

## Towards Ge X-Ray detector monolithically integrated on Si CMOS chip

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### Combine advantages of 2 materials

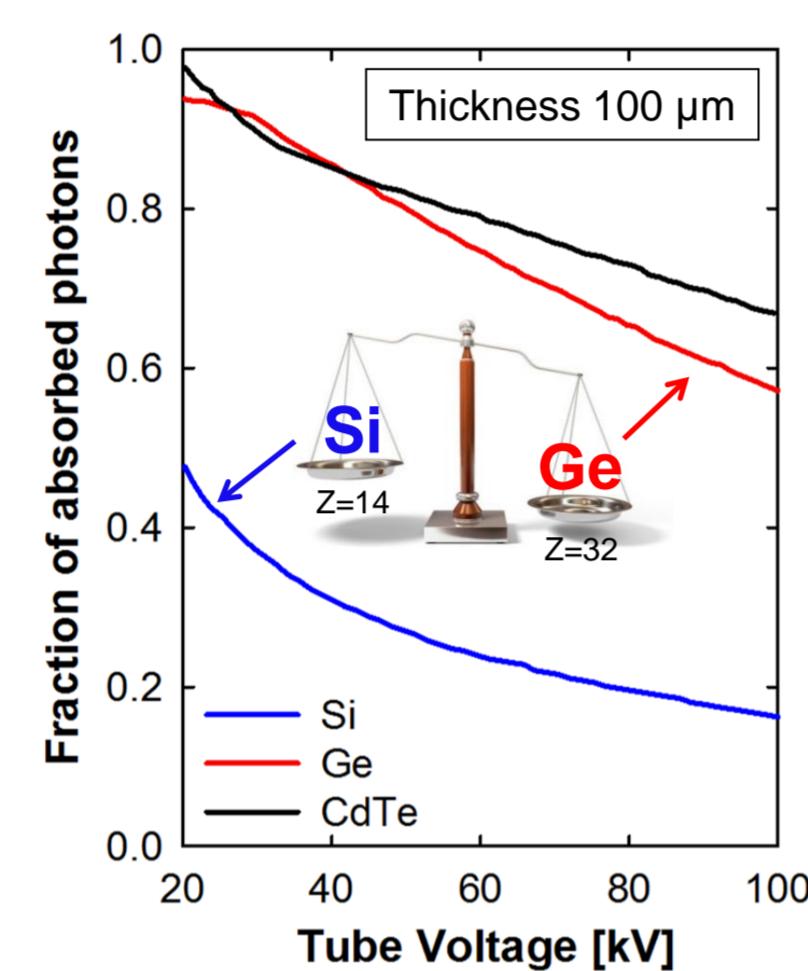
**Ge**

Efficient absorber  
for X-ray radiation

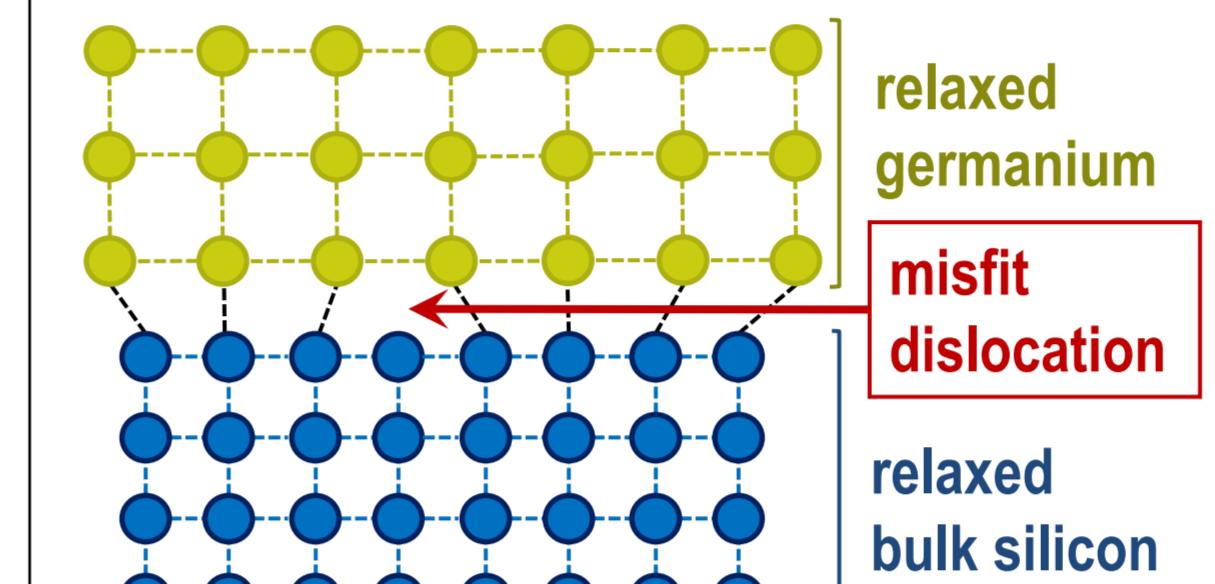
**Si**

Large-scale  
mass production

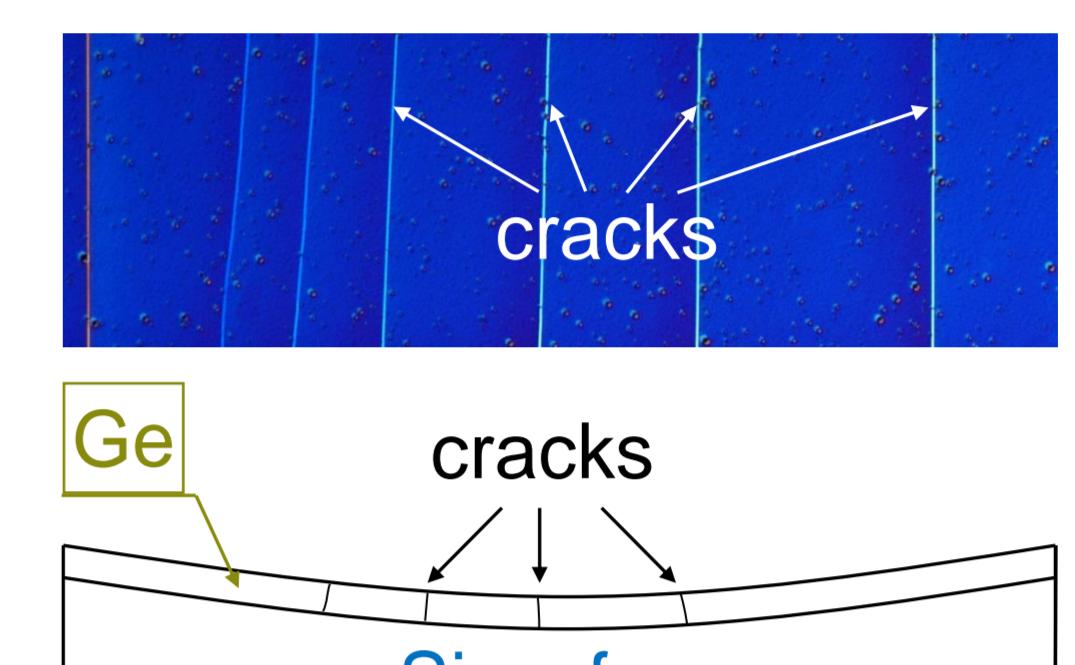
Together they form an innovative X-Ray detector:  
Ge absorbing layer is directly grown on Si chip



### Challenges of planar Ge on Si growth

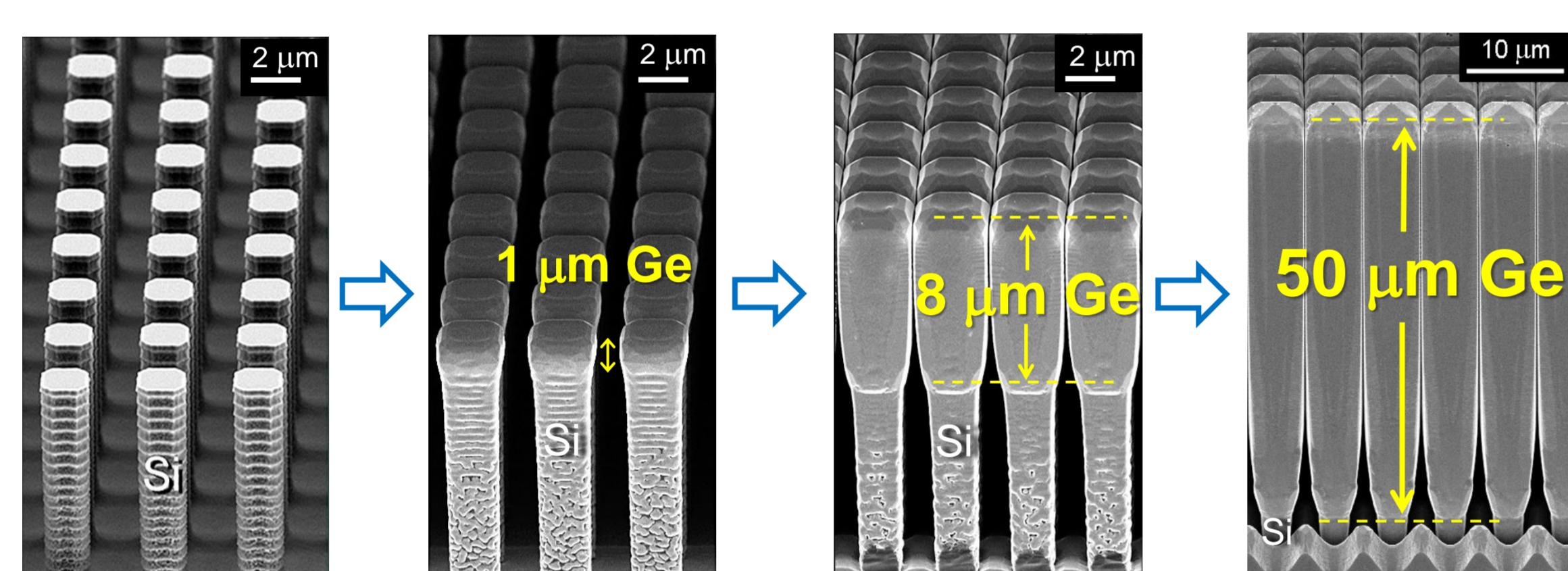


Lattice mismatch (4.2%):  
High dislocation density

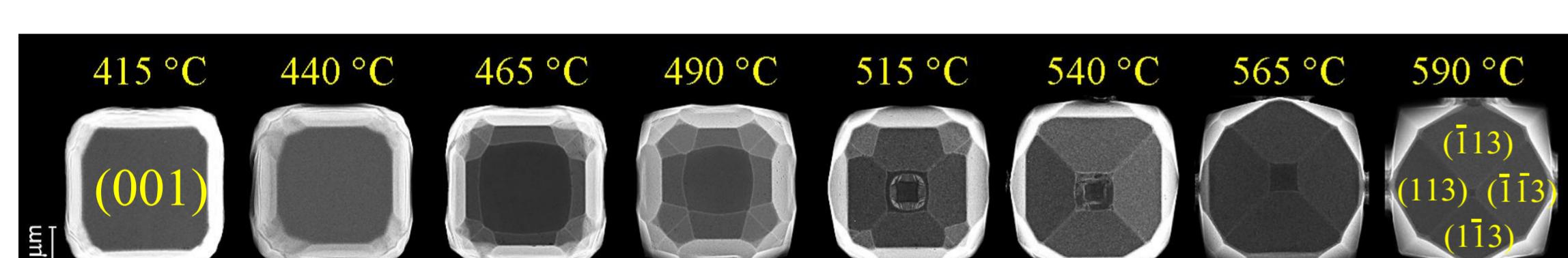


Thermal mismatch (130%):  
wafer bowing & layer cracks

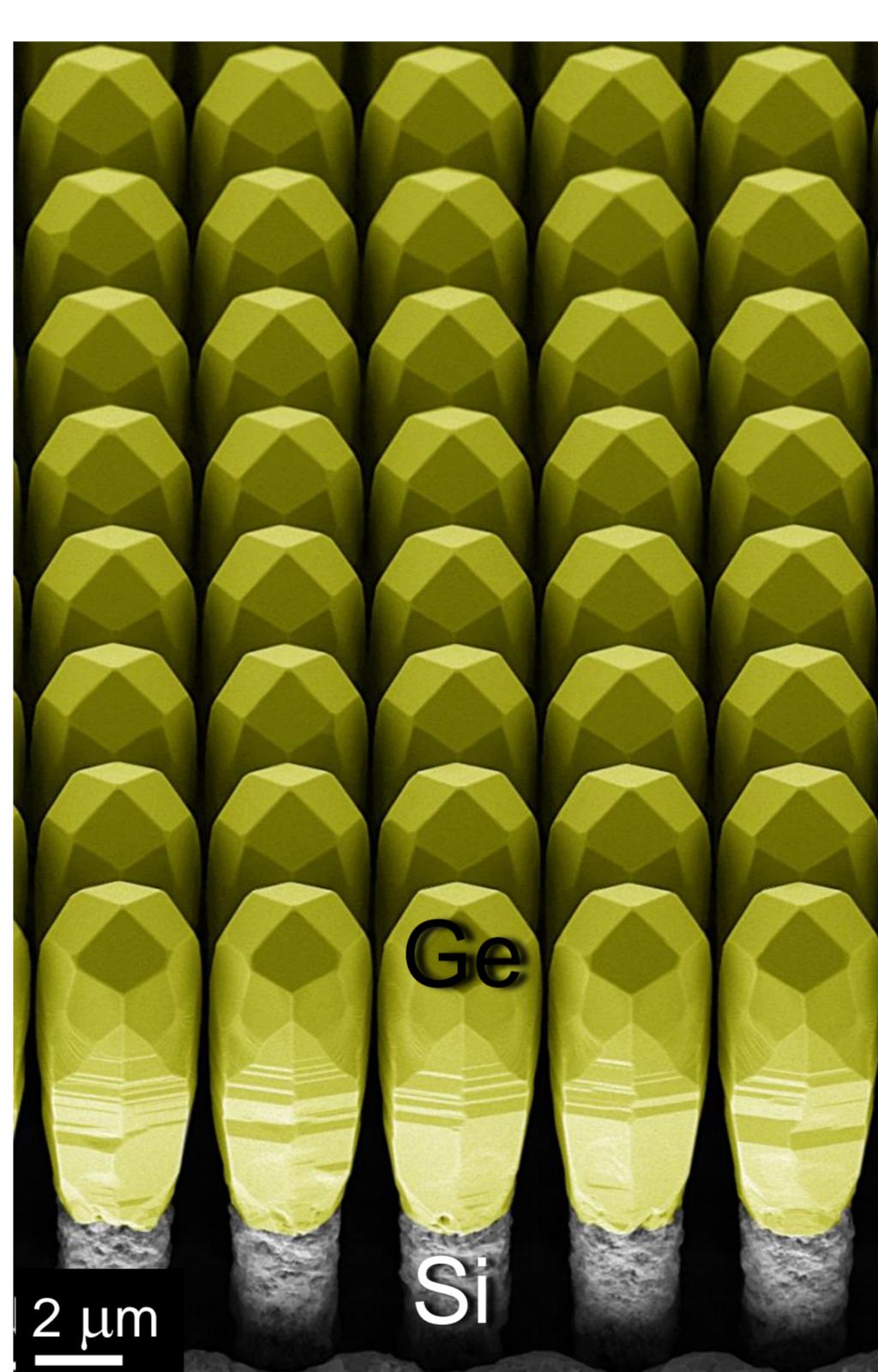
### Solution: Grow space filling arrays of 3D Ge crystals



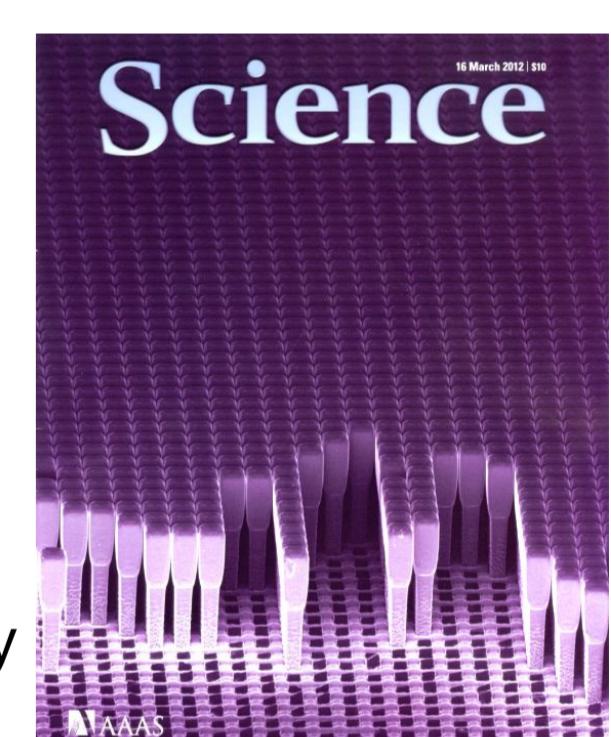
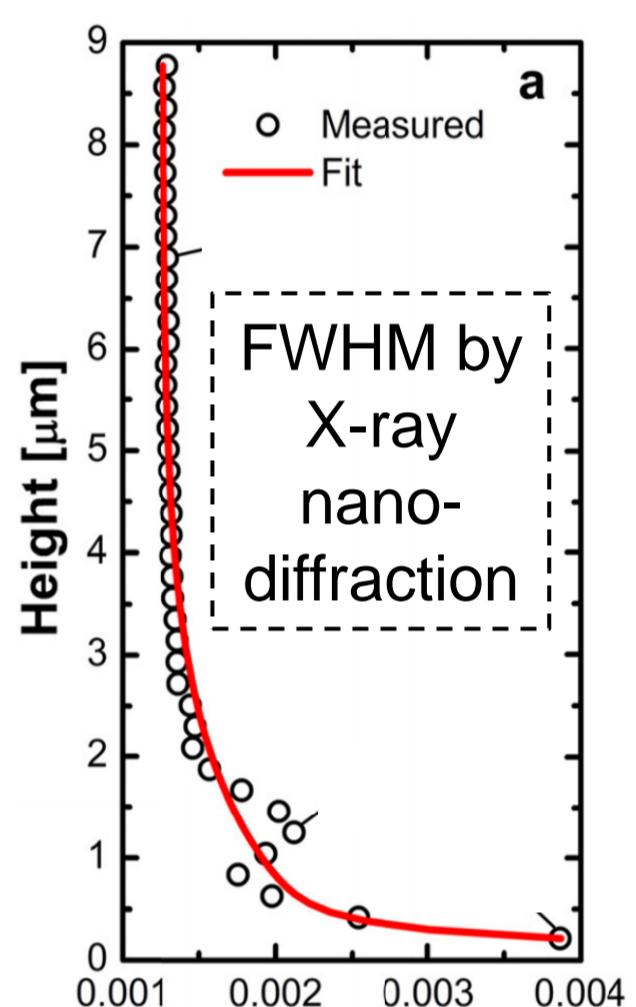
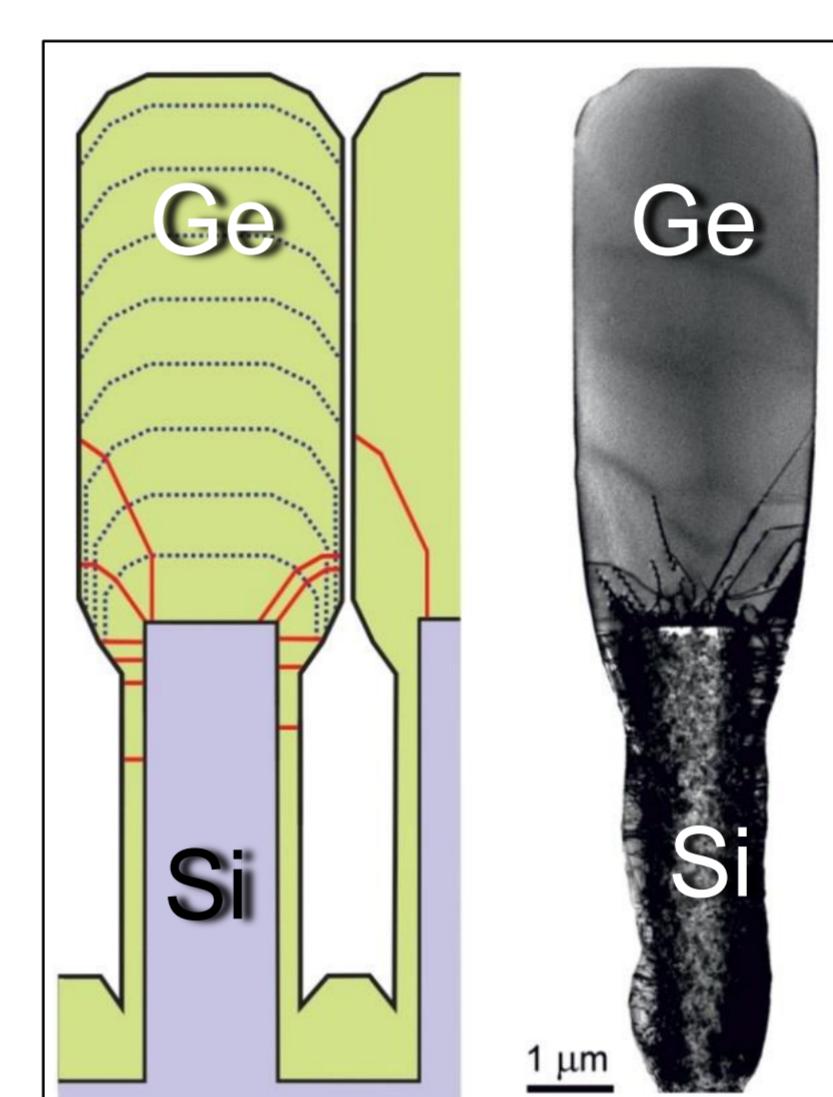
Self limiting lateral growth by "low-energy PECVD": No fusion!  
High growth rate (4 nm/s) at low temperature (< 600°C)



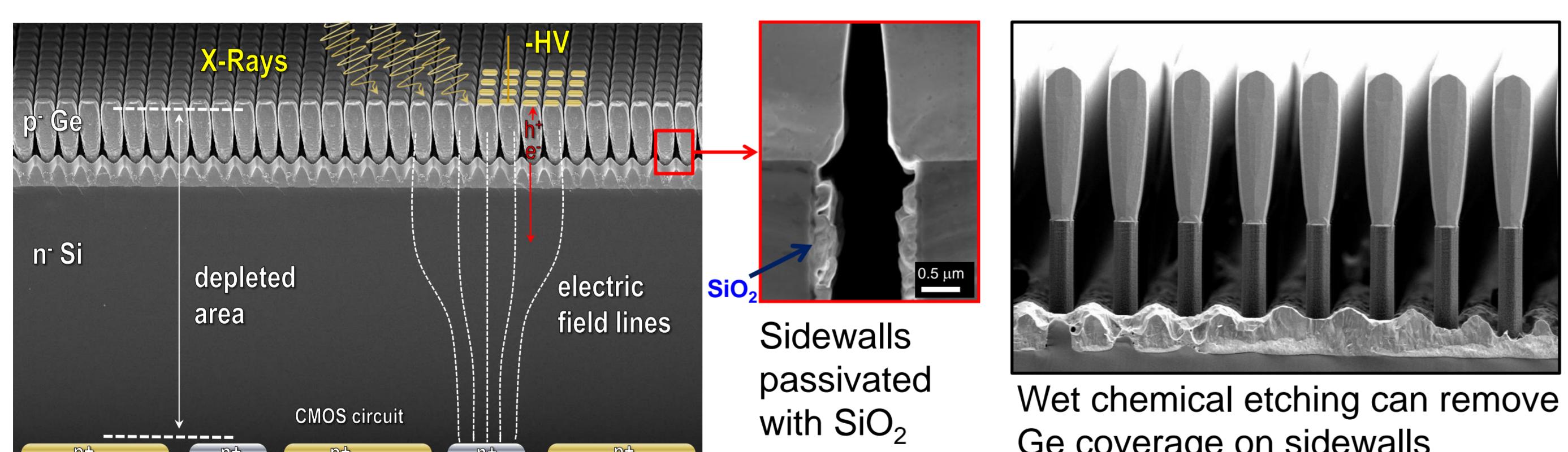
Top facet distribution is tunable with temperature



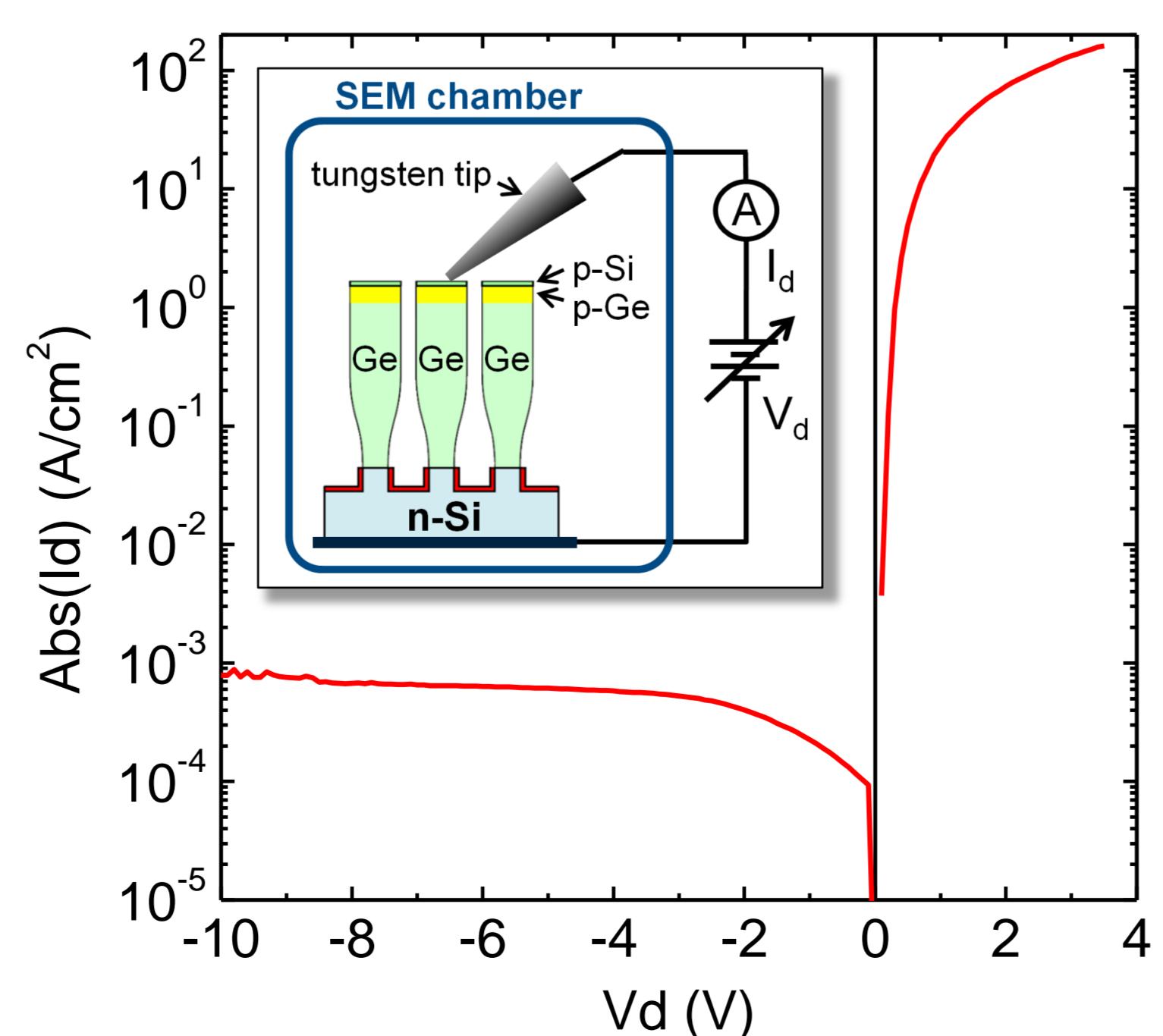
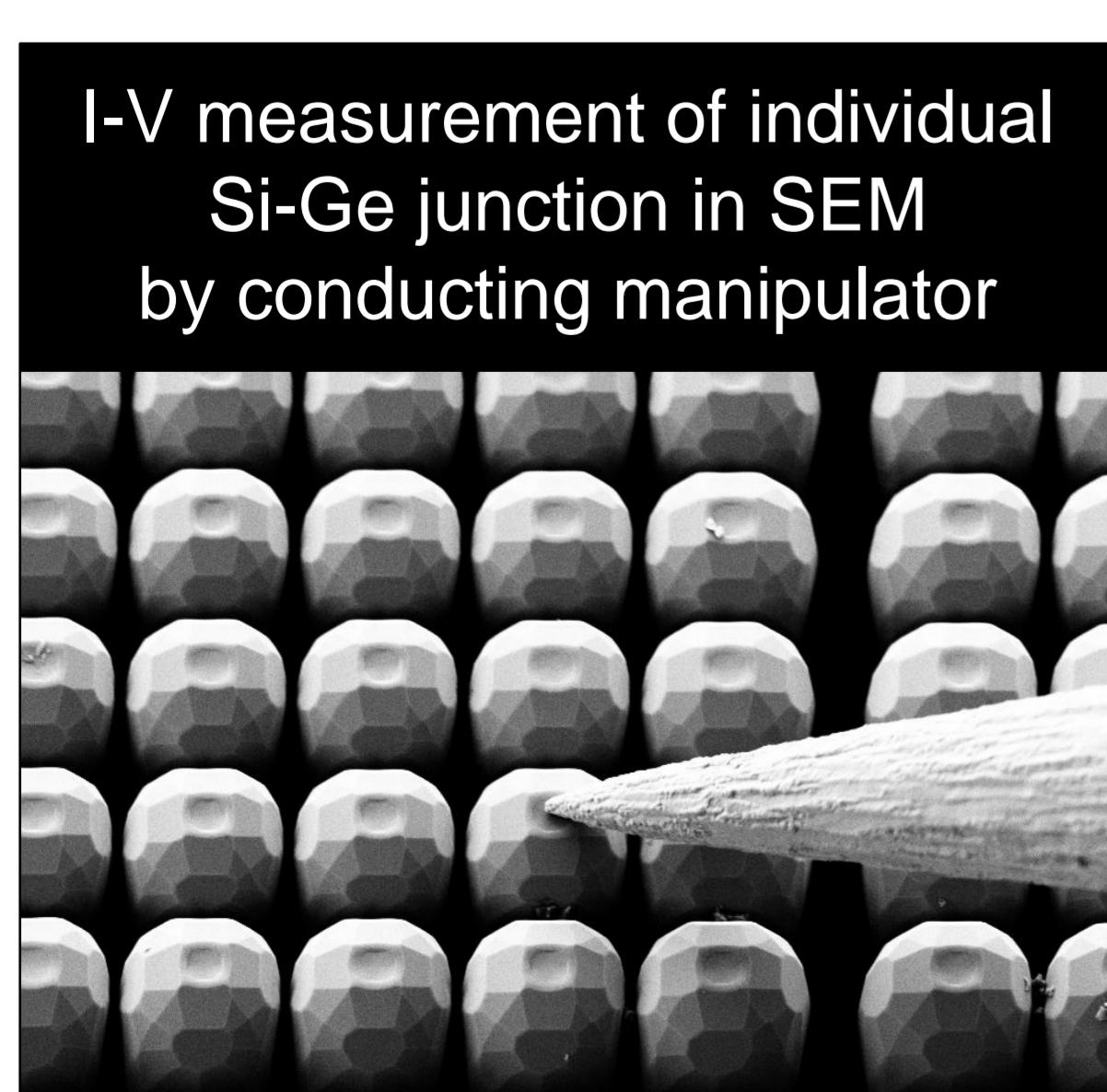
Upper part of Ge is  
dislocation- & strain-free



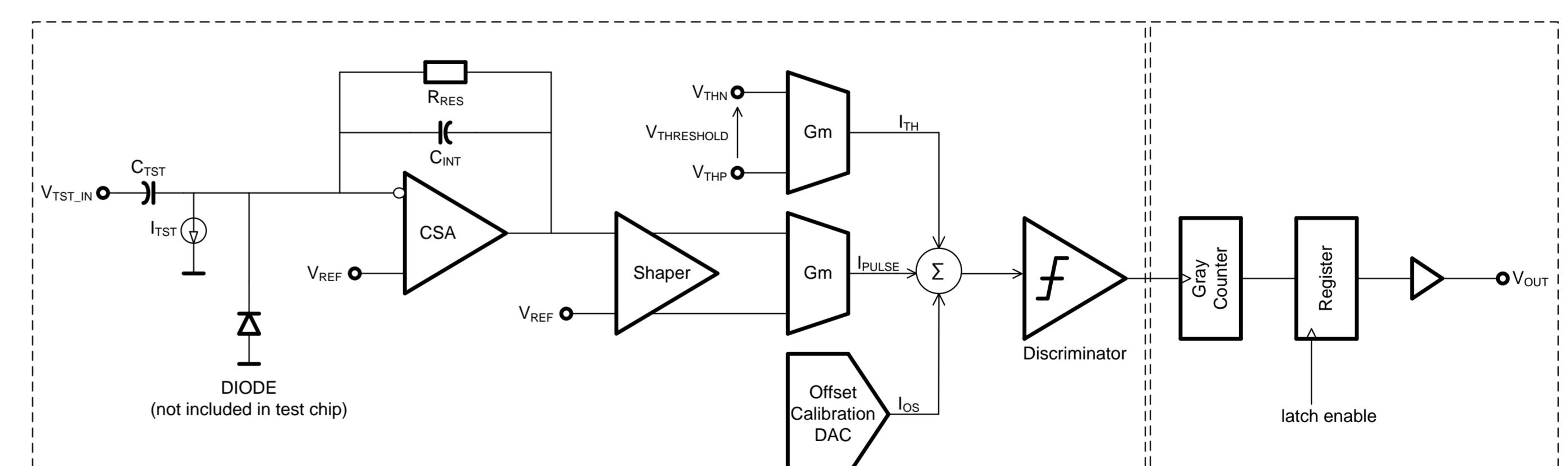
### I-V measurements on single Ge towers



Reverse dark current below 1 mA/cm<sup>2</sup> despite large surface/volume ratio



### CMOS pulse-detector circuit



### Pixel block diagram

