Influence of the substrate temperature on the growth of Ge containing thin films produced by ArF Laser induced Chemical Vapour Deposition (ArF-LCVD)

E.López, S.Chiussi, P.González, J.Serra, C.Serra#, B.León

#CACTI. Universidade de Vigo, Dpto. Física Aplicada, Campus Lagoas Marcosende. E-36310 Vigo (Spain)

ICPEPA 2004
5-9 September 2004
Lecce. Italy
Contribution L-4115

UNIVERSIDADE DE VIGO
Dpto. de Física Aplicada

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

Ge materials

Properties and Advantages:

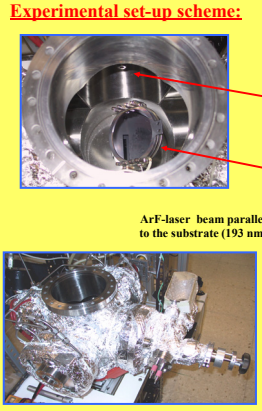
- Pure Ge is a low bandgap semiconductor
- Possibility of tailoring electrical and thermodinamical properties in SiGe and SiGeC
- Easy to micromachine
- Compatible with IC silicon technology

Applications:

- Bolometers. solar cells. microelectronic devices

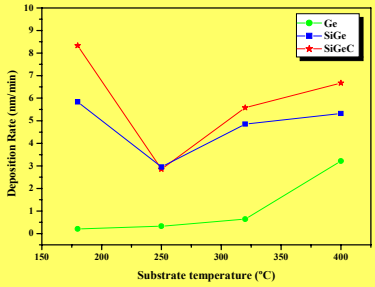
ArF-Laser induced Chemical Vapour Deposition in parallel configuration

Experimental set-up scheme:



HV-system
(Base pressure 10^{-8} mbar)

SiGe and SiGeC films properties at Ts=180ºC-400ºC



Sample	Substrate Temperature (ºC)	Si at. %	Ge at. %	C at. %	RMS (nm)
SiGeC	180	86.1	7.8	6.2	13.29
	250	77.2	18.7	4.2	2.78
	320	90.1	8.2	1.7	4.96
	400	86.1	11.4	2.5	6.68
SiGe	180	59.2	40.8	0	1.21
	250	94.9	5.1	0	4.43
	320	60.2	39.8	0	3.96
	400	64.8	35.2	0	3.43

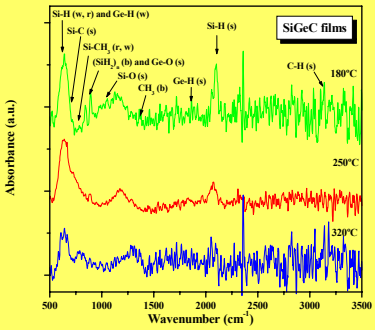
AFM analysis revealed:

- Enhancement of RMS values with increasing Ts in SiGeC contrary to SiGe
- Very high RMS values for 180ºC

Growth rate studies showed:

- Higher deposition rate values are obtained when Si_2H_6 flow is added to precursor gases mixture
- Enhancement of deposition rates with increasing substrates temperatures which is more relevant in pure Ge for Ts above 300ºC
- Abnormal values were observed for samples deposited at 180ºC for SiGe and SiGeC films

FTIR peaks and bands related to:

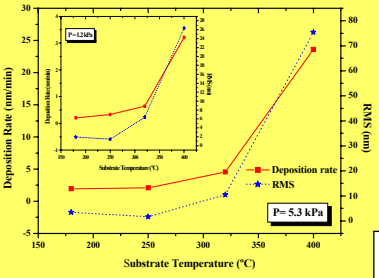


- Si-H and Ge-H vibrations indicate highly hydrogenated films
- C-H and Si-C vibrations confirm the incorporation of C in SiGeC films bonded to H or to Si
- Si-O vibration, mainly at Ts= 180ºC, from native oxide on the Si substrate and/or on the coating
- Ge-O vibration, more relevant in SiGe films deposited at a low Ts of 180ºC

…and an increase of Ts involves:

- A decrease of hydrogenation and oxygenation of the films

Pure Ge films results



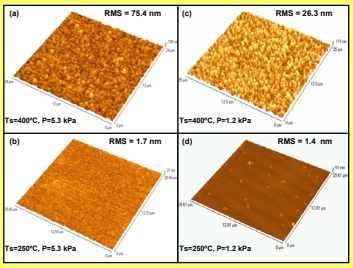
Growth rate studies showed:

- Lower deposition rate values are obtained for pure Ge films than for SiGe or SiGeC alloys
- Enhancement of deposition rates with increasing substrates temperatures
- Higher deposition rates as total pressure rises.

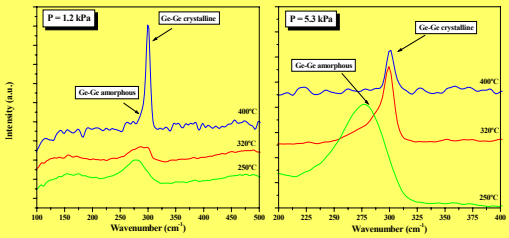
AFM analysis revealed:

- Higher RMS values with increasing total pressure (P) or substrate temperatures (Ts)
- Higher RMS values for pure Ge films than for SiGe or SiGeC alloys for the same conditions of Ts or P

Grain size



Raman spectra



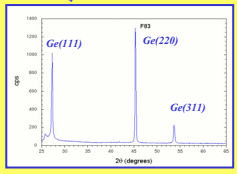
Raman bands assigned to:

- Ge-Ge bonds in an amorphous structure (270 cm^{-1}) for low substrate temperatures
- Ge-Ge bonds in a crystalline structure (300 cm^{-1}) for substrate temperatures above 300 ºC

Ts (ºC)	P (kPa)	XRD results	Medium grain dimension (nm)
320	1.2	Randomly oriented	microcristallites
	5.3	Preferential orientation (220)	40
400	1.2	Randomly oriented	23
	5.3	Preferential orientation (220)	33

XRD: demonstrated the policristallinity of the films deposited above 300ºC.

XRD of a Ge film deposited with 2 sccm GeH_4 at 400ºC and 5.3 kPa



Conclusions

- **Ge containing films were grown by ArF-LCVD in parallel configuration at various substrate temperatures, obtaining different film properties.**
- **An enhancement of deposition rate was observed with increasing substrate temperature or total pressure.**
- **The presence of a silicon source in the precursor gases mixture involves higher growth rates, while the addition of an C_2H_4 flow, when the other deposition parameters were kept constant, does not led to significant changes in the growth rate.**
- **Using higher substrate temperature allows obtaining alloys with different composition, degree of hydrogenation and oxygenation, and structure.**
- **Surface roughness dependence on substrate temperature is influenced by the composition on the film. Pure Ge films have the roughest surfaces due to crystalline grain size formation confirmed by XRD and Raman.**

Acknowledgements

This work has been partially supported by EU as well as by Spanish contracts and grants HA1999-0106, UV62903I5F4, UV62903I5F4, MAT2000-1050, MAT2003-04908, XUGA32107BB92DOG211, PGIDT01PX130301PN, PR405A2001/35-0. The authors wish to thank J.B. Rodríguez (CACTI. Univ. Vigo) and U. Kosch for their extensive technical help and fruitful discussions.

Contact person: fani@uvigo.es