



## **SiGe Epi deposition for NPN HBT base layer**

**Sagy Levy**

**Cypress Semiconductor Process R&D**

## Outline

### **Challenges of SiGe epi –Profile tailoring**

- Reactor characterization
- Profile tailoring

### **Metrology of SiGe epi**

- XRD, Elipsometer for SiGe in production

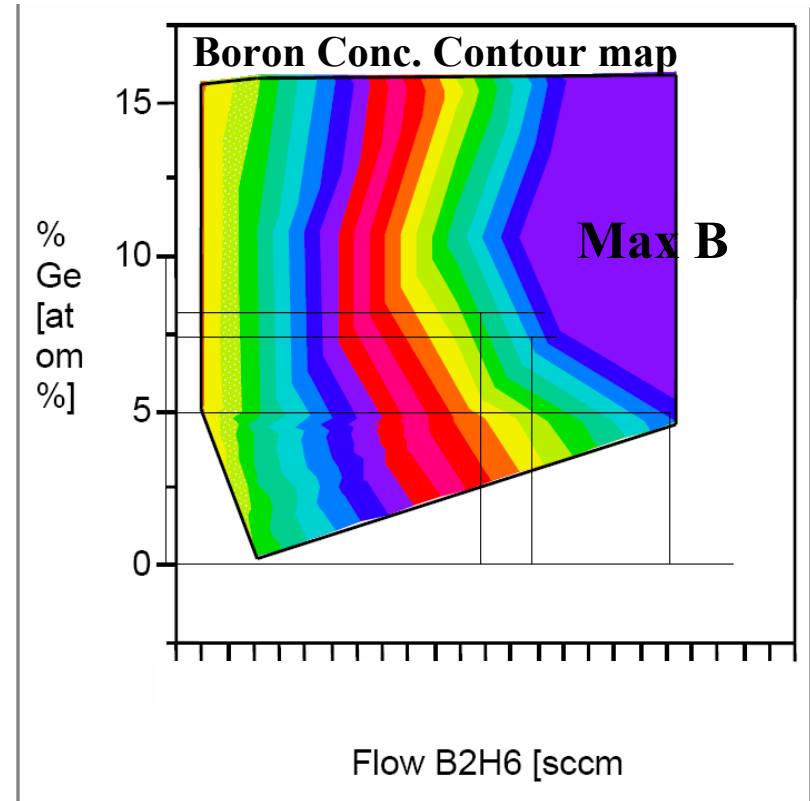
### **Challenges of SiGe epi -defects**

- Crystal Defects originating from process
- Pattern dependency of Crystal defects

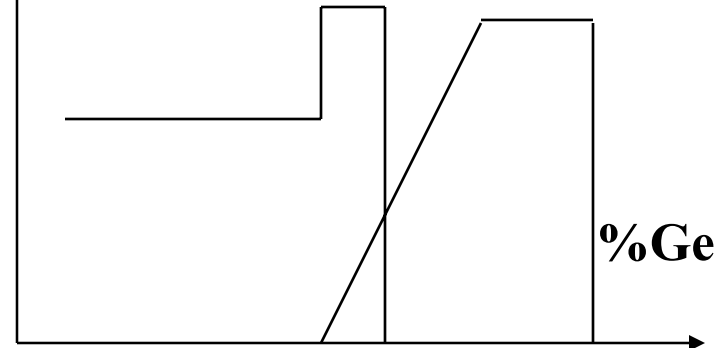


## SiGe Epi Crystal -, %Ge B Profile-reactor characterization

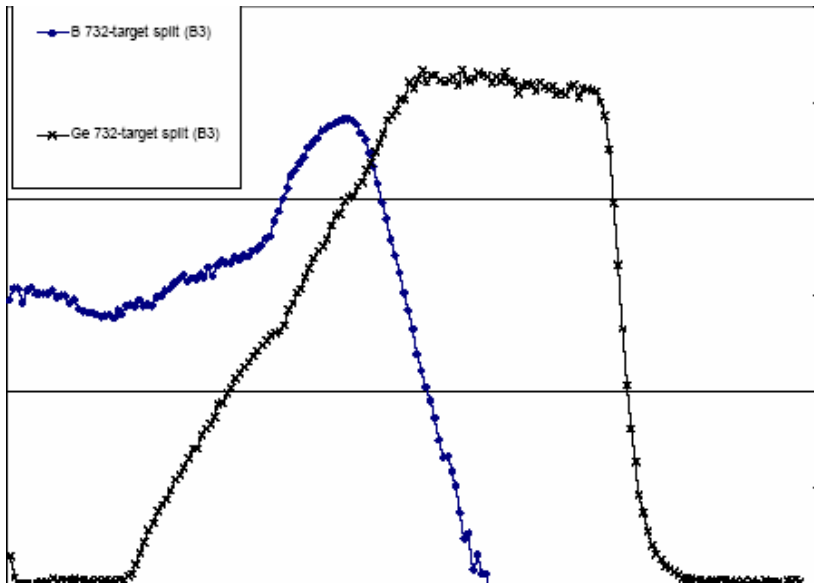
- Complex deposition problem of graded Ge layer with Boron
- In order to have quick R&D learning cycles need to map the reactor
- After relations between different deposition component are established, resulting profile will follow the specified profile easily



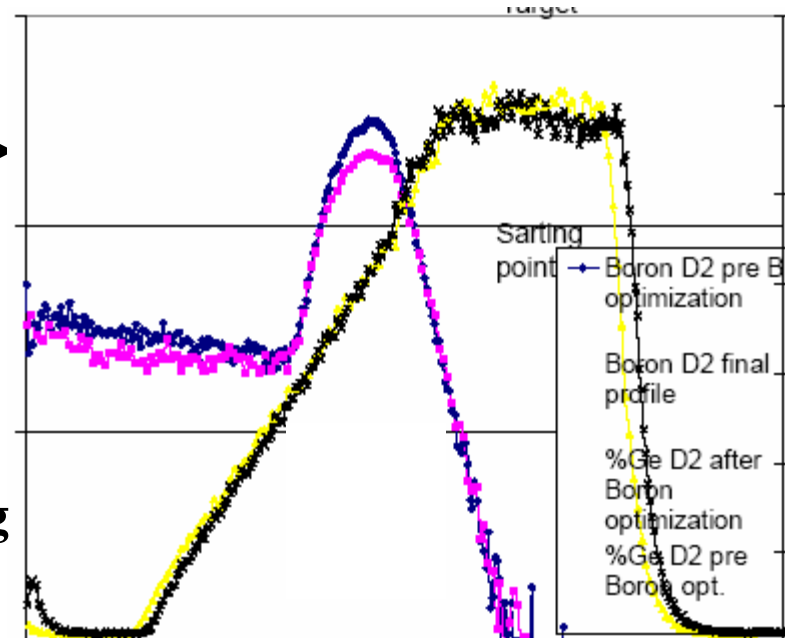
Typical %Ge, Boron profile in base HBT



## SiGe Epi Crystal -, %Ge B Profile



Using  
Reactor  
empiric  
Modeling

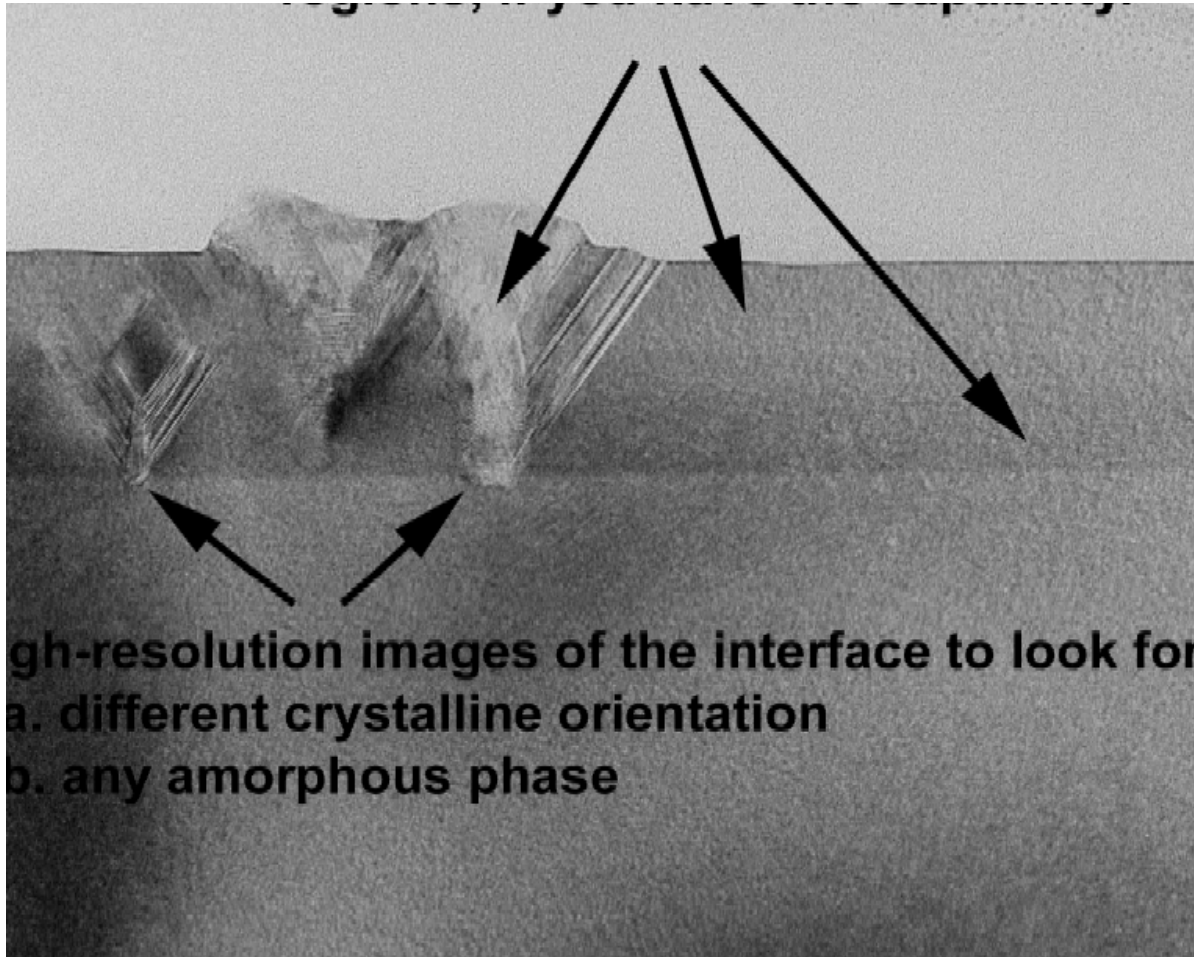




## SiGe Epi Crystal -, %Ge B –deposition issues

- Strong pattern dependency issues- in extreme case flat wafer and pattern wafer show very different growth rates and concentrations
- Pattern dependency drive the need to develop the profile on a pattern wafer
- Main source of pattern dependency is gas depletion effects-deposition rate and concentration depends on pattern density.
- To less extend thermal effect are also an issue which cause pattern density effects via front side emissivity differences

## SiGe Epi Crystal defects



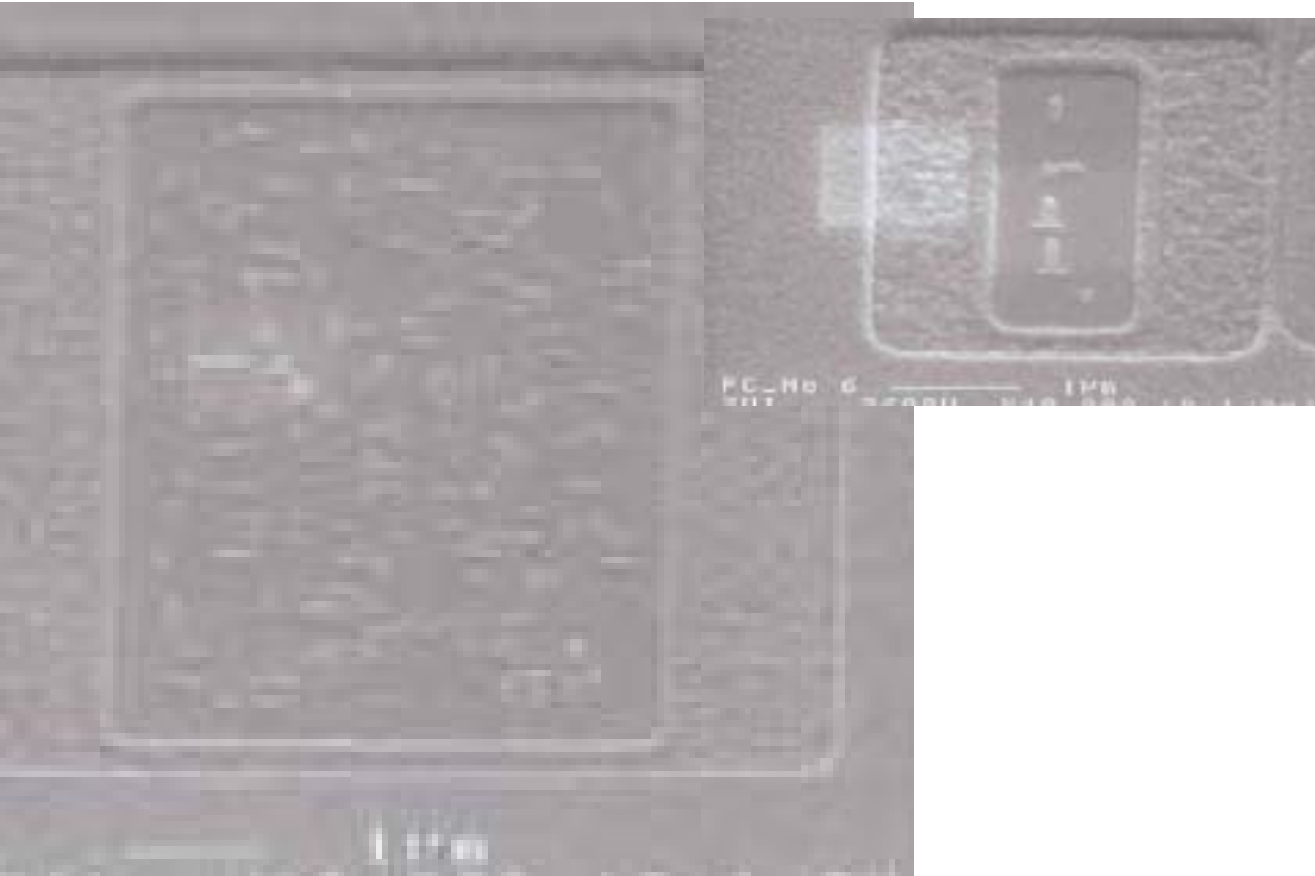
- Crystal defects originating in the interface between silicon and the epi layer (the seed)
- Potential source of defects:
  - Facility
  - Tool
  - SiGe:B deposition process
  - Previous steps



CYPRESS

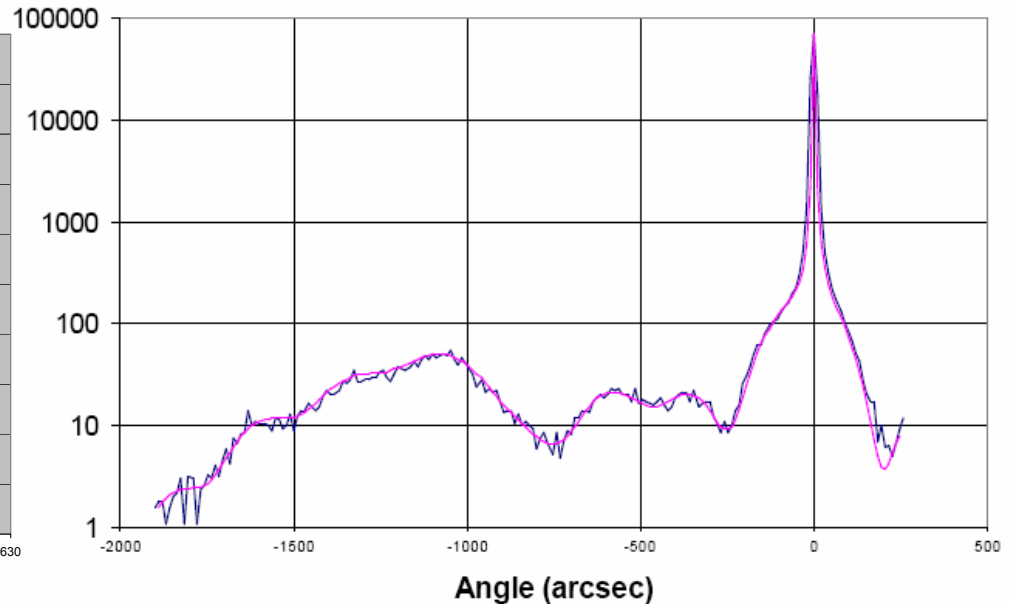
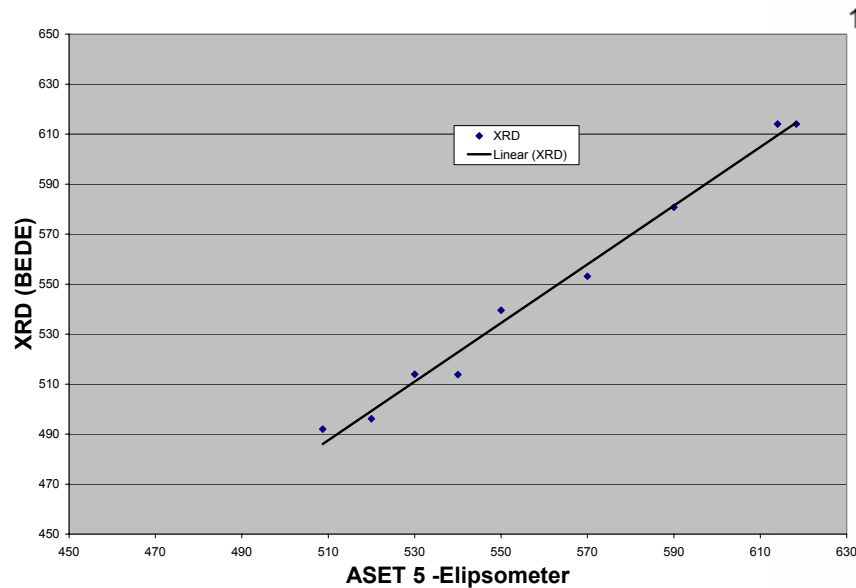
# SiGe Epi for BiCMOS Application

## SiGe Epi Crystal defects-pattern dependency

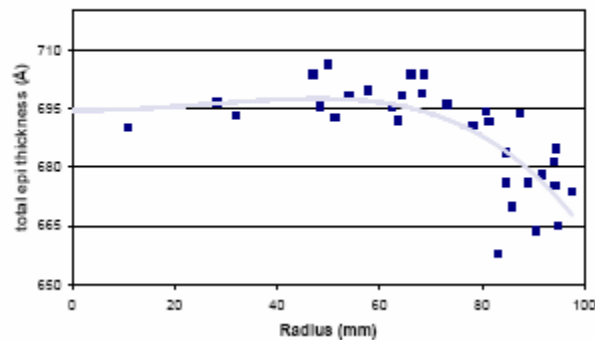


- Same defects originating in the interface between silicon and the epi layer (the seed)
- Defects density has pattern dependency:
  - Might be due to depletion effect if defect originating from gas source
  - Might be due to number of defect nucleation sites if defect originating from the substrate

## SiGe Epi – Metrology Elipsometer and XRD



SiGe epi thickness radial profile



- Monitoring SiGe:epi in R&D/manufacturing environment is very challenging
- XRD is a possible solution, but it is slow and getting wafer maps for process tuning is almost impossible
- Elipsometer (KLA ASET5-) works in a tight narrow process range
- Combination of both can be a winning solution
- Verification from both methods done by TEM- Si cap, Ge graded area can be seen by TEM



# CYPRESS

## SiGe Epi for BiCMOS Application

SiGe Epi Crystal -, PL to check that %Ge and thickness do not exceed critical Value value

- Method to check that the SiGe epi and Ge concentration are not exceeding the critical thickness/conc.
- PL will tell us from which side of the curve are we
- Pattern density effect found for the structural defect

SiGe Thickness

