Transfer of 2D materials using Smart Cut™

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Graphene is a promising candidate for the next-generation electronics and optoelectronics as it offers charge carrier mobility over 10,000 cm^2/Vs, high saturation velocity and high thermal conductivity. Besides graphene, there exists a whole family of other two-dimensional (2D) materials, known as transition metal dichalcogenides (TMDC). Recent progress in the synthesis techniques has made the cost-effective wafer-scale production of 2D materials possible. However, the direct growth of these materials on a dielectric substrate remains challenging. The existing methods of transfer are unreliable or have severe disadvantages. Direct mechanical delamination leads to rupture of the 2D layer. Polymer-supported transfer methods, assisted by chemical etching of donor substrates, leave polymer residues and uncontrolled doping. Besides, implementation of such methods on the large industrial scale is improbable due to their low reliability.

Wafer-scale transfer of thin layers of materials commonly occurs on the semiconductor-on-insulator (SOI) industry. One of the most advanced techniques, the Smart Cut™, was developed at CEA in close collaboration with SOITEC. It is based on the implantation of gas ions inside a target substrate at a controlled depth. As a result, a nm-thick layer of crystalline material can be delaminated and transferred on top of another wafer (typically SiO_2/Si) using direct bonding. Numerous studies have optimized each step of the process on a wide range of substrates, such as Si, SiC, Ge, etc.

The objective of this project was to develop a novel method of large-area post-synthesis transfer of 2D materials - such as graphene and TMDCs - to a target dielectric substrate (SiO_2/Si wafer). The proposed technique [1] is based on the Smart Cut™ technique conventionally used for transfer of ultrathin layers of silicon, and paves the way for monolithic integration of graphene and other 2D materials with Si-based electronics. Successful implementation of such a transfer technique required a thorough investigation of surface interaction of the transferred layer with the donor and target substrates using Raman spectroscopy, AFM, SEM and TEM studies presented in this report.

References

[1] Didier Landru et al., Method for transferring a useful layer, EP 2933828

Figures

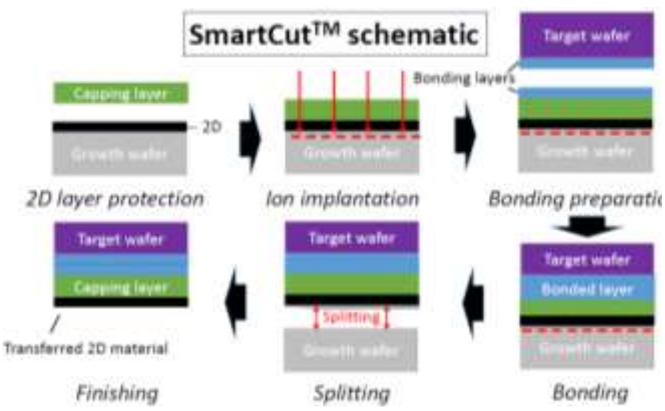

Figure 1: Graphic representation of wafer-scale 2D material transfer using Smart Cut ™