

axcelis

Ion Implantation and Applications for Power Devices





Outline

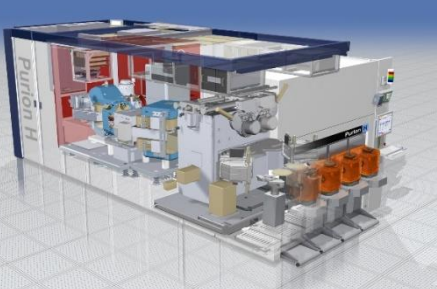
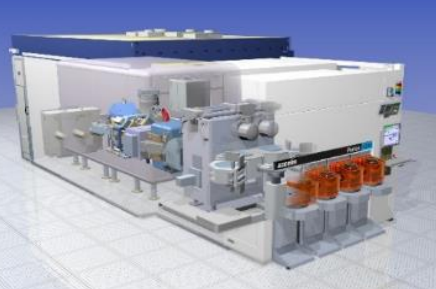
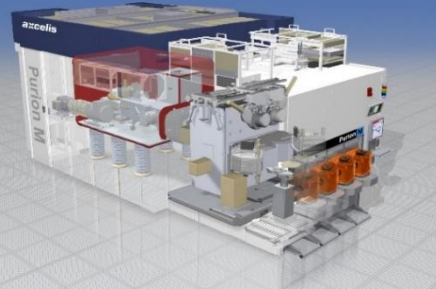

- Introduction
- Silicon carbide doping challenges
 - Implant Species and Source Operation
 - High Temperature Implant for Implant Damage Control
- Silicon Carbide Structure and Implant Solutions
 - High Energy Implant for SiC Trench MOSFET
 - Purion XEmax High Energy System
- Summary

Axcelis at a Glance

- Global leader in technology development and manufacturing of ion implant systems and services for the semiconductor industry for 45 years
 - Serving the ~\$2.7B ion implant systems market
 - Based in Beverly, MA with headcount greater than 1700 worldwide
 - Global customer support infrastructure
 - Growing installed base of greater than 3000 tools
 - Strong IP portfolio
- Supplier of record to leading semiconductor CAPEX spenders in all market segments including DRAM, NAND, Foundry, Logic, Power and Image Sensor



Product Overview - Common Purion Platform

Application Space	High Current	Medium Energy/ High Current	Medium Energy/ Medium Current	High Energy
				
Base Products/Model	Purion H Purion Dragon	Purion H200	Purion M	Purion XE/EXE/VXE Purion XEmax
Power Series™		Purion H200 SiC	Purion M SiC	Purion XE/EXE SiC
Customer Markets	Adv DRAM/NAND & Logic Material Modification	Power Device Mature Technologies	Power Device RF Mature Technologies Adv DRAM/NAND	Power Device Image Sensor Mature Technologies Adv DRAM/NAND

Silicon Carbide Doping Challenges

■ Aluminium: P-type dopant

- Solid source vaporizer like, AlI_3 , AlCl_3
- Source operation control
 - Beam tuning time
 - Implant species change time

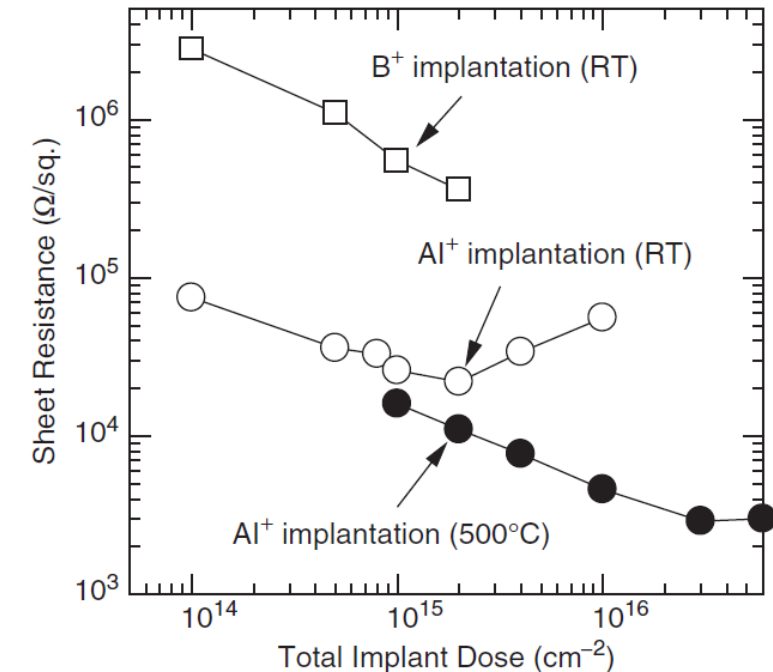
■ Implant damage defects control

- High temperature implant to reduce implant damages
- Improve dopant activation
- $>500^\circ\text{C}$ implant

■ High temperature annealing for dopant activation

- $>1500^\circ\text{C}$
- Surface capping layer for annealing

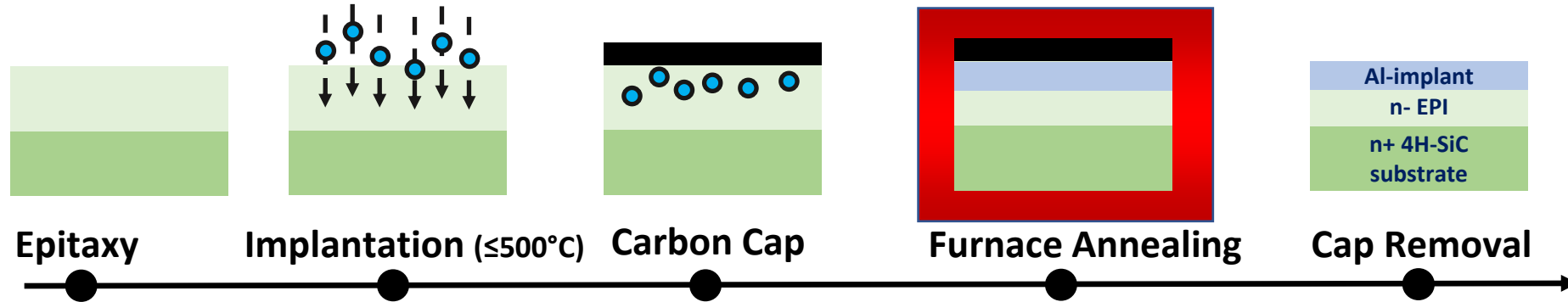
Dopant	Si/SiGe	SiC
N-type	P, As, Sb	N, P
P-type	B, Ga, In	Al
Non dopant	H, He, C, Si, F, Ge	H, He



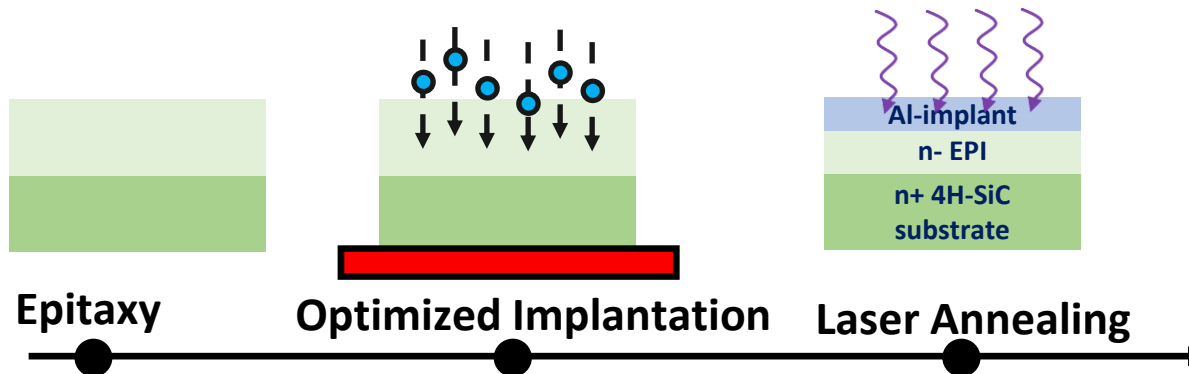
Fundamentals of Silicon Carbide Technology, T. Kimoto, J. Cooper,
Published 23 September 2014, Engineering, Materials Science, Physics

Implant and Annealing Strategy

Industrial process



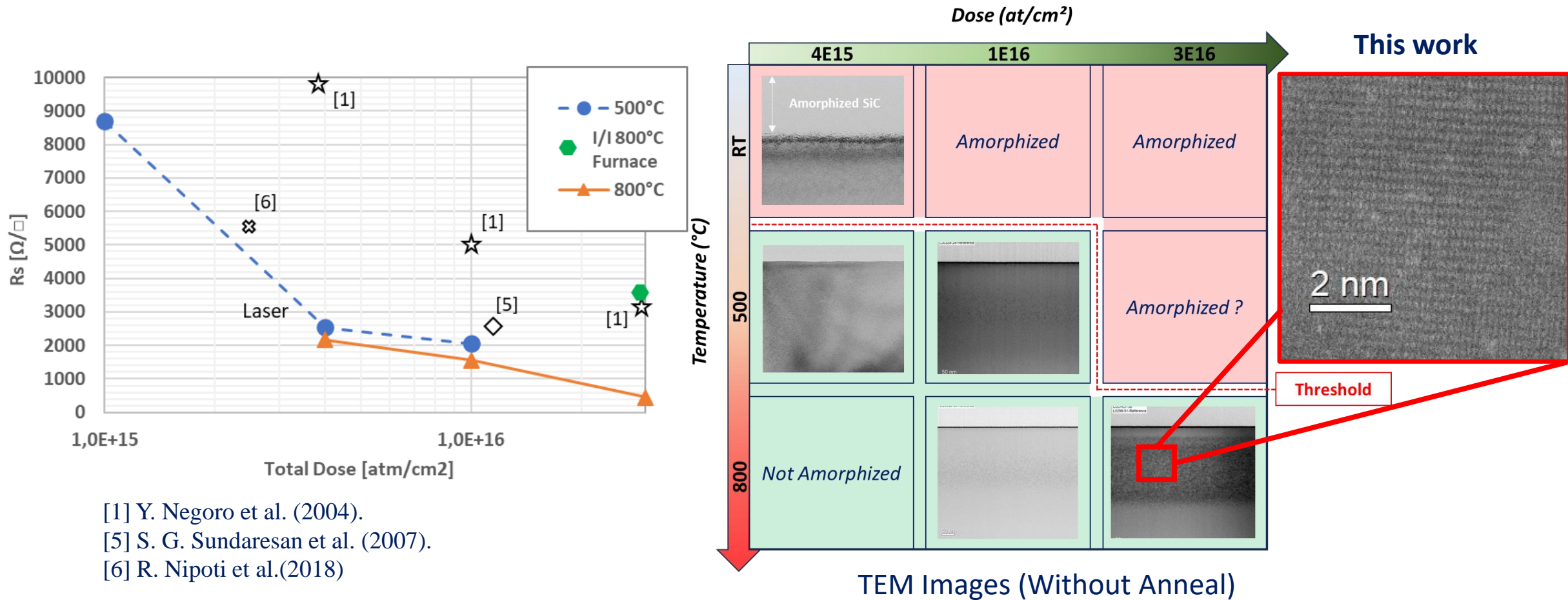
This work



- Advanced ion implantation Control & Minimize defect level
- Avoid capping layer process and to reduce manufacturing costs
- Laser annealing to combine high temperature activation efficiency with no high thermal budget-induced extending defects

Axcelis Internal Work, Presented by F. Mazzamuto at ISCREM 2023 Conference, Italy

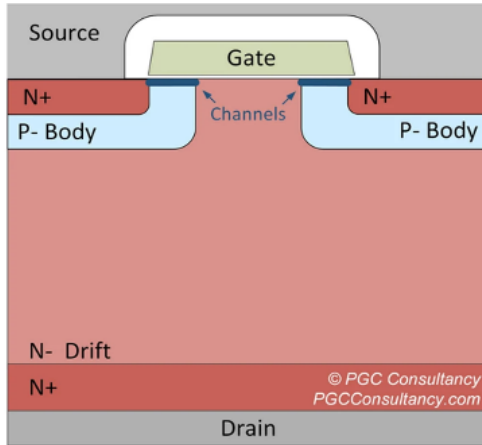
Hot Implant and Annealing Control to Implant Damages



- [1] Y. Negoro et al. (2004).
[5] S. G. Sundaresan et al. (2007).
[6] R. Nipoti et al. (2018)

- High Temperature Implant for SiC Implant Defect Control
- “Warm” or Room Temperature Implants at Lower Lose for Productivity Consideration

Silicon Carbide Structure and Implant Solutions

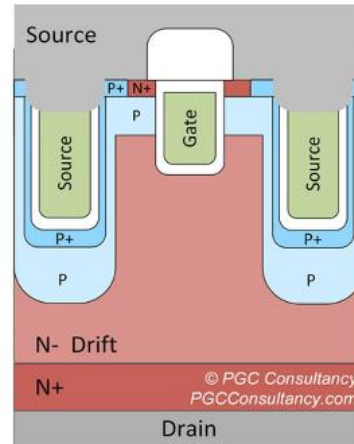
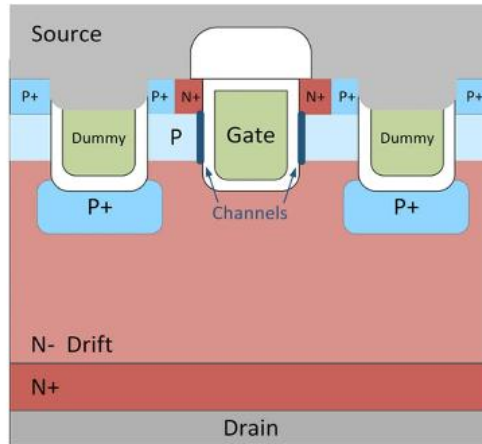
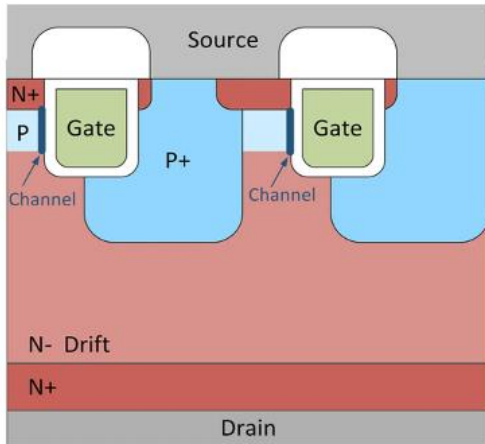
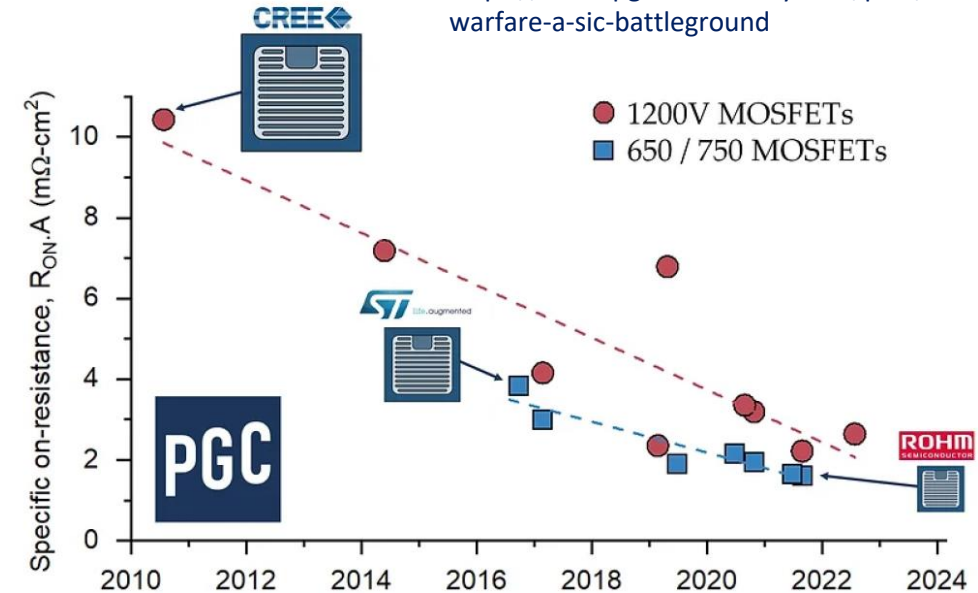


■ Planar MOSFET

- ~18-24 implants
- Max E ~600keV
- Max Dose ~ 2e15

MC + HC/HE

<https://www.pgconsultancy.com/post/rohm-gen-4-a-technical-review>



■ Trench MOSFET

- ~ 30 implants
- Max E ~ 2MeV
- Max Dose ~ 5e15

HE + MC/HC

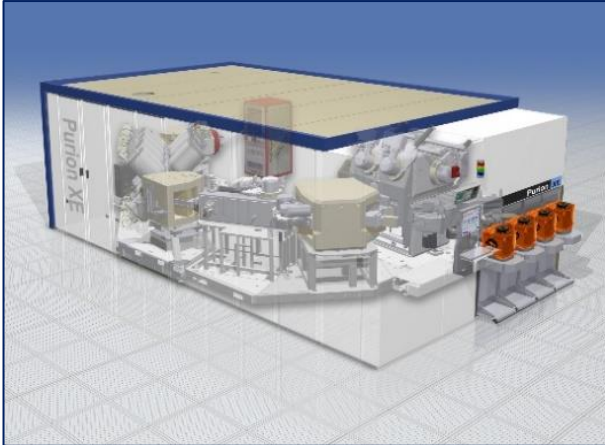
MC = Medium Current

HC = High Current

HE = High Energy

Device structures are driving “different” implant solutions to optimize High Volume Manufacturing

Axcelis High Energy Implant Systems



Purion XE/EXE/VXE
Purion XEmax

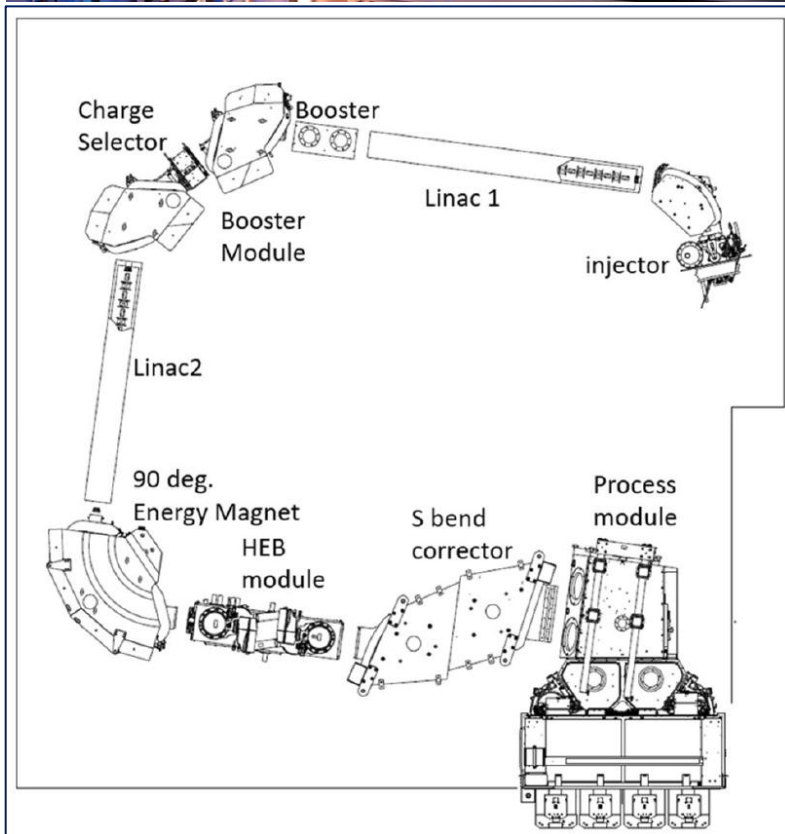
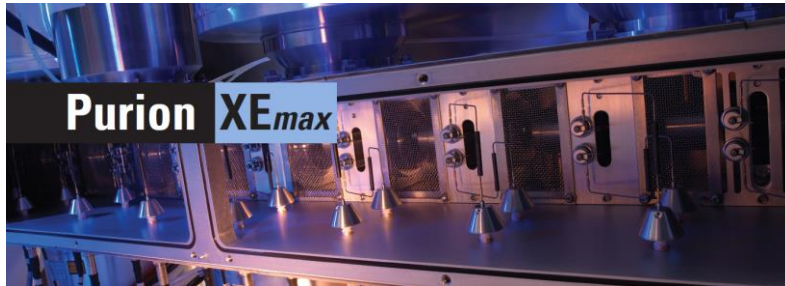
Purion XE/EXE SiC

Power Device
Image Sensor
Mature Technologies
Adv DRAM/NAND

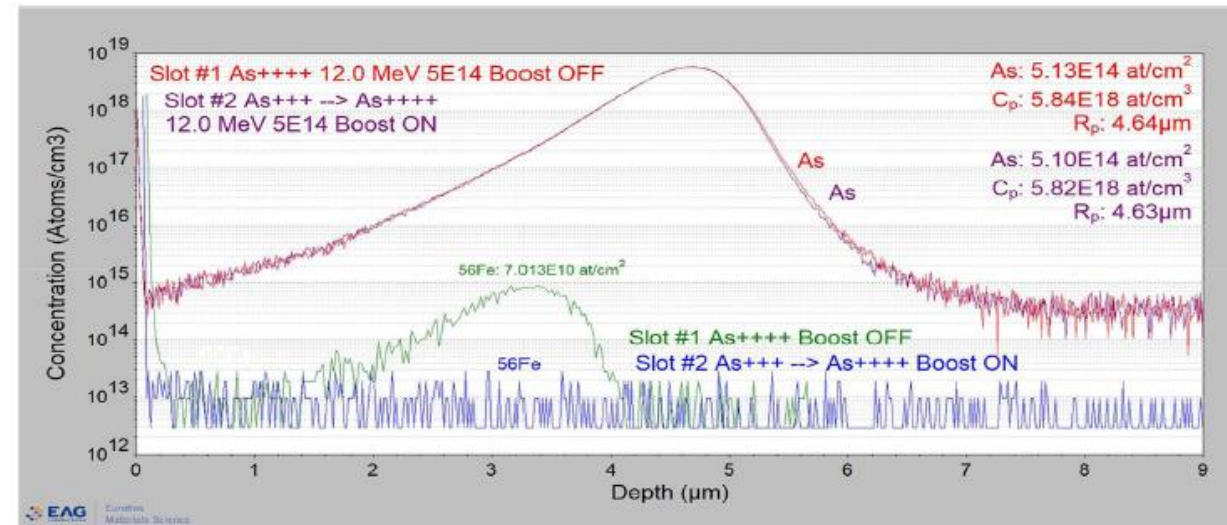
- Linear acceleration (LINAC) technology
 - Market leader
 - High productivity
 - Reliable and cost effective
- High temperature implant for SiC
 - Purion XE
 - Purion EXE
- New developed systems:
 - Purion XEmax
 - Ultra high energy system (15MeV)
 - To satisfy implant roadmap requirement

Axcelis Offers Complete Set of High Energy Systems for IC Manufacturing

Purion XEmax High Energy System



- Designed to achieve high energy implant capability
 - Higher extraction current
 - Longer source life
- Booster module acceleration
 - Select higher charge state ion after booster
 - Eliminate energetic contaminants generated from ion source

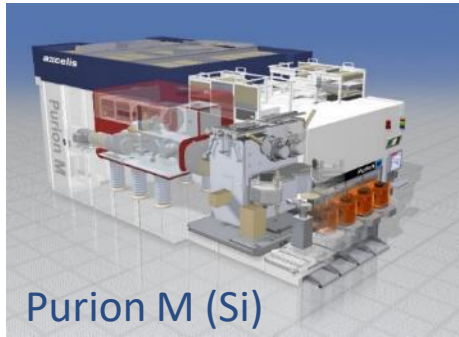


- S bend corrector magnet
 - Provide accurate ion beam angle control

Purion XEmax, Axcelis ultra-high energy implanter with Boost™ technology, Shu Satoh, IIT 2022

Axcelis Purion Power Series for SiC

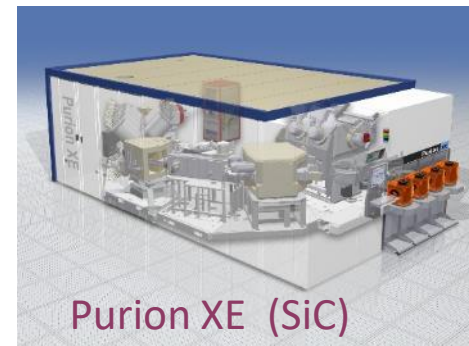
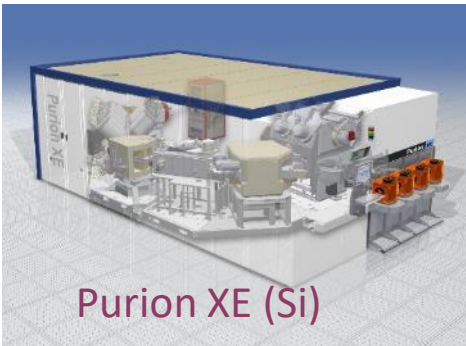
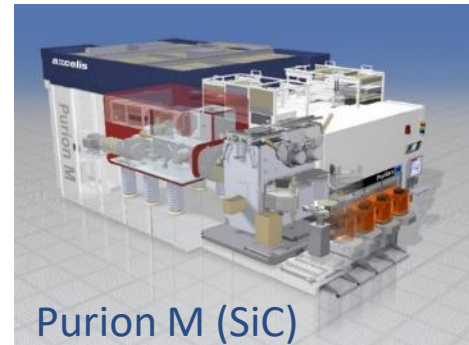
Highest Productivity Solution for ALL Implants in SiC HVM



Al+ Source

150/200mm SiC
Wafer Handling

Heated Implant
Capability (650°C)



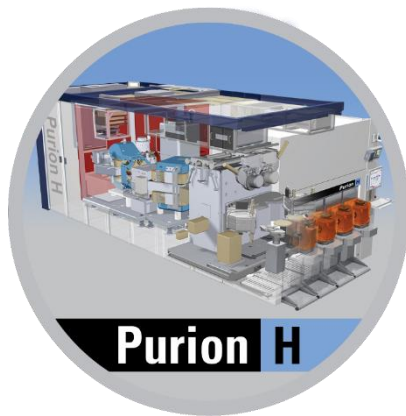
Energy Range (keV)

Species	M	XE	H200
+	335	1200	200
++	670	2700	400
+++	1000	3500	--

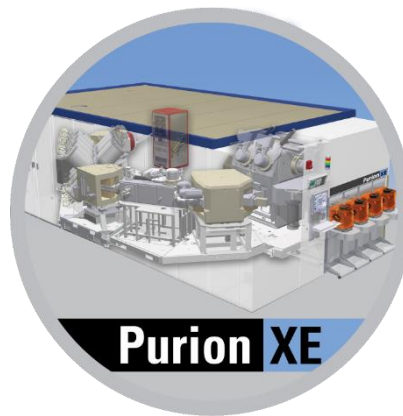
Highest Productivity Tool Set for SiC Manufacturing

Summary

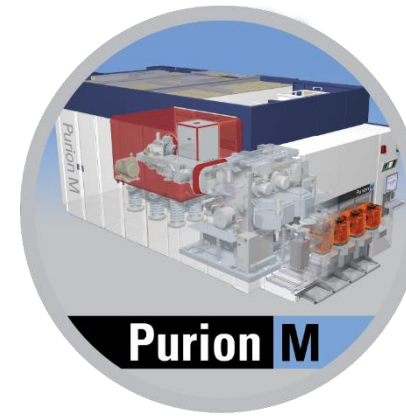
- Axcelis makes critical R&D investments to fuel continued innovation that further differentiates our products
- Axcelis tools provide a variety of competitive advantages across all customer segments
- Axcelis provides SiC implantation solutions
 - Medium energy with high current implant capability
 - Provide high temperature implant capability with high productivity
 - Provide high energy system for profile optimization/engineering



Purion H200 SiC



Purion XE SiC



Purion M SiC