cryst. Volume fraction
- Grain number density
- XRD (111) peak width
- Raman TO HWHM (a-Si:H)

#### Calculate

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

## Results

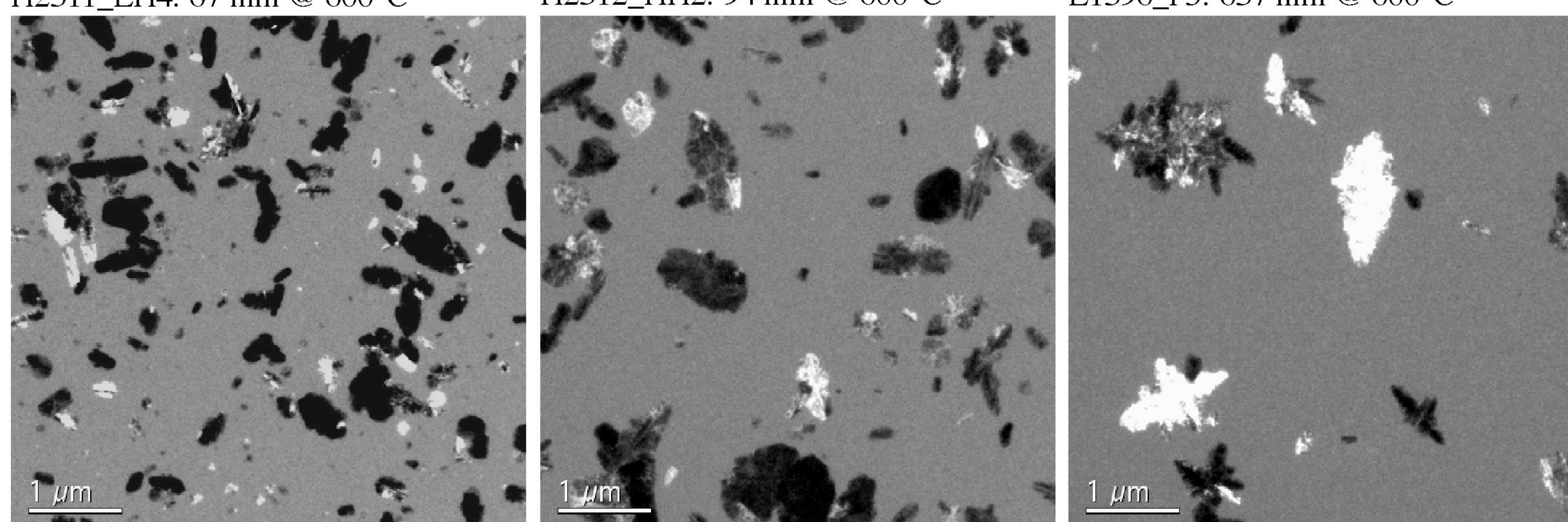
incubation times longer for high  $C_H$  films, much longer for same H content PECVD vs. HWCVD films



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. $\mu\text{m}^3$ ) <sup>-1</sup>	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) ( $\mu\text{m}$ )	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 $\text{cm}^{-1}$	28 $\text{cm}^{-1}$
Raman HWHM (annealed)	28 $\text{cm}^{-1}$	33 $\text{cm}^{-1}$

- 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