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Nanostructuring of 4H-SiC by high temperature annealing

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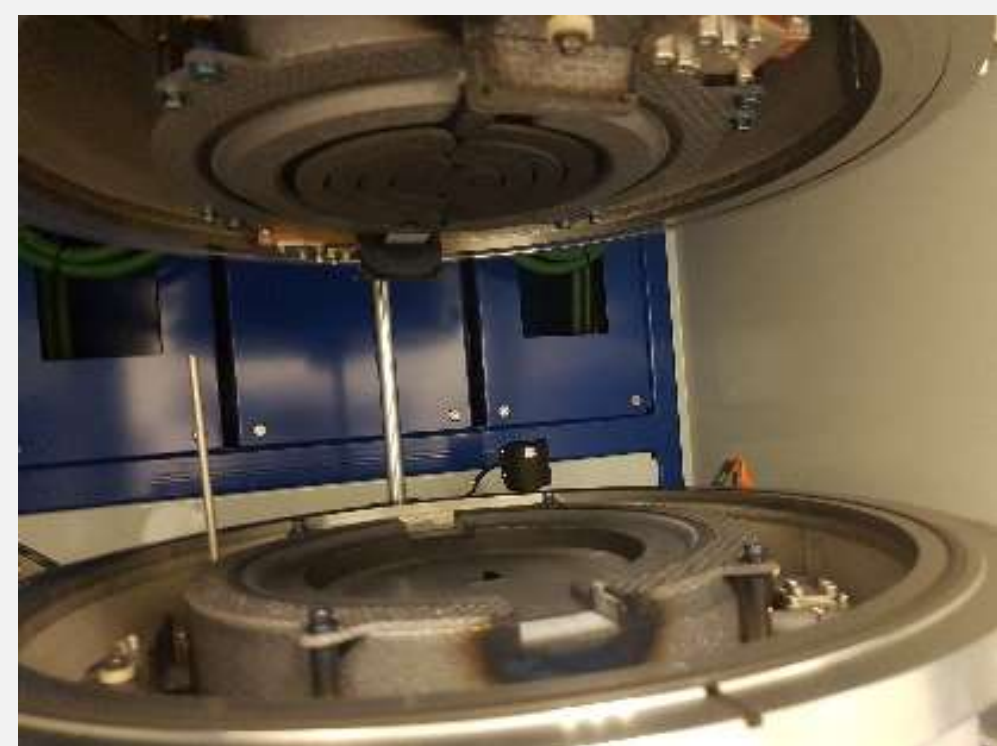
1 Introduction

SiC high refractive index (2.65 at 590 nm) compared to air causes **low extraction efficiency of light emission** [1]. The objective of the project is to improve the extraction of light in 4H-SiC by changing the morphology of its surface. **High temperature annealing** is used to nanostructure 4H-SiC by controlling the sublimation of Si in surface. **PiN diode structures** are then developed.

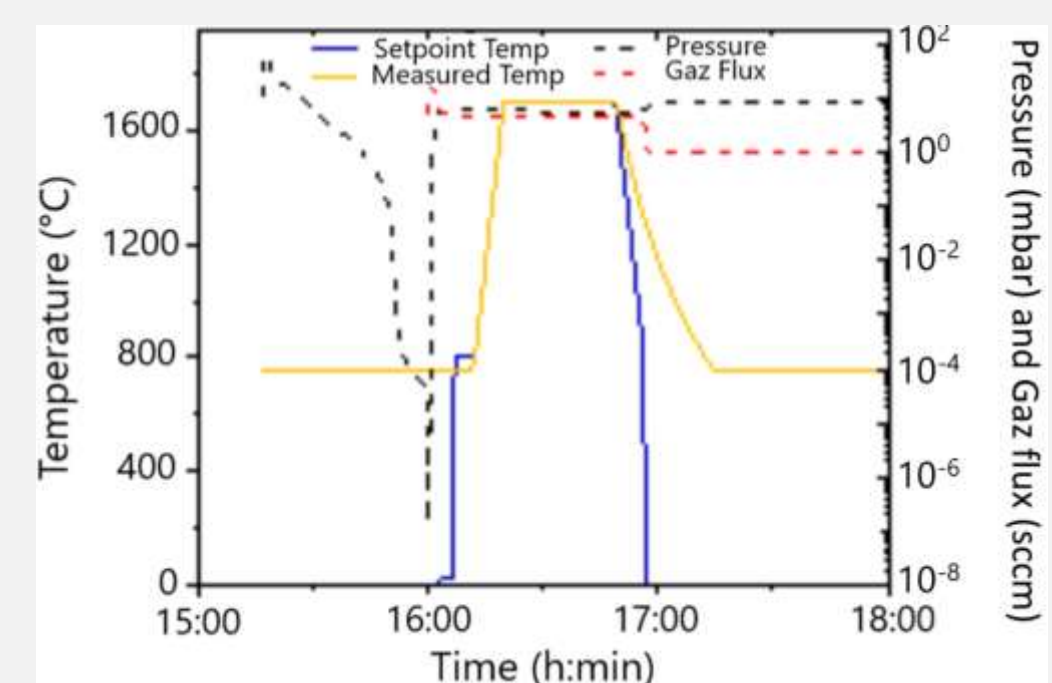
2 Nanostructuring the surface of 4H-SiC

→ Annealing of 4H-SiC in the **AET furnace** with high temperature (up to 1900°C) rapid (2°C/s) temperature process (**RTP**) in Ar.

AET RTP graphite resistive furnace

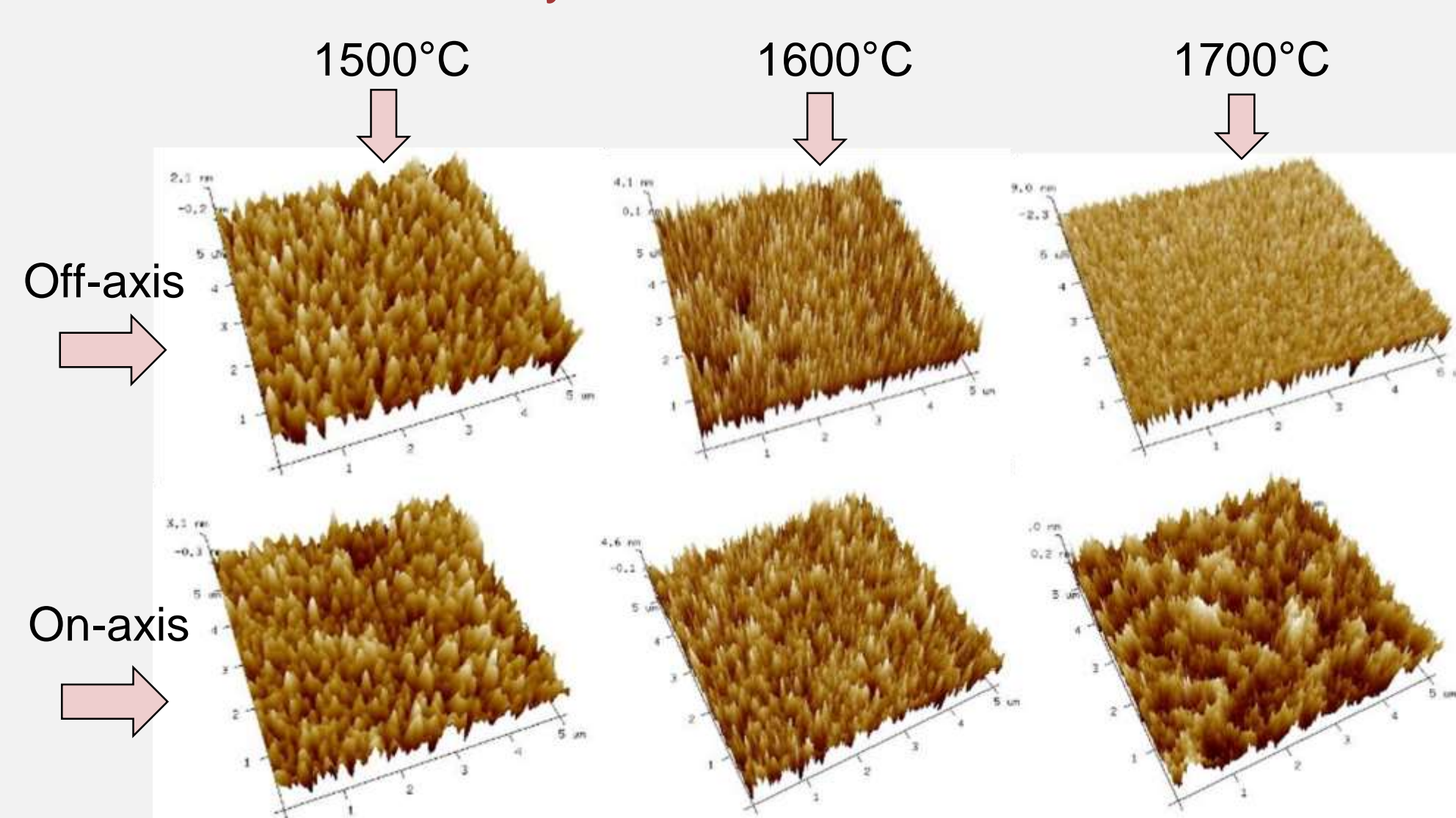


Temperature and Pressure profiles for 30min 1700°C annealing

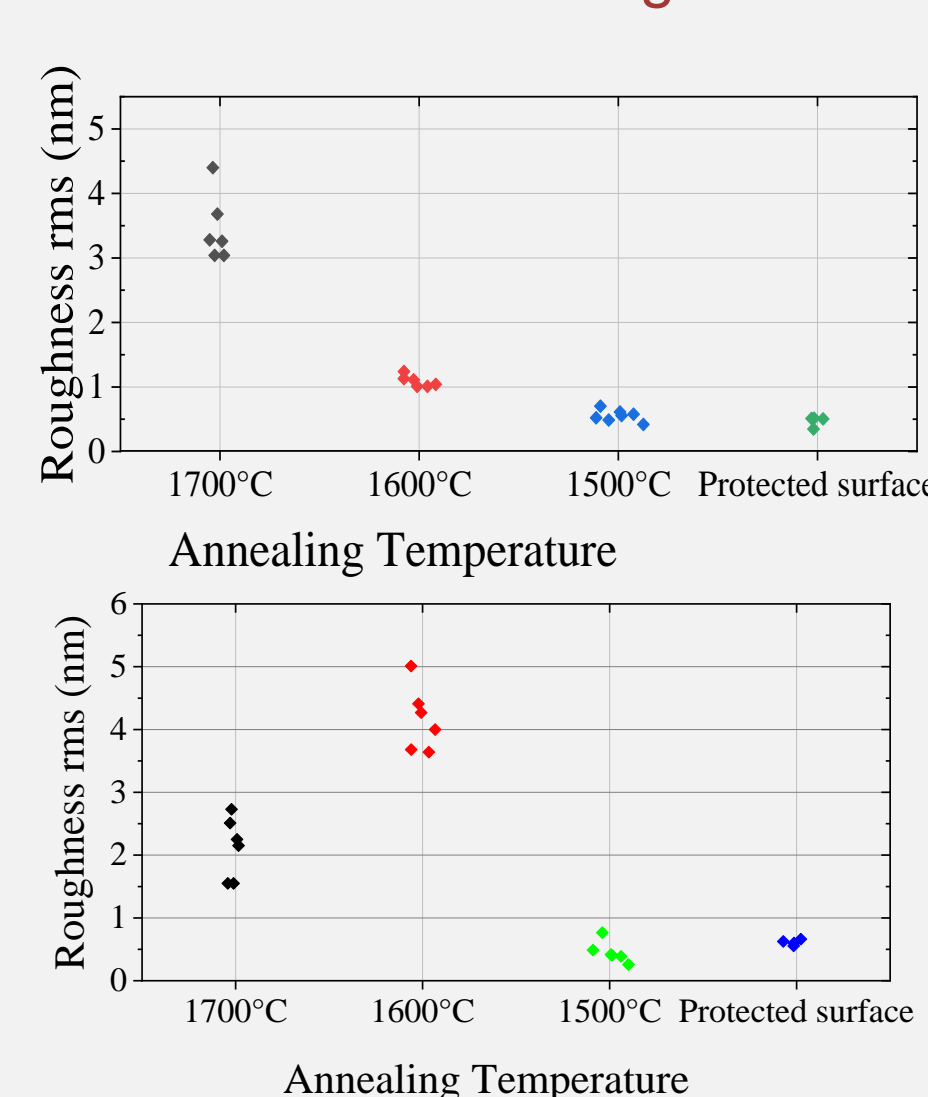


→ **Nanostructuring** of the surface after high temperature annealing

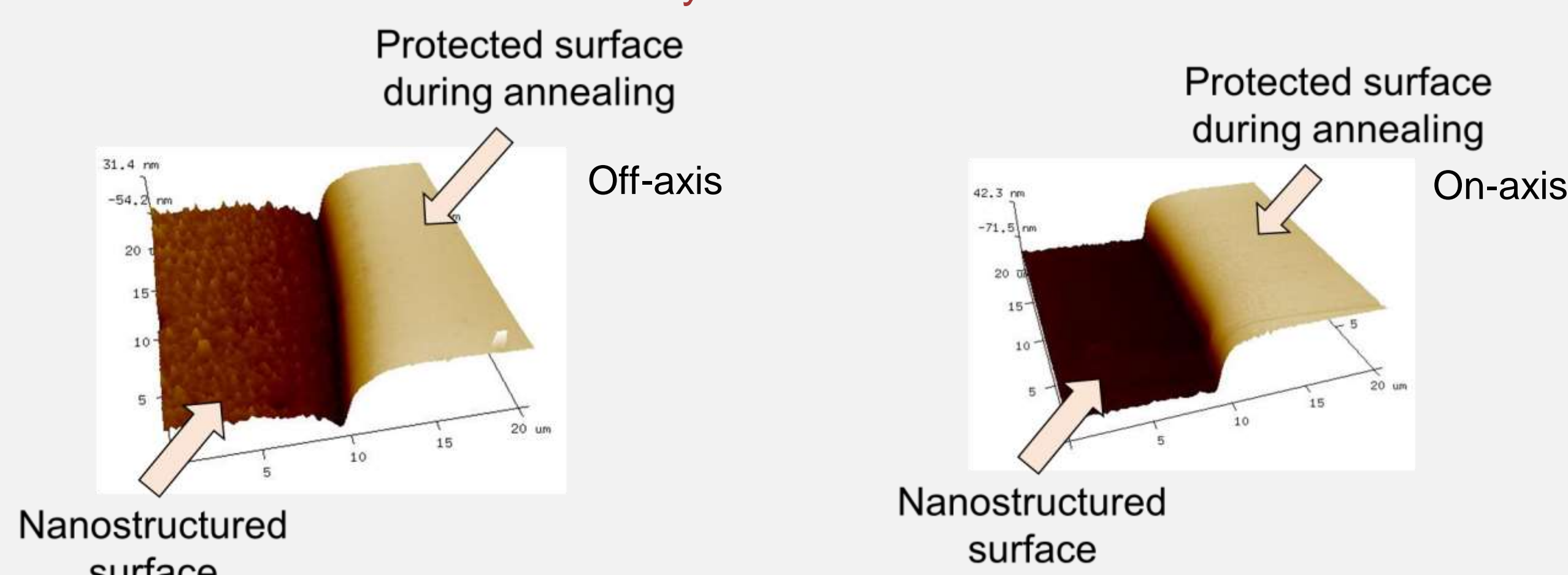
AFM analysis of annealed 4H-SiC surface



Mean surface roughness (rms) after annealing



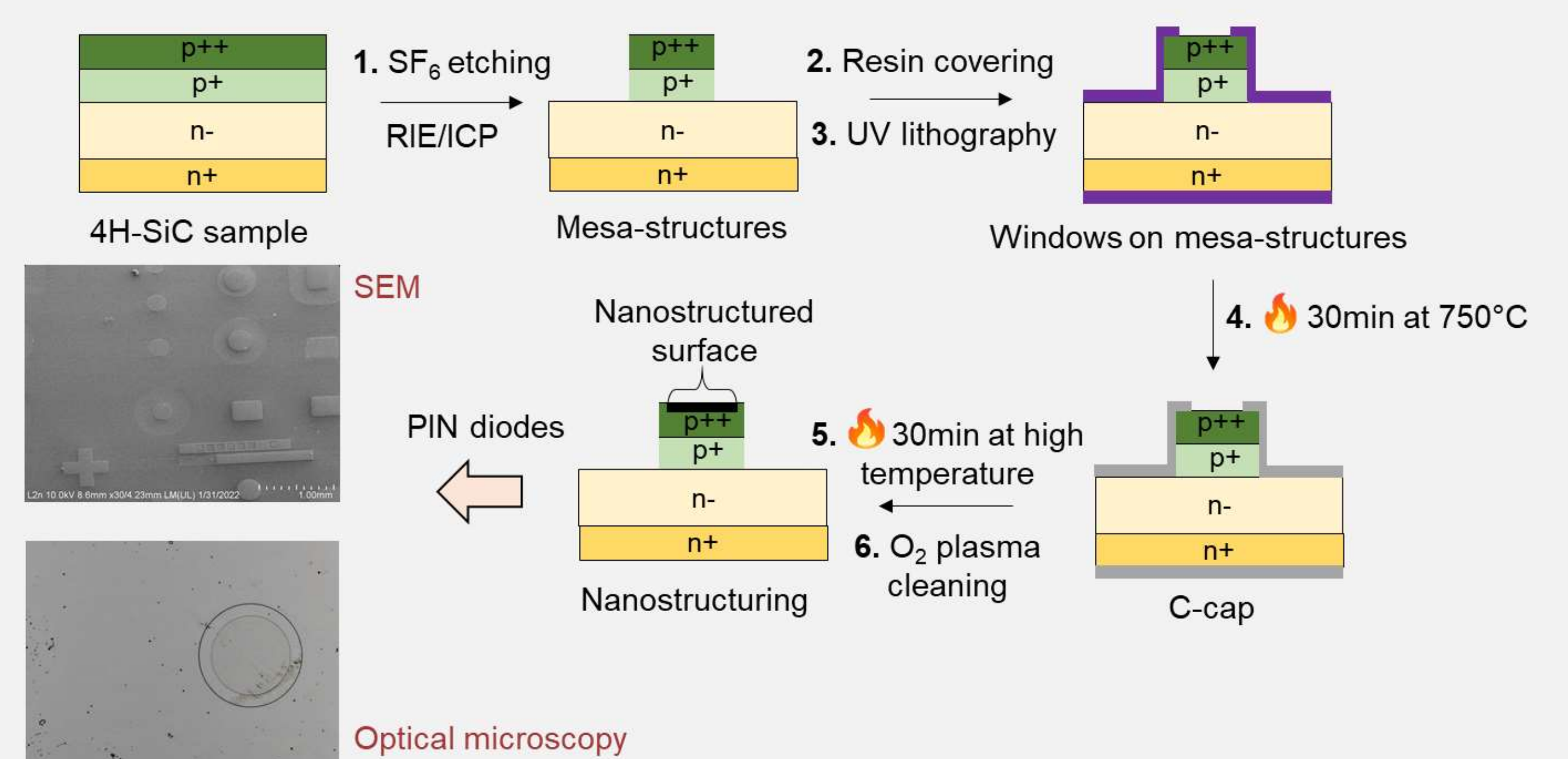
AFM analysis of 1700°C annealed surface



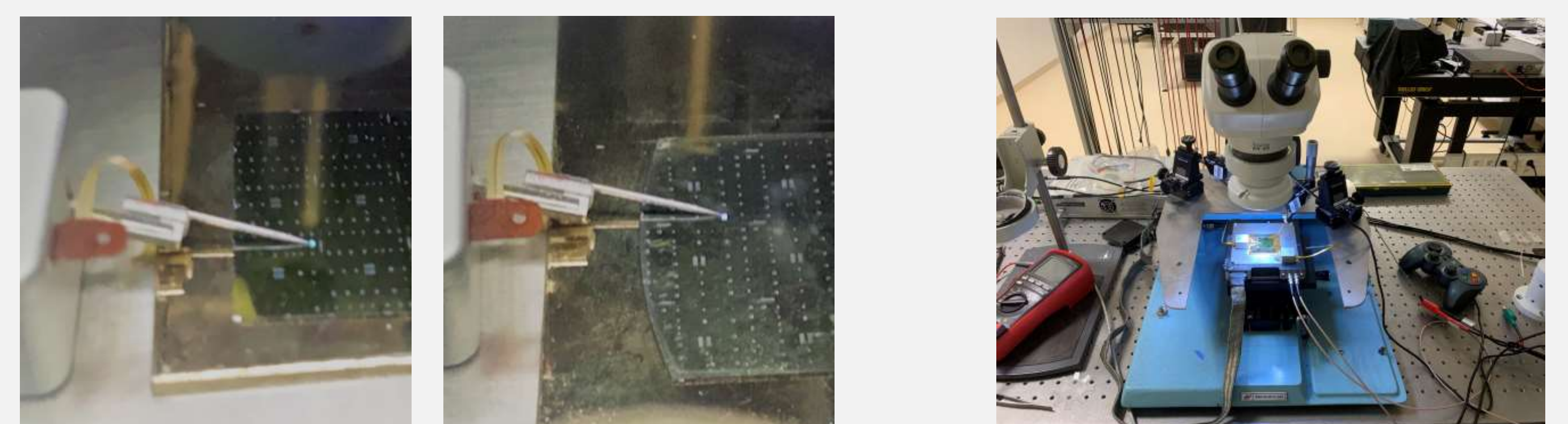
- The surface morphology of 4H-SiC becomes **needle-shaped**, like black silicon [2], after high temperature annealing.
- Si sublimation during high temperature annealing leads to a slight **etching** of the surface.

3 Fabrication of PiN diode structures

→ **Electrically isolated** PiN diode structures with a **nanostructured** surface are developed.



4 Electroluminescence of the PiN diode structures



→ **Ohmic contacts** :

- C face : Ti / Ni → 10 / 120nm
- Si face : Ni/Ti/Al/Ni → 11/25/150/11nm
- RTA annealing: 800-900°C / 90s

→ The electro-luminescence of the PiN diode structures is **blue**.

5 Conclusion

- The surface of 4H-SiC is **nanostructured** and present a **needle-shape** surface morphology for annealing at higher temperatures (1700 and 1600°C).
- Electrical measurements show an **electro-luminescence** of the PiN diode structures under a **forward bias of 8V**. The off-axis sample has a better luminescence than the on-axis one but we don't observe any difference of luminescence when the high temperature annealing changes from 1500°C to 1700°C.
- Further spectral analysis of this luminescence will be made to determine if it varies depending on the annealing temperature of the diodes.

References

1. Y. Ou, V. Jokubavicius, M. Kaiser, P. Wellmann, M. K. Linnarsson, R. Yakimova, M. Syväjärvi, and H. Ou, Fabrication of Broadband Antireflective Sub-Wavelength Structures on Fluorescent SiC, Materials Science Forum, 740, 1024-1027, 2013.
2. X. Liu, P. R. Coxon, M. Peters, B. Hoex, J. M. Cole, and D. J. Fray, Black silicon: fabrication methods, properties and solar energy applications, Energy Environ. Sci. 7, 3223-3263, 2014.

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