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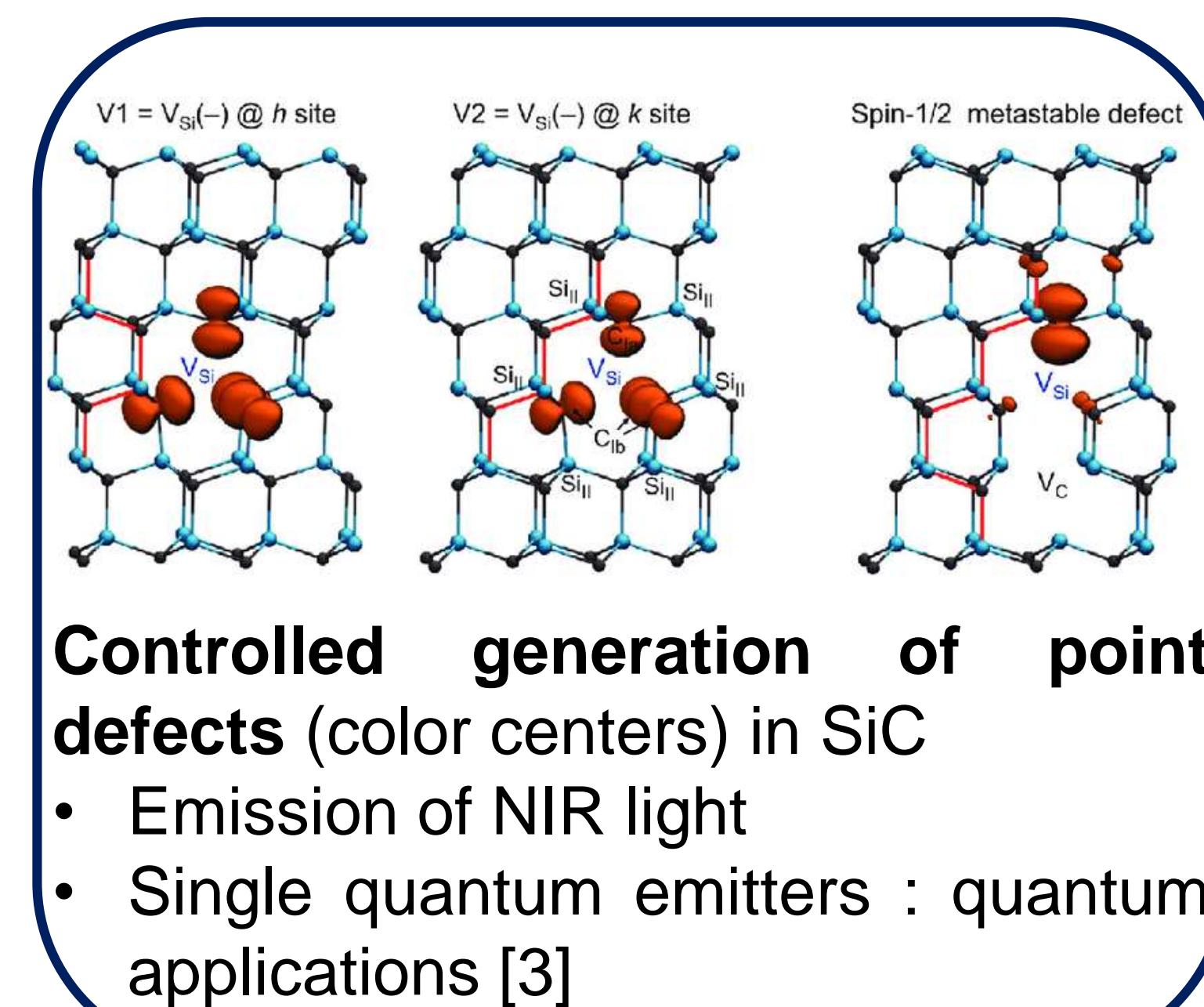
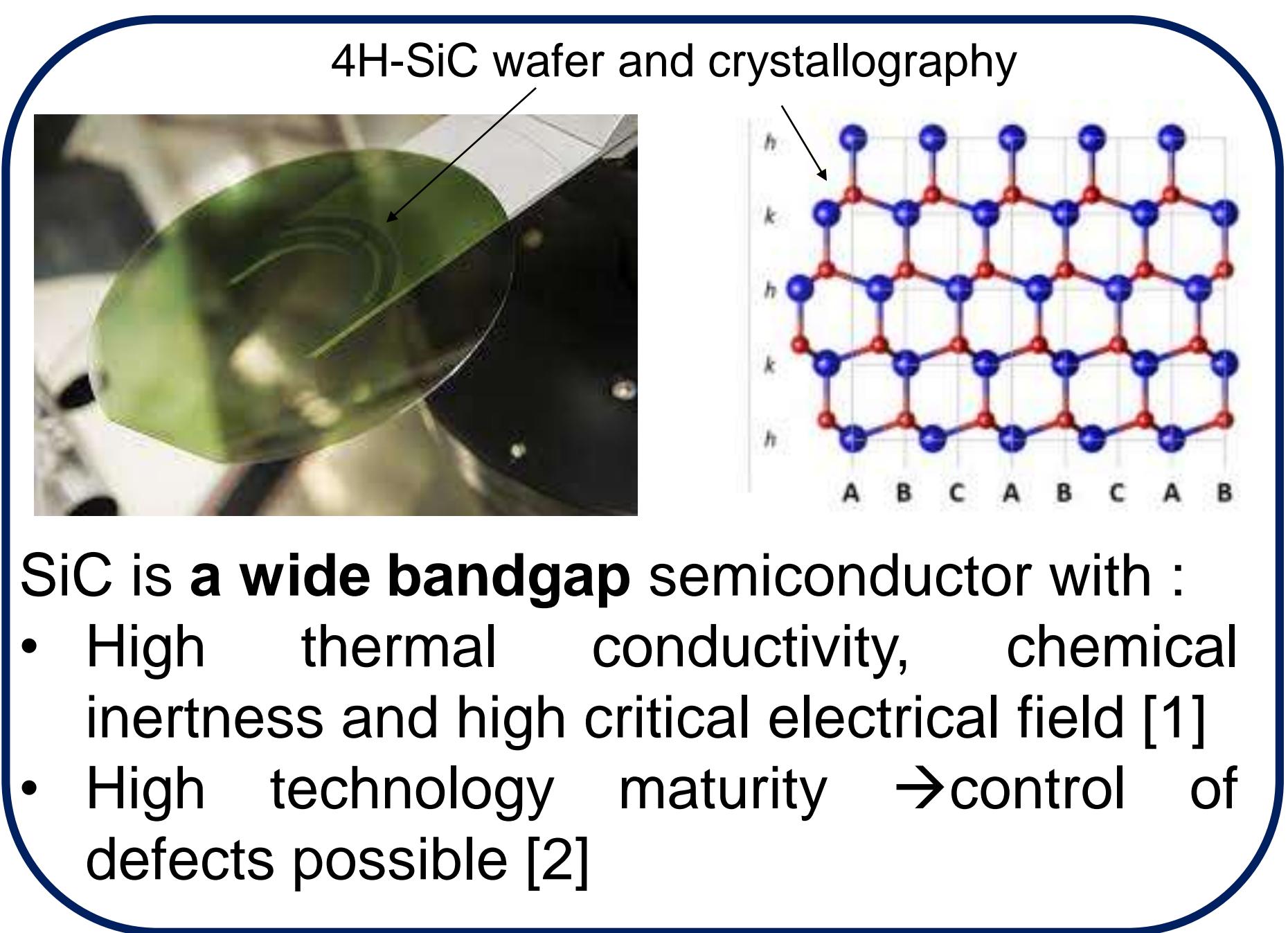
Characterization of silicon vacancies and di-vacancies in hexagonal silicon carbide formed by nitrogen and aluminum ion implantation.

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Context and objectives



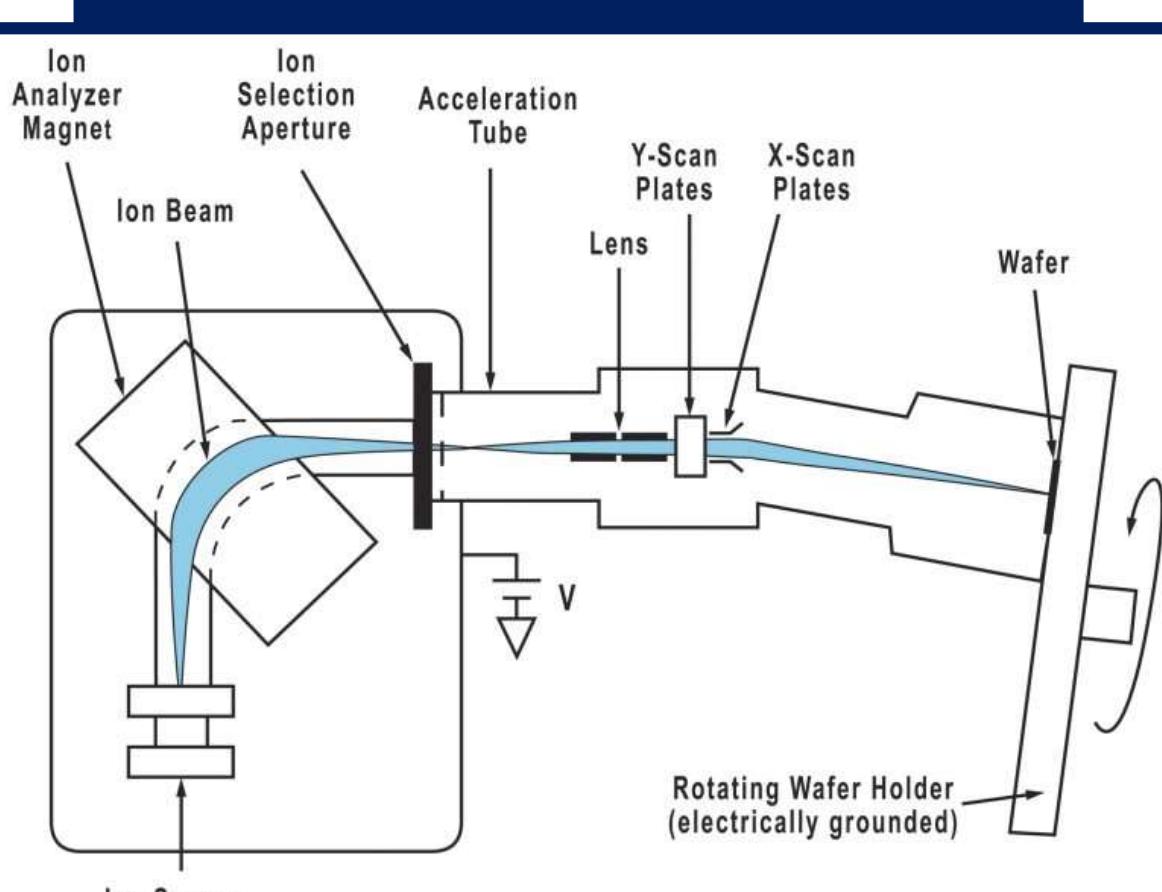
Objective : Determination of the optimal ion implantation parameters to generate silicon vacancies (V_{Si}) and di-vacancies (V_cV_{Si}) in 4H-SiC

Ion implantation allows :

- Simulations close from the experimental results
- A control of the point defects depth in the material
- Limited defects in the SiC matrix with well-controlled parameters
- Generation of color centers in localized and large areas [4]

Materials and methods

Ion implantation



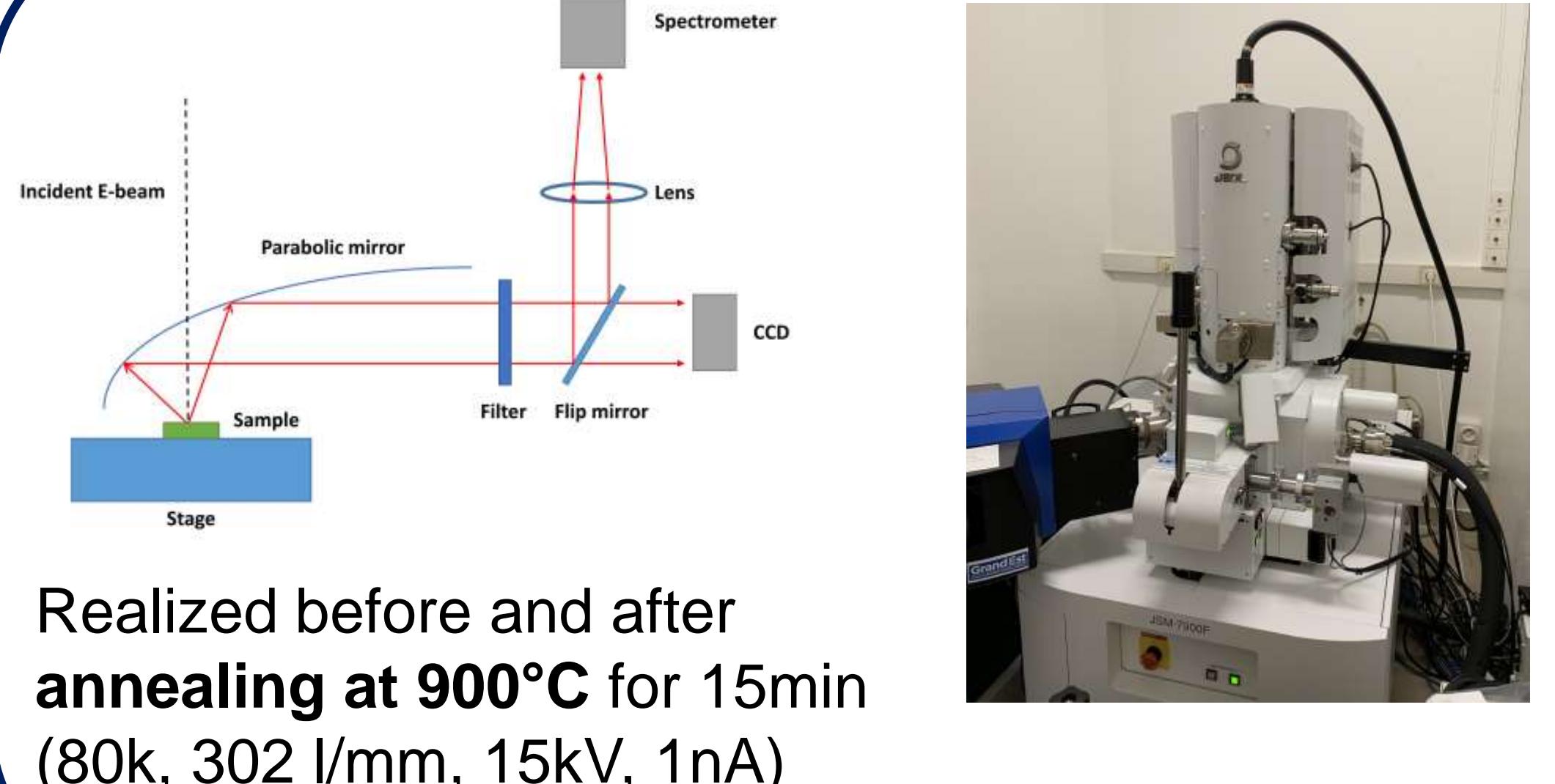
- N or Al implantations in 4H-SiC 10μm thick epilayer
- Temperature, dose and energy are changed
- Tilt and twist angles are 7 and 90° respectively

Ion implantation simulations

I2SiC software based on Montecarlo method and binary collision approximation (BCA) [5]

The diagram shows a particle's path through a medium, illustrating the 'Straight path between collisions' and 'Scattered ion' paths.

Cathodoluminescence with JEOL SEM



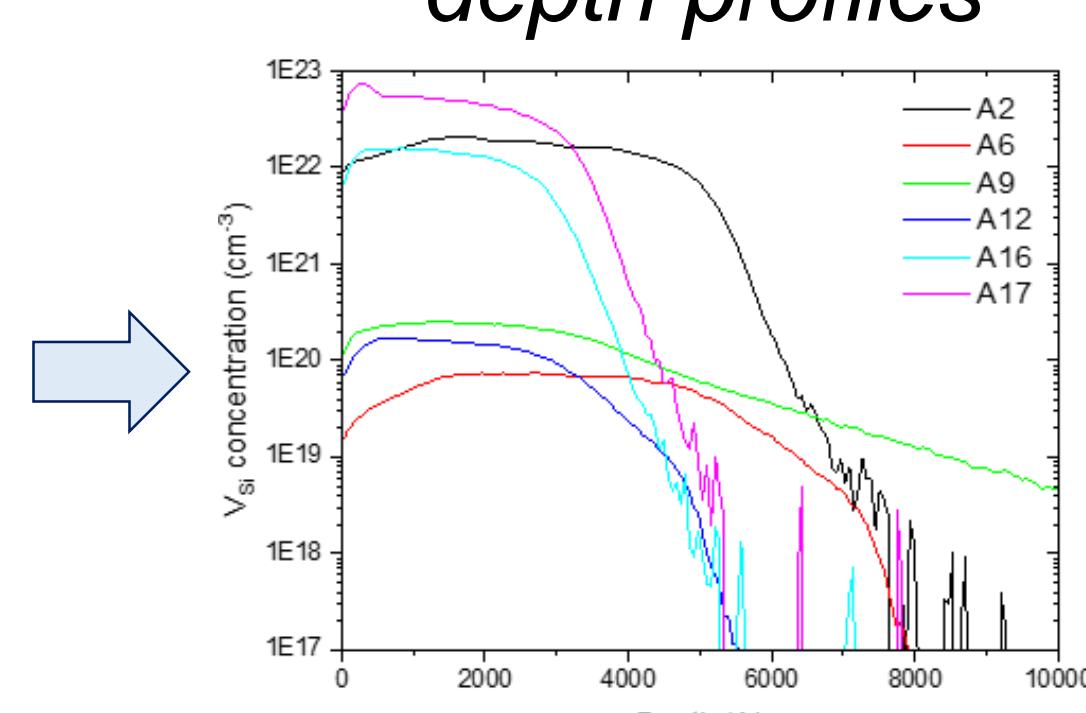
Results and Discussion

I2SiC simulations

Implantations parameters

Name	Dopant	Temperature [°C]	Energy [keV]	Dose [cm ⁻²]				
A2	N15	RT	400	6.4E14				
			270	4.6E14				
			170	4E14				
			100	3.8E14				
<hr/>								
Total: 1.88E15								
A6	N	RT	400	3.2E12				
			270	2.3E12				
			170	2E12				
			100	1.9E12				
<hr/>								
Total: 9.4E12								
A9	Al	RT	300	5.9E12				
			190	2.9E12				
			115	2.08E12				
			60	1.42E12				
			25	6.81E11				
			<hr/>					
Total: 1.3E13								
A12	N	RT	190	5.6E12				
			135	3.8E12				
			90	3.4E12				
			50	3.2E12				
			30	2.2E12				
			<hr/>					
Total: 1.8E13								
A16	N	300	160	5E14				
			110	2.8E14				
			70	2.5E14				
			40	1.8E14				
			20	1.3E14				
			<hr/>					
Total: 1.34E15								
A17	N	400	190	1.5E15				
			135	9E14				
			90	9E14				
			50	8E14				
			20	1.3E15				
			<hr/>					
Total: 5.4E15								
A23 NA NA NA NA								

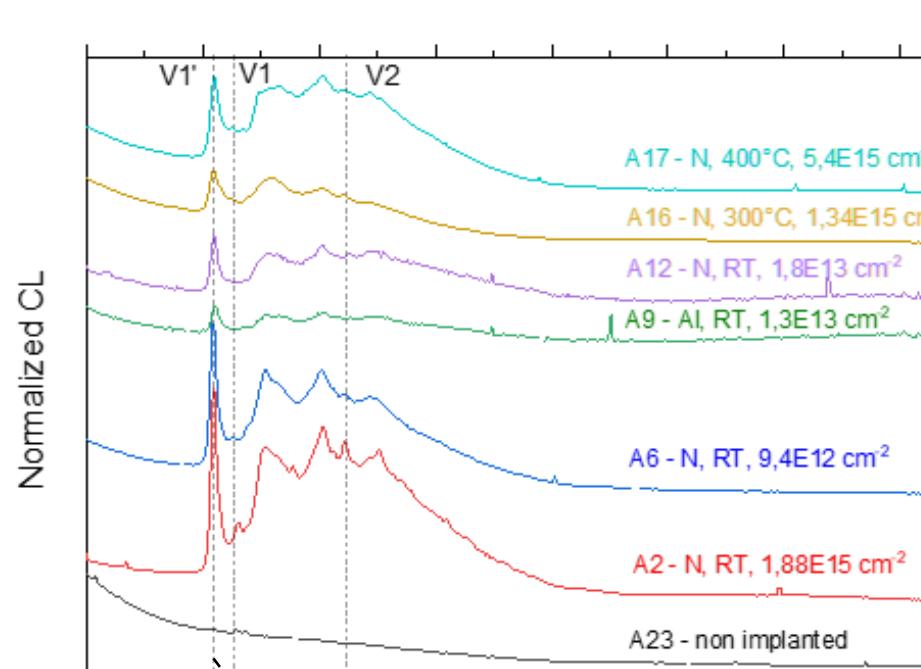
Simulated V_{Si} depth profiles



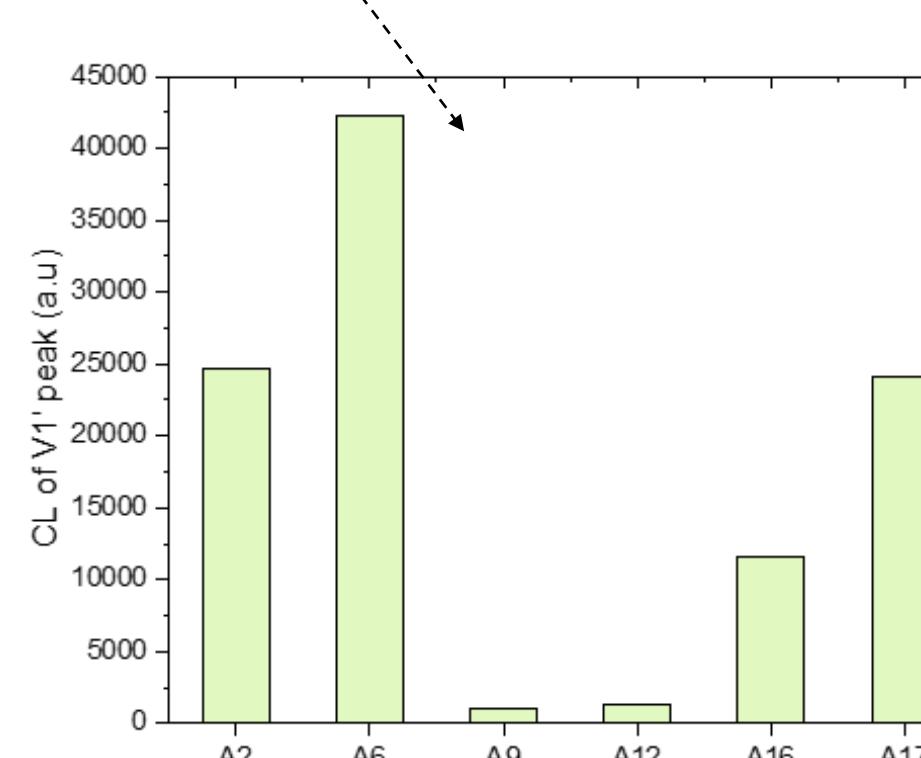
- Higher implantation energy leads to a deeper generation of V_{Si}
- Higher implanted dose leads to a higher concentration of V_{Si}

Normalized CL spectra

Before Annealing

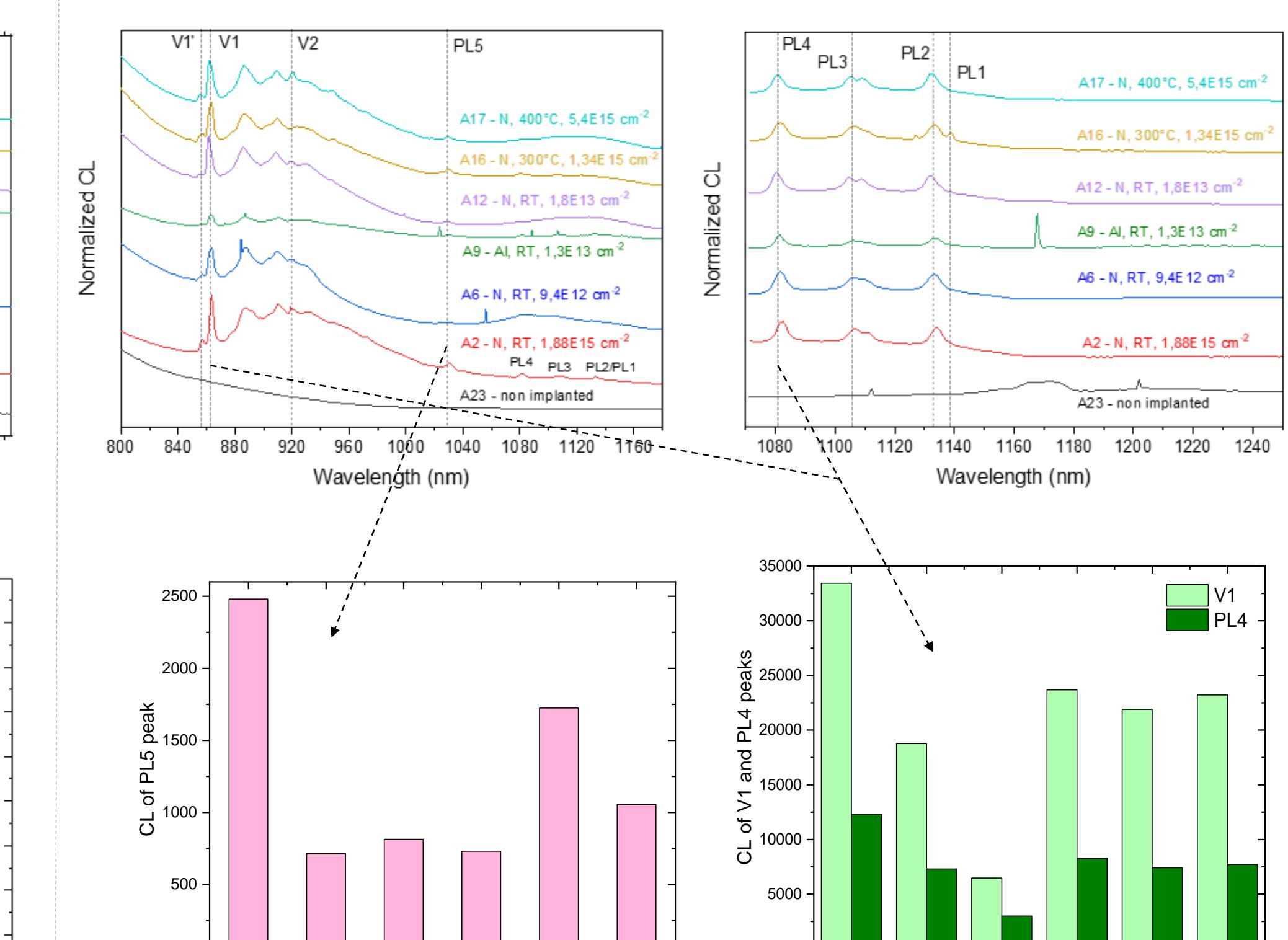


Relative intensity of CL peaks

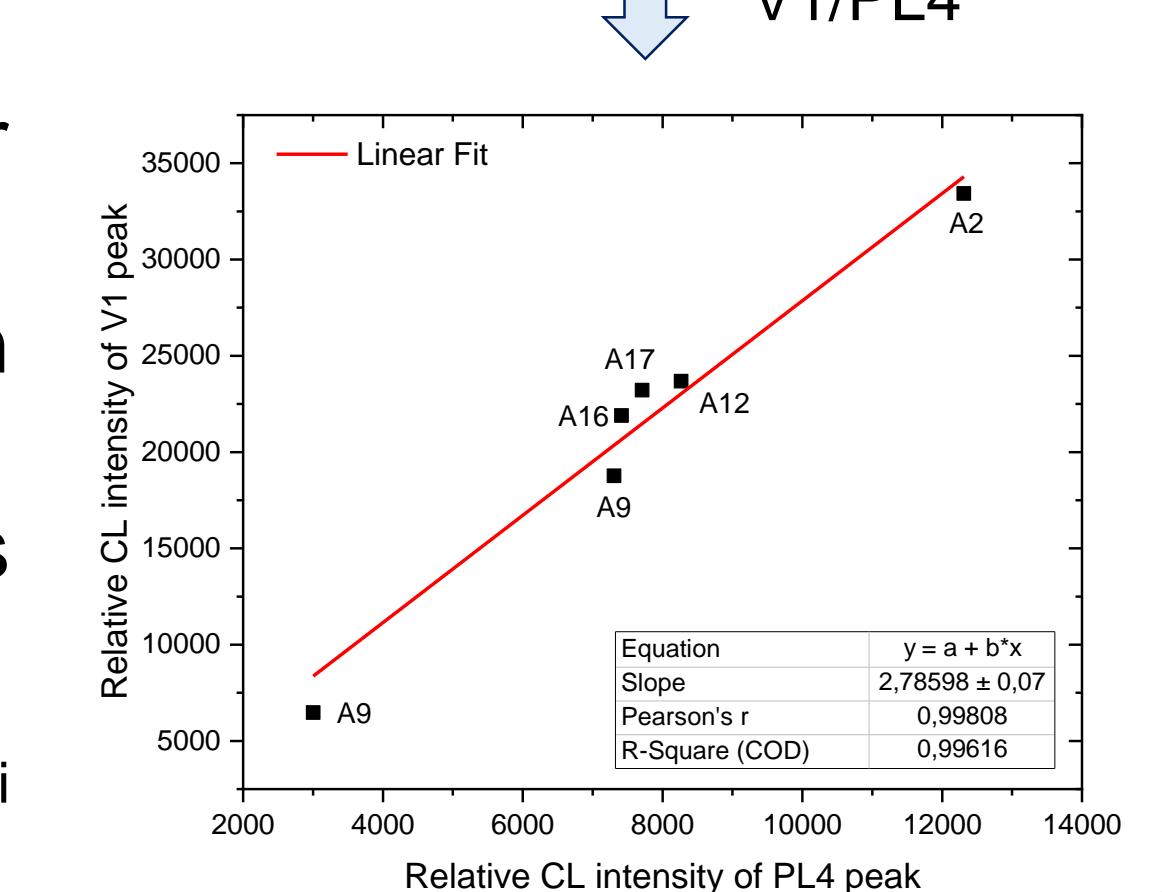


Cathodoluminescence

After annealing at 900°C for 15min



V1/PL4



Conclusion

- Implantation of 4H-SiC samples realized
- Simulation of implantations realized to see V_{Si} depth profiles
- Cathodoluminescence measurements are obtained
 - Before annealing : V_{Si} concentration maximal for high energy, low dose N-implantation at RT
 - After annealing : V_{Si} concentration maximal for high energy, high dose N-implantation at RT and the concentration of V_CV_{Si} is proportional to the concentration of V_{Si}

- V1' configuration favored before annealing and V1 configuration favored after annealing at 900°C for 15min.
- Concentration of V_CV_{Si} proportional to the concentration of V_{Si} in V1 configuration after annealing.
- Presence of 6H-SiC inclusions in stacking faults produced during ion implantations (PL5 peak) [6]
- Al implantation decreases the V_{Si} and V_CV_{Si} concentrations

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