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Context and objectives

4H-SiC wafer and crystallography

SiC is a **wide bandgap** semiconductor with :

- High thermal conductivity, chemical inertness and high critical electrical field [1]
- High technology maturity → control of defects possible [2]

Controlled generation of point defects (color centers) in SiC

- Emission of NIR light
- Single quantum emitters : quantum applications [3]

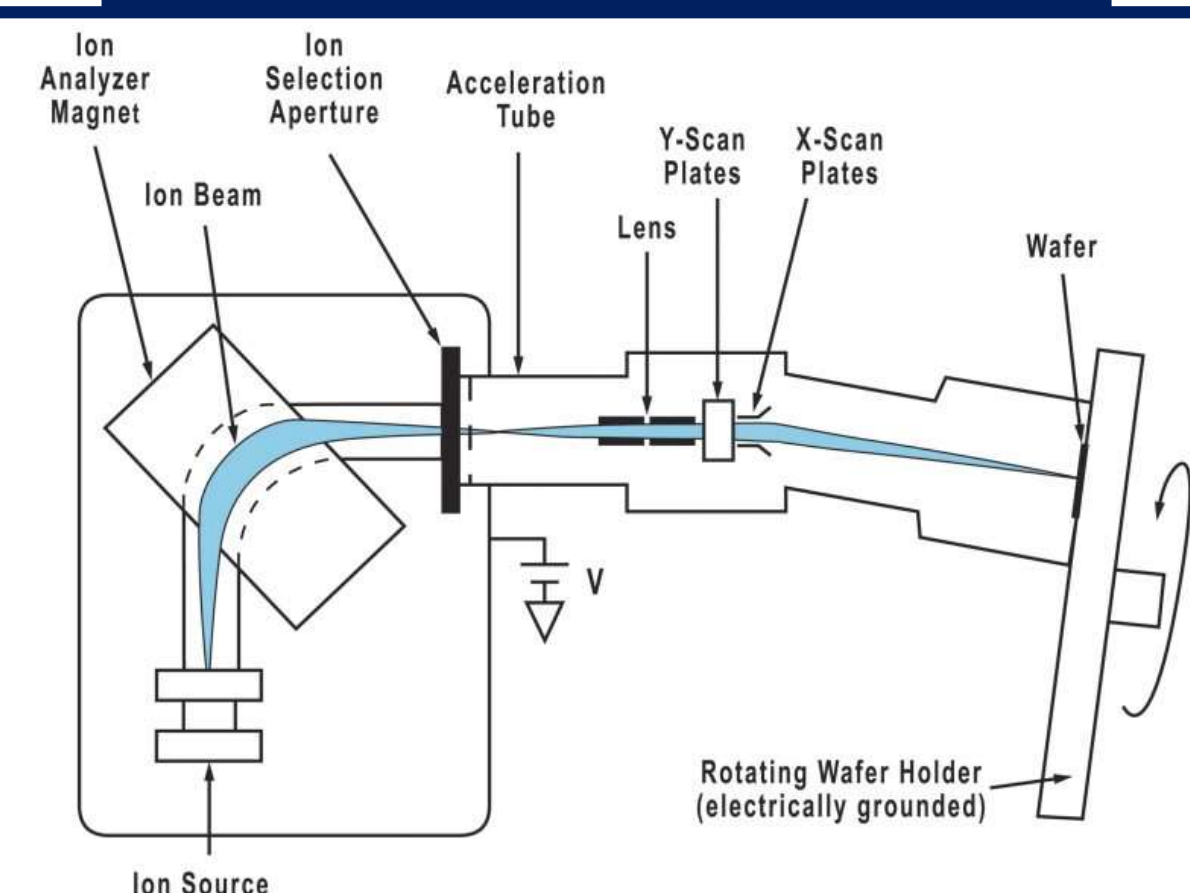
Objective : Determination of the optimal ion implantation parameters to generate silicon vacancies (V_{Si}) and di-vacancies ($V_C V_{Si}$) in 4H-SiC

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]

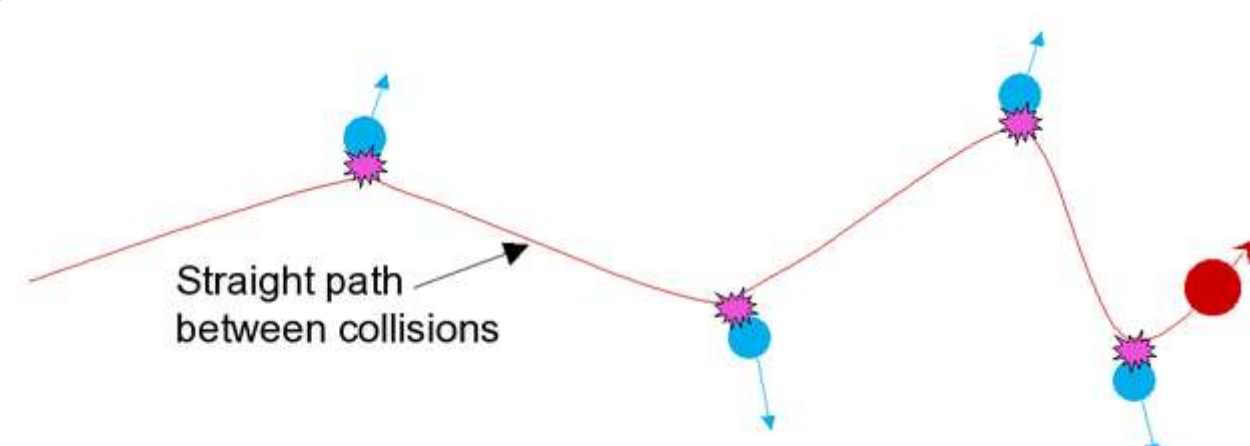
Materials and methods

Ion implantation



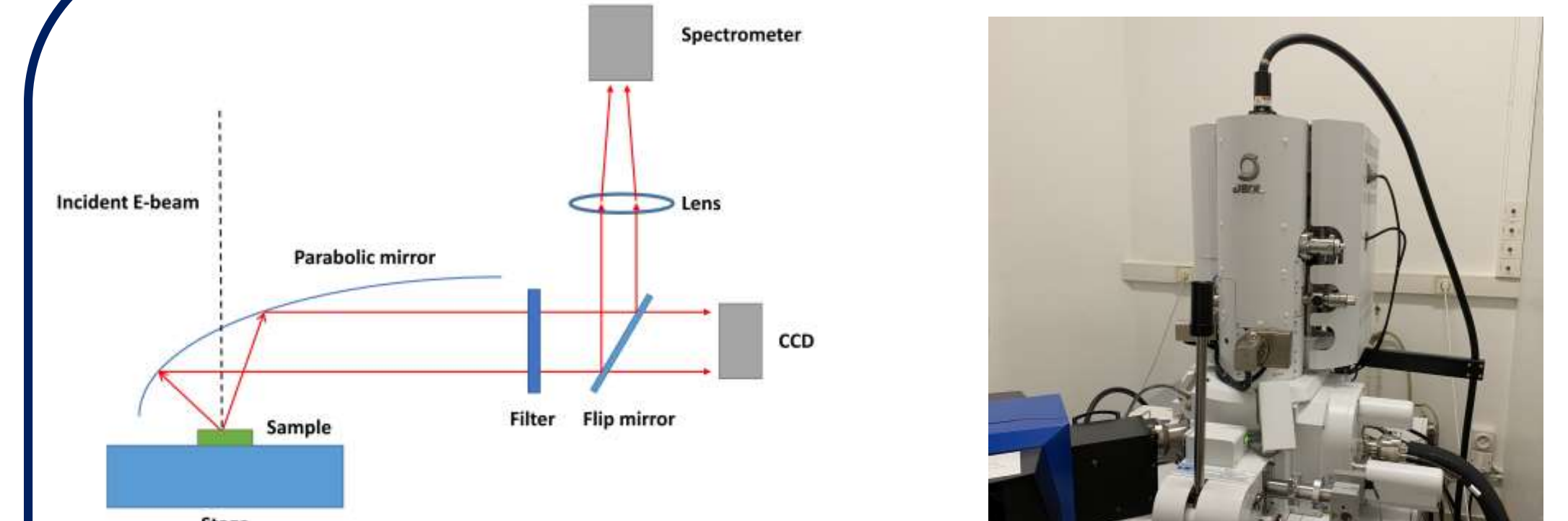
- **N or Al** implantations in 4H-SiC 10 μ m thick epilayer
- Temperature, dose and energy are changed
- Tilt and twist angles are 7 and 90° respectively

Ion implantation simulations



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

Cathodoluminescence with JEOL SEM



Realized before and after **annealing at 900°C** for 15min (80k, 302 l/mm, 15kV, 1nA)

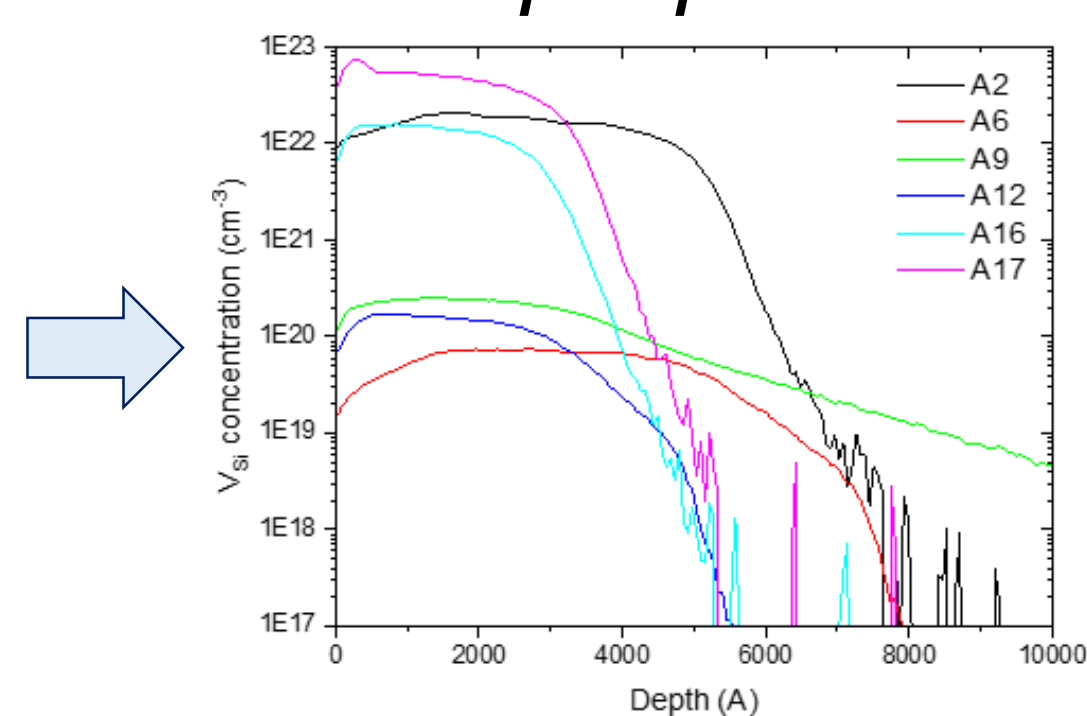
Results and Discussion

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
Total: 1.88E15				
A6	N	RT	400	3.2E12
			270	2.3E12
			170	2E12
			100	1.9E12
Total: 9.4E12				
A9	Al	RT	300	5.93E12
			190	2.9E12
			115	2.08E12
			60	1.42E12
			25	6.81E11
Total: 1.3E13				
A12	N	RT	190	5.6E12
			135	3.6E12
			90	3.4E12
			50	3.2E12
			30	2.2E12
Total: 1.8E13				
A16	N	300	160	5E14
			110	2.8E14
			70	2.5E14
			40	1.8E14
			20	1.3E14
Total: 1.34E15				
A17	N	400	190	1.5E15
			135	9E14
			90	9E14
			50	8E14
			20	1.3E15
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}

Conclusion

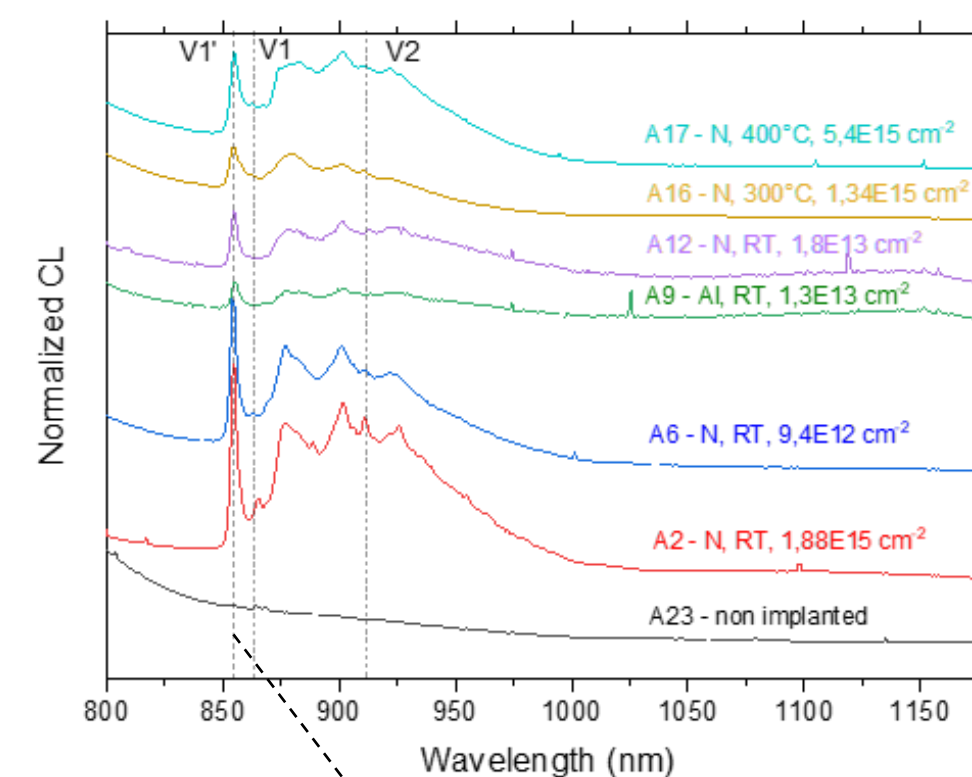
- Implantation of 4H-SiC samples realized
- Simulation of implantations realized to see V_{Si} depth profiles
- Cathodoluminescence measurements are obtained
 - Before annealing : V_{Si} concentration maximal for high energy, low dose N-implantation at RT
 - After annealing : V_{Si} concentration maximal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

References

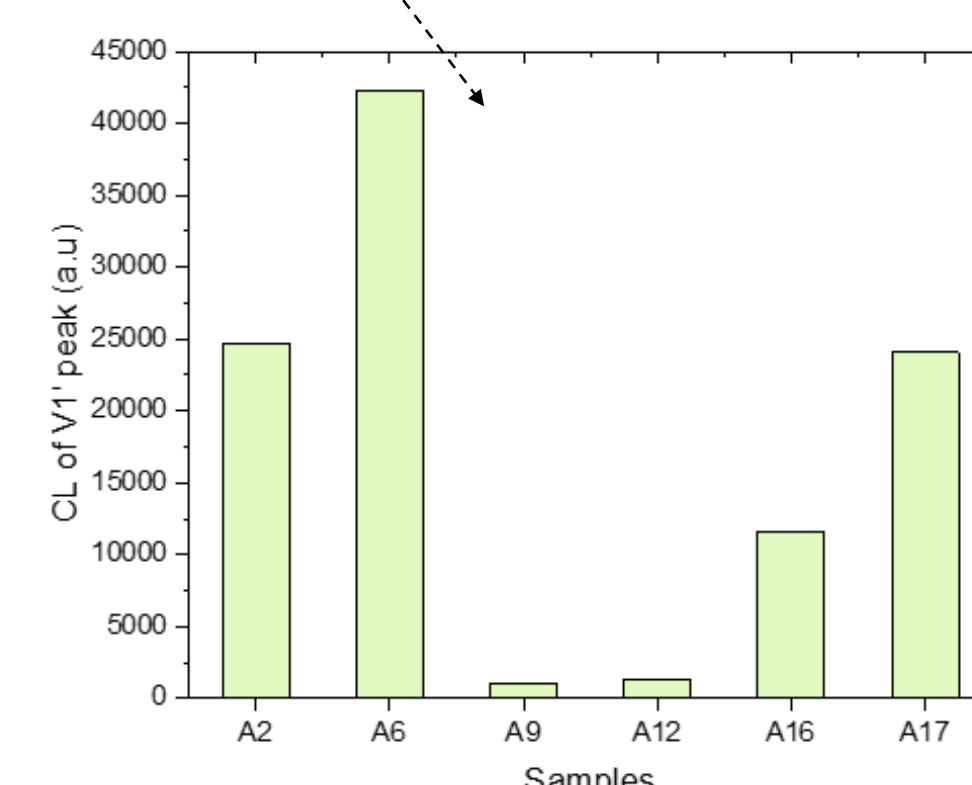
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Before Annealing

Normalized CL spectra

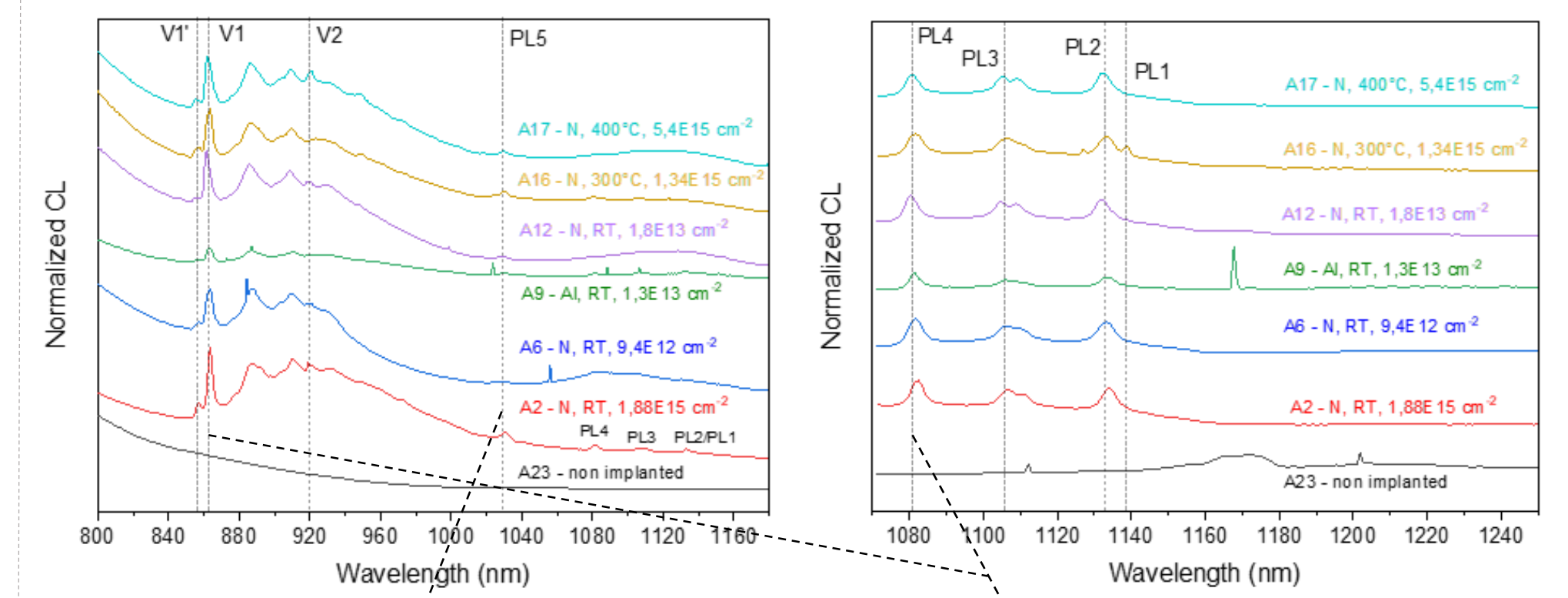


Relative intensity of CL peaks

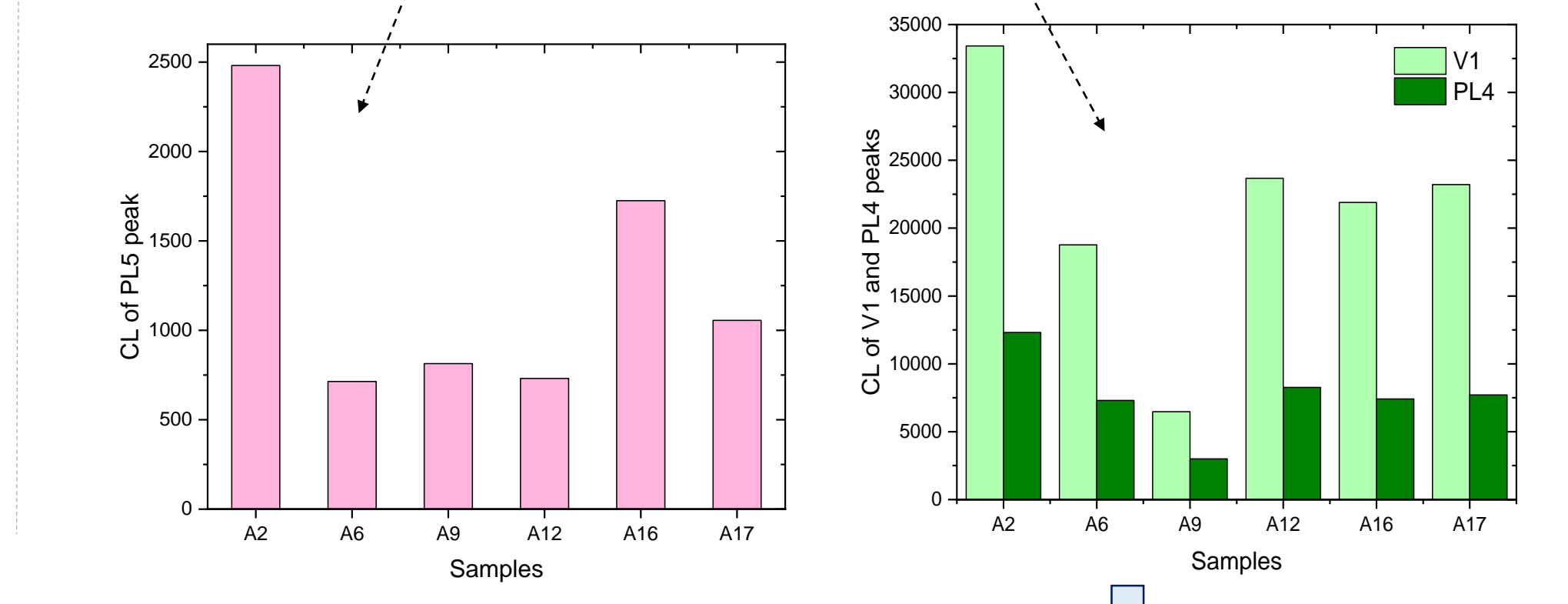


After annealing at 900°C for 15min

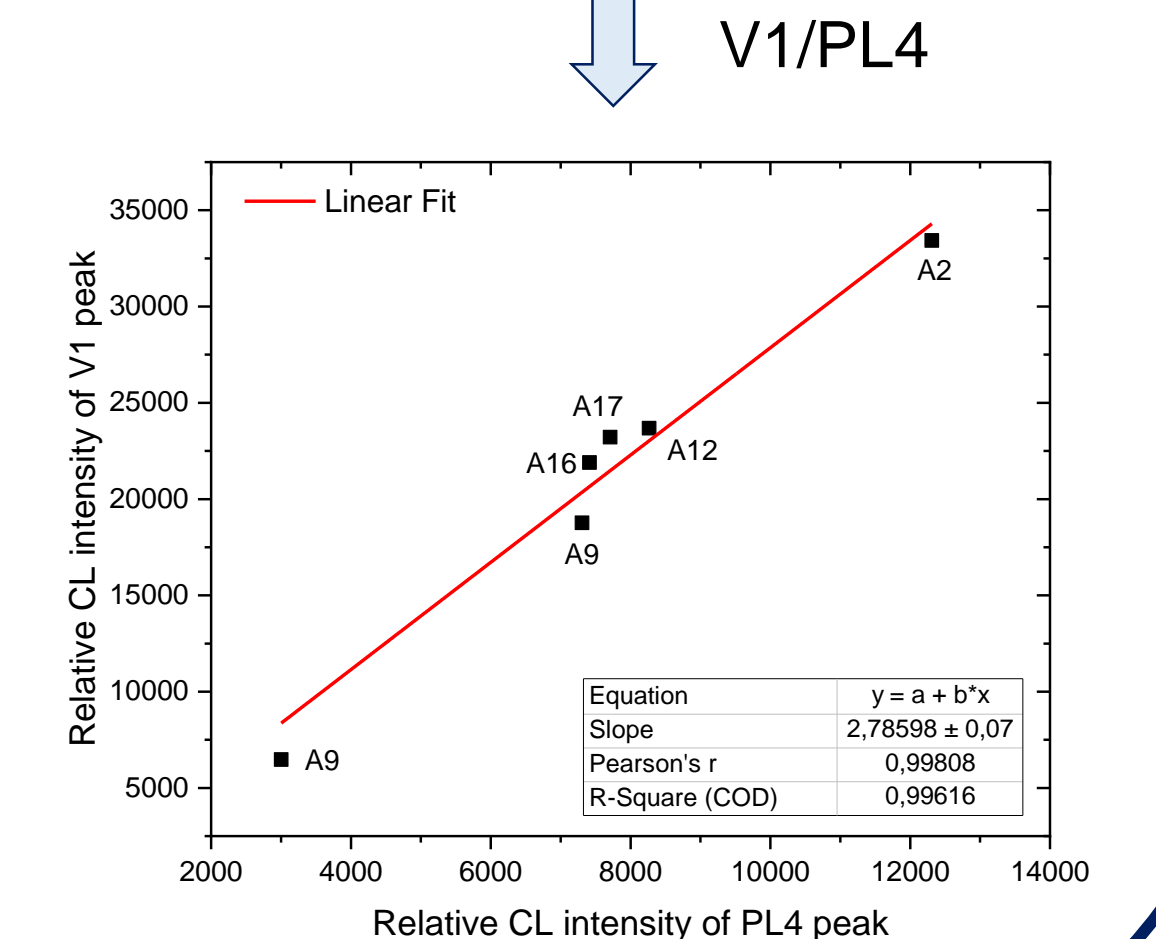
Normalized CL spectra



Relative intensity of CL peaks



- V1' configuration favored before annealing and V1 configuration favored after annealing at 900°C for 15min.
- Concentration of $V_C V_{Si}$ 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 $V_C V_{Si}$ concentrations



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