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Excimer Laser Assisted Processing of Silicon-Germanium-Carbon Films

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SiGeC thin films

Properties and Advantages

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

Applications

* Micro- and Nanoelectronic devices
* Thin films Solar cells

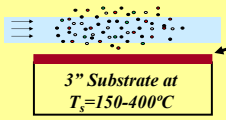
Laser assisted techniques

For growing thin amorphous films

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

Photolysis of the adequate precursor gases (GeH_4 - Si_2H_6 - C_2H_4) in He

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



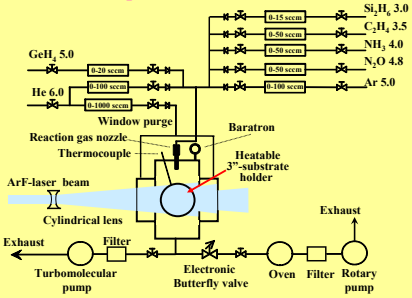
Growth of a thin amorphous hydrogenated SiGeC coatings (a-SiGeC:H)

Laser assisted techniques

Advantages

* Allow single chamber processing
* Useful for a large variety of materials
* High control of the deposition rate
* Relatively low thermal budget
* Ultra-rapid processes
* Established in TFT-production

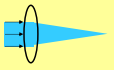
HV-system for Laser Processing of 3" wafers
LCVD Set-Up



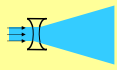
Optical components and masks enable single or multi-photon for processing of

* large areas *(complete wafers)*
* locally selected regions *(bottom-up technol.)*

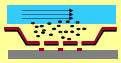
Beam narrowing



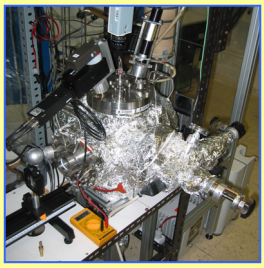
Beam widening



Stencils (masks)



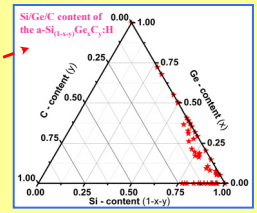
HV-system
(Base pressure 10^{-8} mbar)

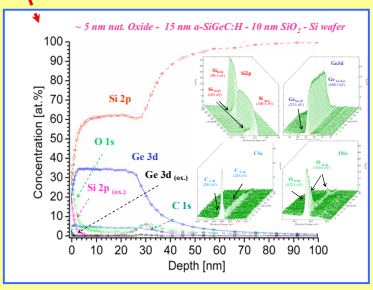


with optical processing control and movable 3" substrate holder

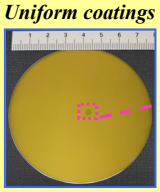
Well tailored composition and depth profiles

XPS *element analysis and depth profiling*

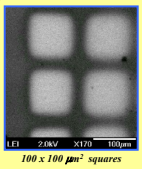




Uniform coatings in depth on large areas and on selected regions with low roughness *(Profilometry, AFM, SEM, TEM)*

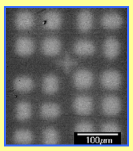


Deposition using a TEM mesh as mask



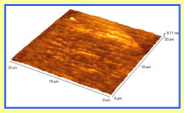
100 x 100 μm² squares

SEM-images



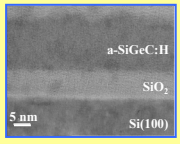
Stencil assisted deposition

AFM-surface analysis



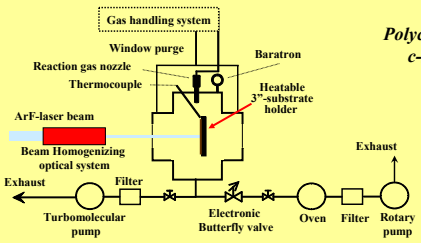
Roughness < 2 nm RMS

TEM cross section view

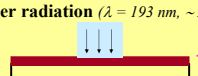


For modifying thin hydrogenated amorphous SiGeC

HV-system for Laser Processing of 3" wafers
ELC and PLIE Set-Up



ArF-Laser radiation *(λ = 193 nm, ~20 ns, top-flat intensity profile)*



a-SiGeC:H coating

ELC: Fluence < 200 mJ/cm²

Polycrystalline c-SiGeC

PLIE: Fluence > 200 mJ/cm²

Graded epitaxial c-SiGeC

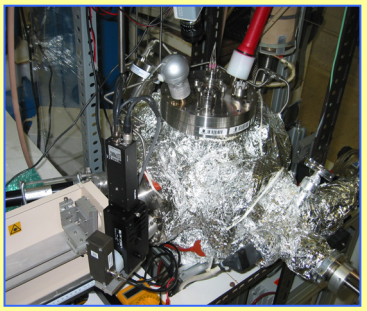
Dehydrogenation *of the coating and* ***Crystallisation*** *to poly- or nano- size grains*
(grain size depends on film thickness and laser fluence)

Melting *of coating + part of the Si-wafer*
Mixing *of the elements in the molten pool*
Crystallisation *of SiGeC using Si as seed*

Excimer Laser assisted Crystallisation *(ELC)*

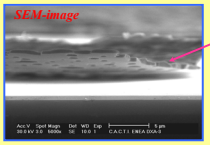
Pulsed Laser Induced Epitaxy *(PLIE)*

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



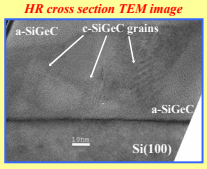
* Step by step process needed for avoiding formation of holes via explosive dehydrogenation *(SEM)*
* Fine grained material with grain sizes of tenth of nm *(TEM, XRD)*
* Repetitive pulses at high fluences promote segregation of Ge and C *(XPS and TOF-SIMS depth profiling)*

SEM-image



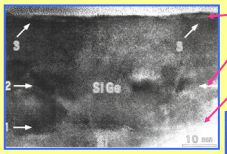
Explosive dehydrogenation damaged film

HR cross section TEM image



Partially crystallised nanocrystalline alloy

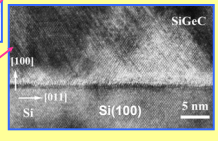
HR cross section TEM images



(3) Isolated flat Ge islands

(2) Interface between strained and partially relaxed SiGe

(1) Si(100)/SiGe(100) interface



c-SiGeC on Si (100)

* Ge concentration increasing from substrate to film surface *(XPS and TOF-SIMS depth profiling)*
* Heteroepitaxial growth of SiGe and SiGeC on Si(100) *(TEM, XRD)*
* Ge and C gradient can be adjusted through energy density and Nº of pulses *(XPS depth profiling, RBS)*

- **Excimer Laser assisted techniques such as ArF-LCVD as single process or in combination with ELC or PLIE allow the production of a great variety of thin SiGeC alloys for Micro- and Nano-electronic devices**
- **Coatings with well tailored thickness, composition and crystalline structure can be obtained on large areas as well as on selected regions**
- **Processes are fast with low thermal budget and well defined heat affected zones**

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