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Compositional, structural and optical properties of Si-rich a-SiC:H thin films deposited by ArF-LCVD

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ArF-Laser induced Chemical Vapour Deposition (ArF-LCVD)

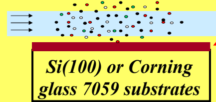
Advantages

- Allows single chamber processing
- Low thermal budget technique
- Fast process with acceptable growth rates
- High control of the deposition rate
- Useful for a large variety of materials

ArF-LCVD in parallel configuration

Photolysis of precursor gases mixture: Si_2H_6 and C_2H_4 diluted in He

ArF-Laser radiation parallel to the substrate
(λ = 193 nm, E $\approx$ 0.7 W/cm²)



Growth of a thin amorphous hydrogenated SiC film (a-SiC:H)

Si(100) or Corning glass 7059 substrates

P = 1.2 kPa
Ts = 180-400 ºC

a-SiC:H coatings

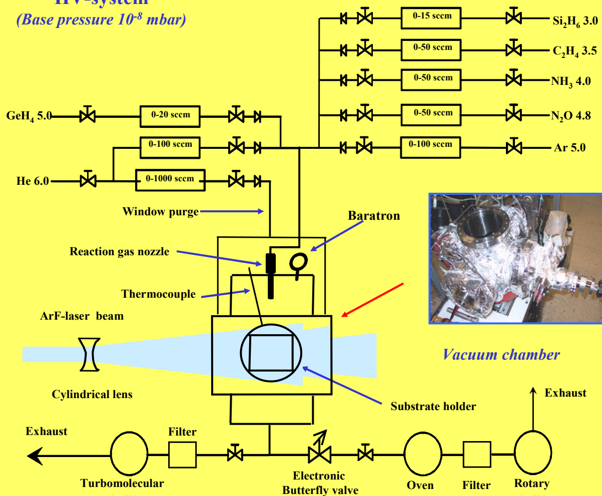
Properties and Advantages:

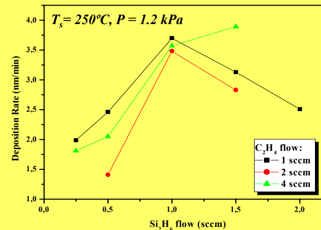
- Adjustable bandgap
- Mechanical strength
- Chemical stability
- Irradiation resistivity to high T

Applications:

- Photovoltaics
- Thin film transistors
- Passivation layer in IC devices

Experimental Set-up for ArF-LCVD



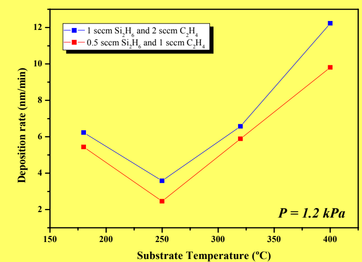


Vacuum chamber

a-SiC:H film properties

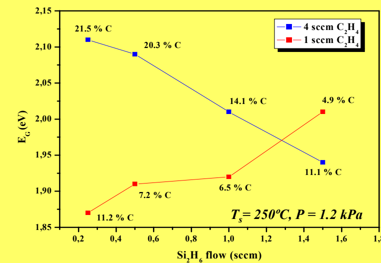
Growth rate studies showed:

- Higher influence of deposition rate on Si_2H_6 flow than on C_2H_4 flow
- Equal gas flow ratios led different deposition rates
- Enhancement of deposition rates with increasing substrate temperatures
- Abnormal values were observed for samples deposited at 180ºC



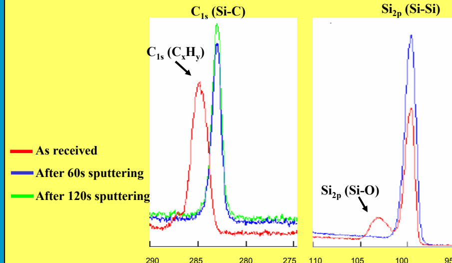
Optical studies revealed:

- Almost equal values were found for E_G and E_{04} varying between 1.6 and 2.4 eV
- Higher E_G values were observed with increasing C content in the film
- Unexpected enhancement of E_G values with increasing Si_2H_6 flow when a low C_2H_4 flow of 1 sccm was used



a-SiC:H film properties

XPS-depth profile analysis

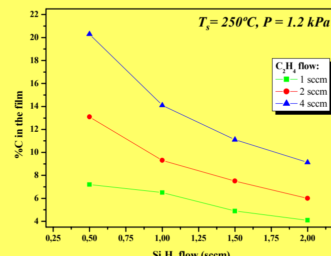


XPS analysis revealed:

- Existence of 5 nm thick oxide cap layer
- Si-rich films with C content varying from 4% to 23%
- Presence of Si bonded to C
- Elements are homogeneously distributed in depth
- More C content as higher C_2H_4 flow was used
- Different C content in films with the same precursor gas flow ratios
- A decrease of C content with increasing Ts

Si_2H_6 flow:C_2H_4 flow (sccm)	Ts(ºC)	% at C	Deposition Rate (nm/min)	RMS (nm)	BE for C1s peak (eV)
0.5 sccm : 1 sccm	180ºC	5.1	5.4	6.1	282.87
	250ºC	7.2	2.5	1.1	282.88
	320ºC	1.1	5.9	1.7	282.84
	400ºC	1.2	9.8	0.6	282.57
1 sccm : 2 sccm	180ºC	6.1	6.2	5.4	282.78
	250ºC	9.3	3.6	2.3	282.69
	320ºC	1.5	6.6	3.9	282.63
	400ºC	1.1	12.6	0.8	282.66

AFM: Homogeneous and very smooth surfaces were obtained, especially at higher temperatures of 400ºC.



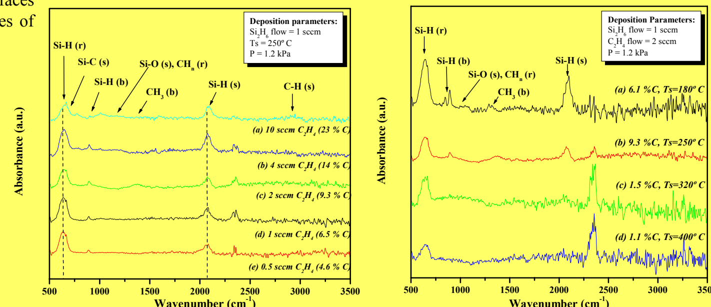
FTIR peaks and bands related to:

- Si-H and C-H vibrations indicate highly hydrogenated films
- Si-C vibration confirms the formation of SiC
- Si-O vibration, mainly at Ts= 180ºC, from native oxide on the Si substrate and/or on the film

…and an increase of Ts involves:

- A decrease of hydrogenation and oxygenation of the coatings

FTIR Spectra



Conclusions

- **Homogeneous smooth amorphous hydrogenated SiC films with C content up to 23% were grown by ArF-LCVD .**
- **Equal gas flow ratios, when other deposition parameters were kept constant do not involve the same film properties .**
- **An increase of substrate temperature led higher growth rates, smoother surfaces, a decrease of hydrogenation and oxygenation phenomena and a considerable diminishing of C content.**
- **For low C content, E_G is clearly affected by an increase of disilane flow which seems to be related to hydrogenation phenomenon.**

Acknowledgements

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