ICSCRM 2022
DAVOS, Switzerland

TECHNOLOGY RESEARCH INSTITUTE

Evaluation of crystal quality and dopant activation of Smart Cut™-transferred 4H-SiC thin film

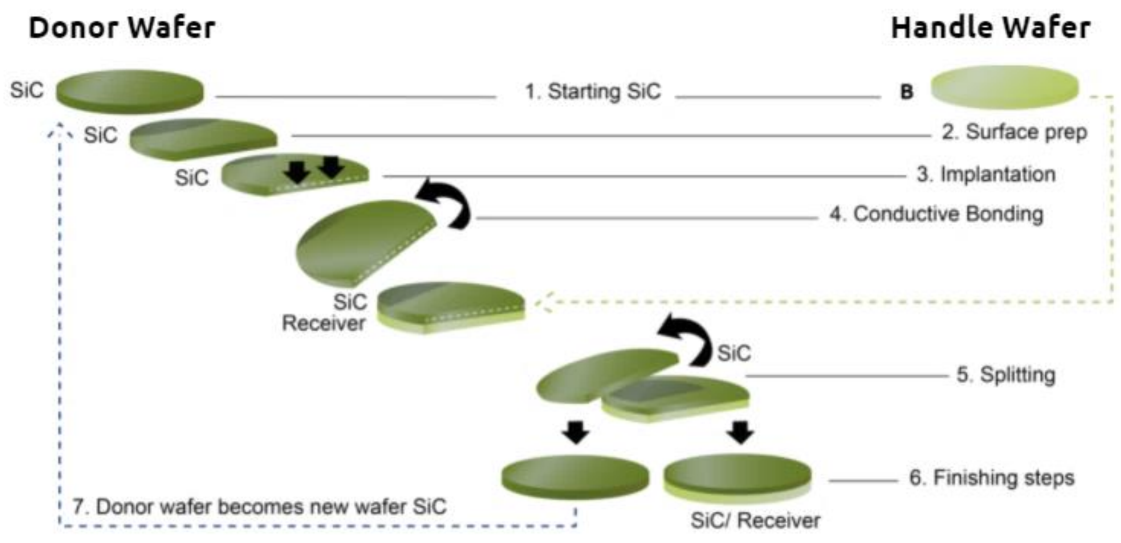
G. Gelineau[1], J. Widiez[1], E. Rolland[1], K. Vladimirova[1], A. Moulin[1], V. Prudkovskiy[1], N. Troutot[1], P. Gergaud[1], D. Mariolle[1], S. Barbet[1], V. Amalbert[1], G. Lapertot[2], K. Mony[2], S. Rouchier[3], R. Boulet[3], G. Berre[3], W. Schwarzenbach[3], Y. Bogumilowicz[1]

[1] *CEA-Leti, Univ. Grenoble Alpes, F-38000 Grenoble, France*
[2] *Univ. Grenoble Alpes, CEA, Grenoble INP, IRIG, PHELIQS, 38000 Grenoble, France*
[3] *Soitec SA, Chemin des Franques, 38190 Bernin, France*

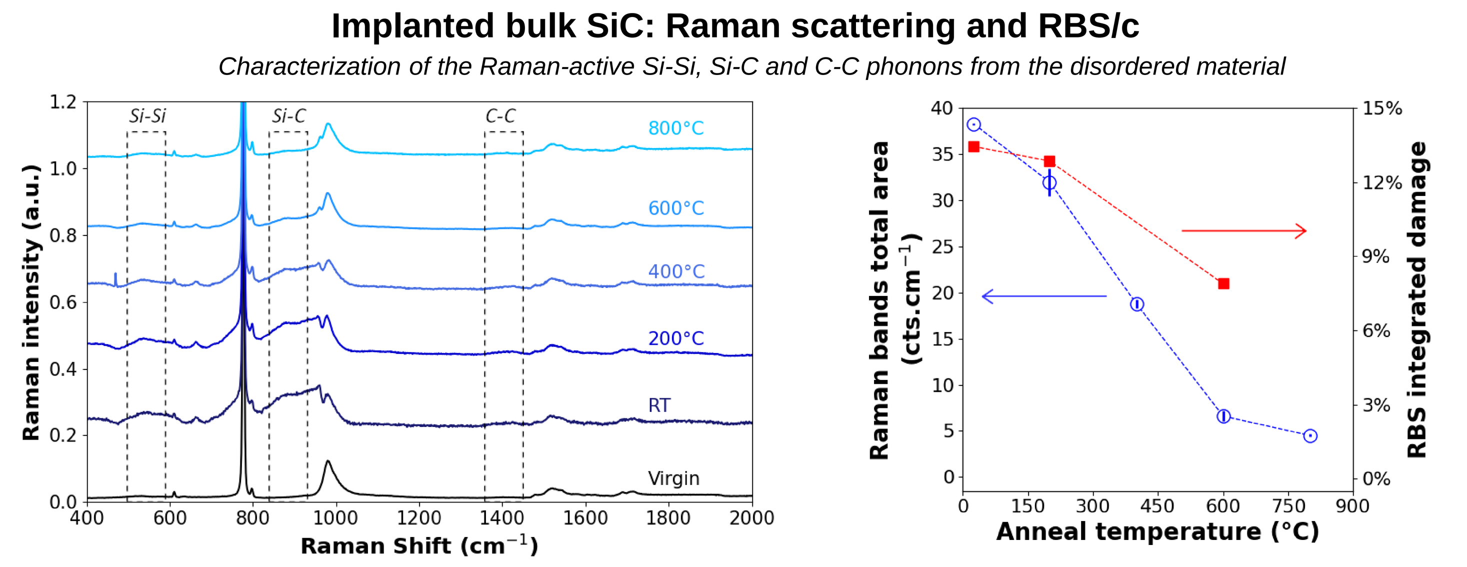
Introduction

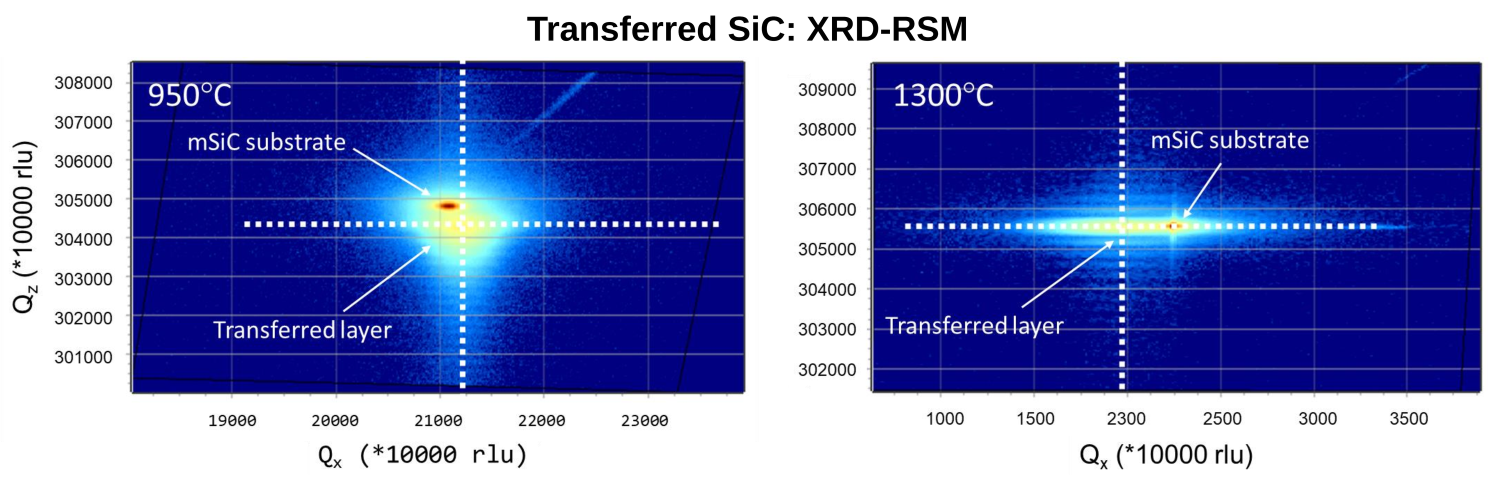
Despite a growing number of manufacturers, a global SiC wafer shortage is feared among the community as the production ramp up from 6" to 8" wafer size is still to be effective. The Smart Cut™ technology offers a state-of-the art opportunity for yield and cost improvement, by combining the high quality of a 4H-SiC transferred layer (reusability of the donor wafer up to 10 times) with the ultra low resistivity of a polycrystalline SiC handle substrate [1].

In this paper, we present for the first time studies over a broad range of temperature (from RT to 1900°C) allowing to analyze the entire progress of crystal recovery: from the evolution of the quality of the implanted and then transferred material, to its electrical reactivation.



Implanted And Transferred SiC Crystal Quality





Methods:

H⁺-implantation and annealing of bulk 4H-SiC, then layer transfer on monocrystalline 4H-SiC (mSiC) wafer. Characterization with Raman scattering, XRD-RSM, channeled RBS.

Main results:

- ✓ The transferred layer is still strained after 950°C, although that 90% of the initial damage is healed after a 800°C anneal.
- ✓ Full recovery of the crystalline quality after 1300°C.
- ✓ No further evolution with 1500°C or 1700°C anneal (not shown).

Dopant Reactivation

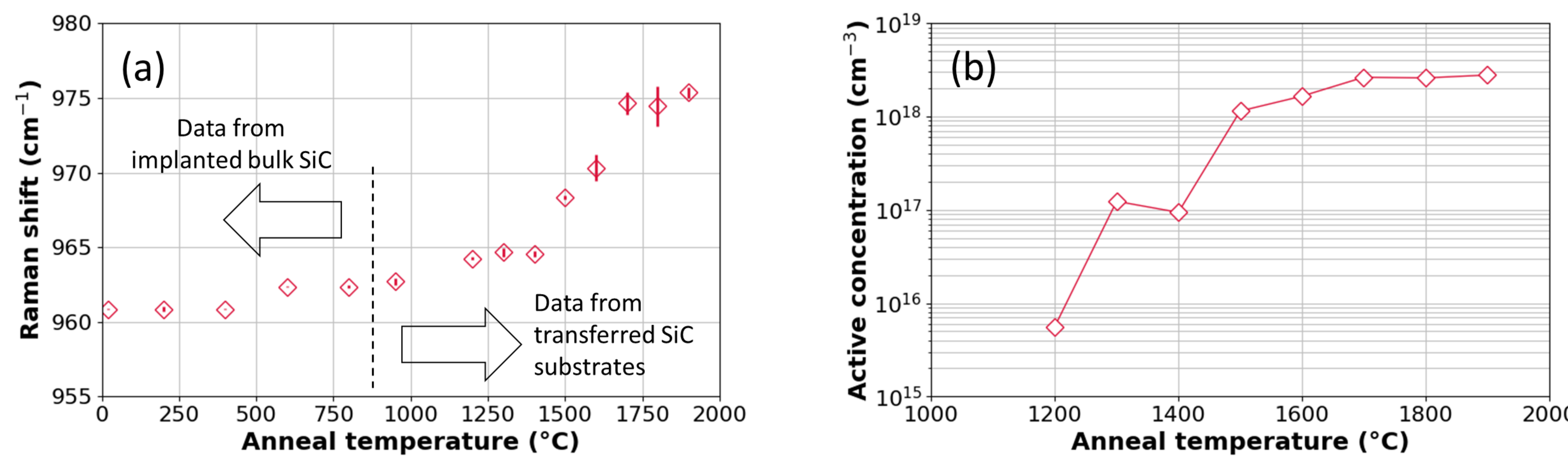
Methods:

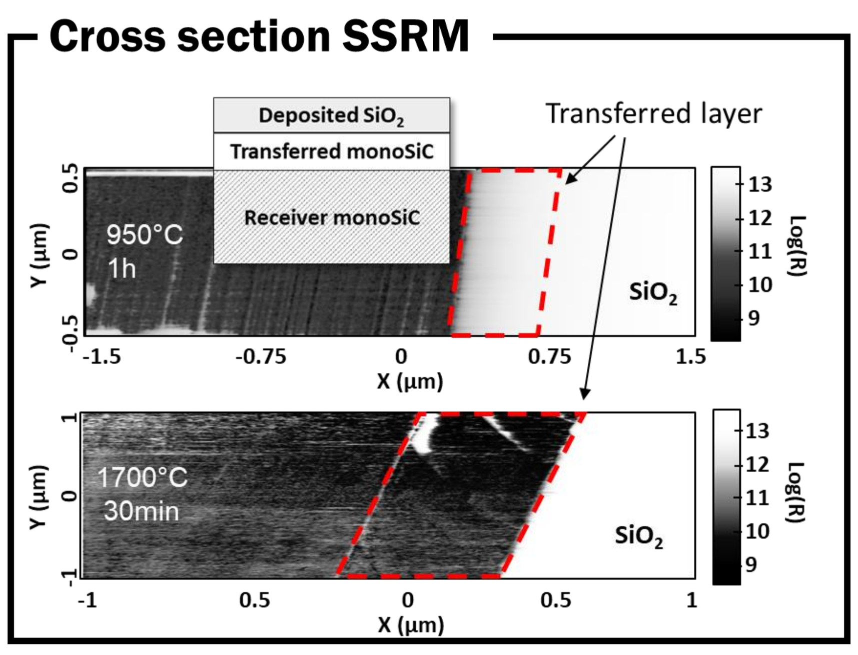
Coupling between the LO phonon and the plasmon in polar semiconductors [2].

Two series of samples were analyzed with Raman spectroscopy:

- T < 850°C: implanted bulk SiC
- T > 850°C: transferred SiC substrates

Raman LOPC peak fitting [3] allows one to assess the electrical activation of the implanted or transferred material.





Main results:

- ✓ RT-1300°C : insulating material (LOPC peak position below undoped 4H-SiC's uncoupled LO mode at 964 cm⁻¹ [3]).
- ✓ 1400°C-1700°C : steep activation of nitrogen impurities.
- ✓ 1700°C and over : The doping level of the donor substrate is recovered (see SSRM micrographs).

Conclusion

We hereby report for the first time studies of healing and reactivation mechanisms of a transferred 4H-SiC thin film over a wide range of temperatures. Raman, RBS and XRD-RSM measurement allowed the assessment of the crystal recovery after ion implantation. Those showed that the thin mSiC layer is still strained after a 950°C anneal, but is fully reorganized after 1300°C. Then, the Raman LOPC mode was studied in order to follow the active concentration of the transferred layer. Interestingly, the nitrogen reactivates in the same range of temperatures that that of implanted impurities [4]. SiC thin film transfer process optimizations can now be carried on using this protocol, for instance with the investigation of ion implantation alternatives – such as the dose or the species of the implanted ions.

Contact Person

Guillaume GELINEAU
guillaume.gelineau@cea.fr

References

[1] S. Rouchier *et al.*, *Trans. Tech. Publ.*, 1062, 131-135, 2021.
[2] L. Artús *et al.*, Phys. Rev. B, 60(8), 5456-5463, 1999.
[3] H. Harima *et al.*, *J. Appl. Phys.*, 78, 1996, 1995.
[4] V. Simonka *et al.*, presented at SISPAD 2017, Japan, 2017.

Partners: soitec TRANSFORM

Funded by the KDT JU Grant No. 101007237

ICSCRM 2022
DAVOS, Switzerland