Tailored film properties and surface morphology of Ge containing films through ArF-Excimer Laser assisted growth

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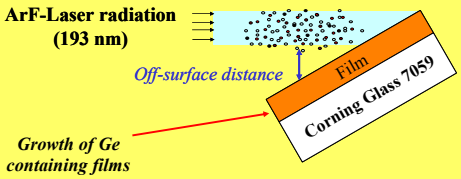
ArF-Laser induced Chemical Vapour Deposition (ArF-LCVD)

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 tilted configuration

Precursor gases mixture Si_2H_6 , GeH_4 and C_2H_4 in He



Ge, SiGe and SiGeC coatings

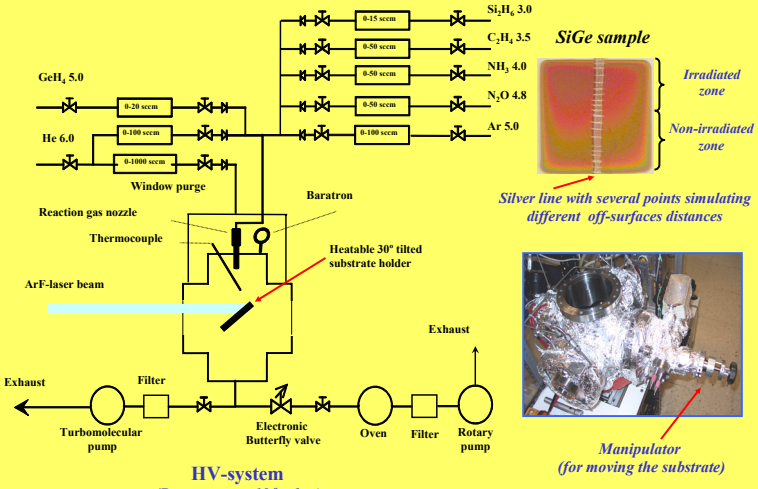
Properties and Advantages

* Pure Ge is a low band gap semiconductor
* Possibility of tailoring optical, electrical and thermodinamical properties
* Easy to micromachine
* Compatible with IC silicon technology

Applications

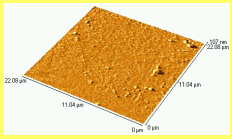
* Bolometers, solar cells, microelectronic devices

Experimental Set-up for ArF-LCVD



Ge containing films properties at Ts=250ºC

➡ **XPS analysis:** Composition independent from off-surface distance and beam to substrate geometry, being the average composition $Si_{0.88}Ge_{0.12}$ and $Si_{0.85}Ge_{0.11}C_{0.04}$



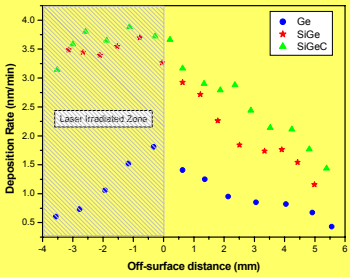
SiGe irradiated zone
RMS ≈ 2 nm

Sample	RMS at -2.00 mm	RMS at 2.7 mm
Ge	11.78	4.57
SiGe	2.02	8.27
SiGeC	1.77	6.48

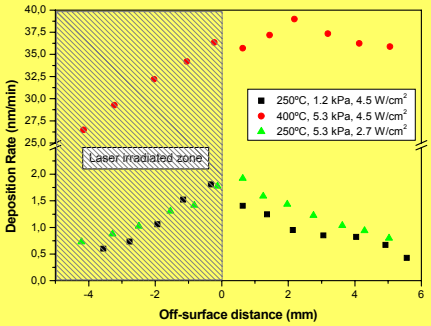
➡ **AFM:** Constant low surface roughness of SiGe and SiGeC films in the irradiated zone, increasing with higher off-surface distances in the non-irradiated zone

➡ **Growth rate studies revealed:**

- Similar values for SiGe and SiGeC being higher than for pure Ge films
- Enhancement of deposition rate with decreasing off-surface distance in the non-irradiated zone
- Almost constant growth rate in the laser irradiated zone was observed for SiGe and SiGeC alloys but not for the pure Ge system



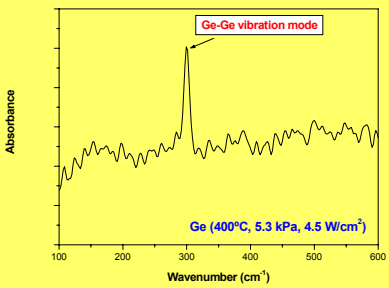
Pure Ge films results

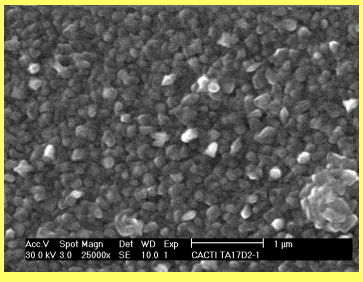


➡ **Increase of substrate temperature (400ºC) provokes:**

- Higher growth rates *(Profilometry)*
- Structural changes → Raman peak at 300 cm^{-1} corresponding to the Ge- Ge vibration mode for crystalline Ge *(Raman spectroscopy)*
- Presence of sub-micro-crystals along all the film *(SEM)*
- Rougher surfaces in contrast to smoother ones obtained at 250ºC *(AFM)*

Off-surface distance	RMS (nm) values for pure Ge films		
	250ºC, 1.2 kPa	250º C, 5.3 kPa	400ºC, 5.3 kPa
-1.5mm	16.3	2.2	31.4
0.63 mm	5.7	4.2	15.6
2.7 mm	4.6	3.1	14.6





Non-irradiated zone SEM image of a pure Ge coating deposited at 400ºC

➡ **Growth rate studies revealed:**

- Deposition rate is affected by an increase of total pressure from 1.2 to 5.3 kPa that can be compensated by lowering the laser power density from 4.5 to 2.7 W/cm^2
- Considerable higher deposition rate values were observed at a substrate temperature of 400ºC → **Pyrolitic contribution**
- Enhancement of the deposition rate with increasing off-surface distance in the laser irradiated zone in all cases → **Possible ablation phenomenon**

Conclusions

- **ArF-LCVD is an effective method for controlling deposition rate and tailoring film properties by changing exclusively the off surface distance.**
- **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.**
- **The stoichiometry remained constant along the films, but surface roughness, surface morphology and structure varied depending on the composition and several deposition parameters such as substrate temperature, total pressure or laser power density.**
- **A possible ablation phenomenon occurs in the irradiated zone of pure Ge films as the ablation threshold of Ge is reached.**

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