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Growth and Modification of Thin SiGeC Films at Low Substrate Temperatures through UV Laser Assisted Processing

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SiGeC thin films

Properties and Advantages

* Adjustable lattice + band gap
* Reduce diffusion of dopants
* Easy to micro-machine
* Compatible with IC silicon technology

Applications

* Solar cells
* Photo-detectors
* Microelectronic devices

Laser assisted techniques

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

Photolysis of Si_2H_6, GeH_4 and C_2H_4 in He

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

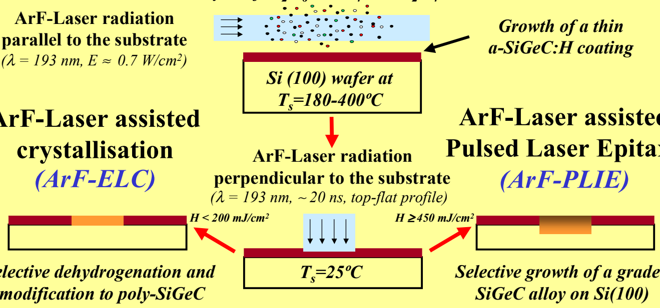
Growth of a thin a-SiGeC:H coating

Si (100) wafer at T_s=180-400ºC

ArF-Laser assisted crystallisation *(ArF-ELC)*

ArF-Laser assisted Pulsed Laser Epitaxy *(ArF-PLIE)*

ArF-Laser radiation perpendicular to the substrate
(λ = 193 nm, ~ 20 ns, top-flat profile)



Selective dehydrogenation and modification to poly-SiGeC

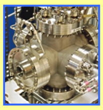
Selective growth of a graded SiGeC alloy on Si(100)

Laser assisted techniques

Advantages

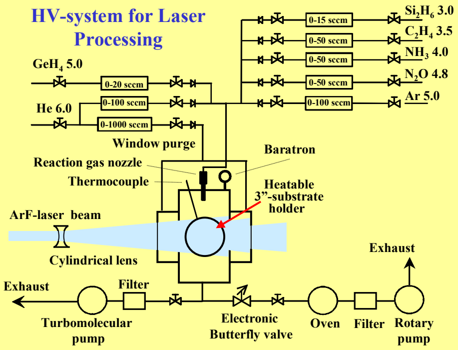
* Allow single chamber processing
* Useful for a large variety of materials
* Acceptable growth rates
* High control of the deposition rate
* Low thermal budget techniques
* Ultra-rapid processes
* Established in TFT-production

ArF-LCVD

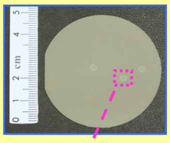


* Uniform coatings on Corning 7059 and 3" Si-wafers *(Profilometry, AFM, SEM)*
* Si GeC:H with ~ 5 nm thick native oxide cap-layer *(XPS-depth profiling)*
* Hydrogen in µ-voids as well as bonded to Si, Ge and C *(FTIR-spectroscopy)*

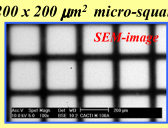
HV-system for Laser Processing



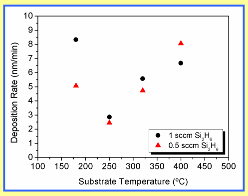
Si (100) wafer coated uniformly and in selected regions

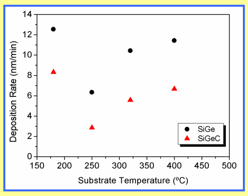


(200 x 200 µm² micro-squares)

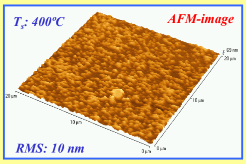


ArF-LCVD results



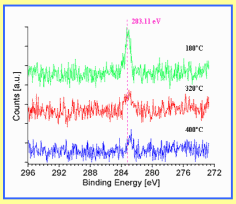


Surface Roughness



Ts (ºC)	250	320	400
RMS (nm)	1.5	2.6	10

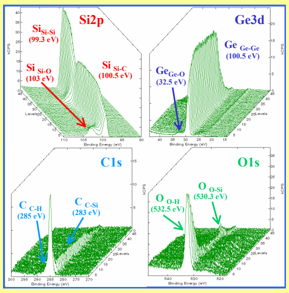
XPS of C1s transition

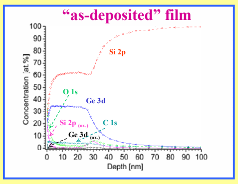


Increase of substrate temperature provokes:

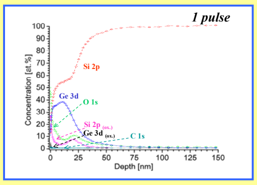
- Higher growth rates analogous to the SiGe system
- Higher Ge-content *(XPS)*
- Rougher surfaces *(AFM)*
- Lower concentration of substitutional Carbon *(XPS)*

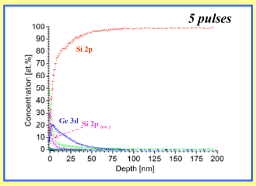
Composition and structure of the alloy after irradiating with different fluences and Nº of pulses

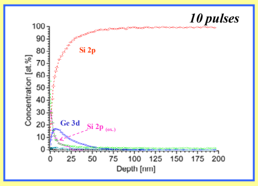




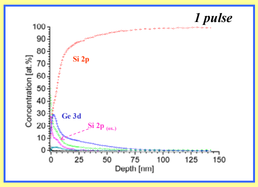
Films irradiated with 185 mJ/cm² pulses (1 Hz)

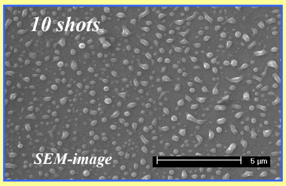






Films irradiated with 450 mJ/cm² pulses (1 Hz)





With low laser fluence (185 mJ/cm²)

- Segregation of Ge to the surface forming Ge islands
- Carbon loss (Desorption due to oxidation after segregation)
- Native SiO_2 interface diffuses gradually with pulse Nº
- Alloy thickness does not increase
  (Wafer has not been molten)

With high laser fluence (450 mJ/cm²)

- Alloy thickness increases
  (Wafer has been molten)
- No island formation
- Interface has been cleaned

Conclusions

- **ArF-LCVD enables the growth of uniform SiGeC films with tailored composition at relatively low substrate temperatures.**
- **Irradiation of the films with low fluence (185 mJ/cm²) provokes island formation due to Ge segregation.**
- **Loss of C is detected and attributed to desorption, probably due to oxidation on the alloy surface caused by processing in air .**
- **Above 450 mJ/cm² an increase of the alloy depth is observed, indicating that the Si(100) substrate has partially been molten .**
- **Gradual diffusion till removal of native SiO_2 interface has been observed.**

Acknowledgements

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