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Scalable Graphene Growth on a Semiconductor

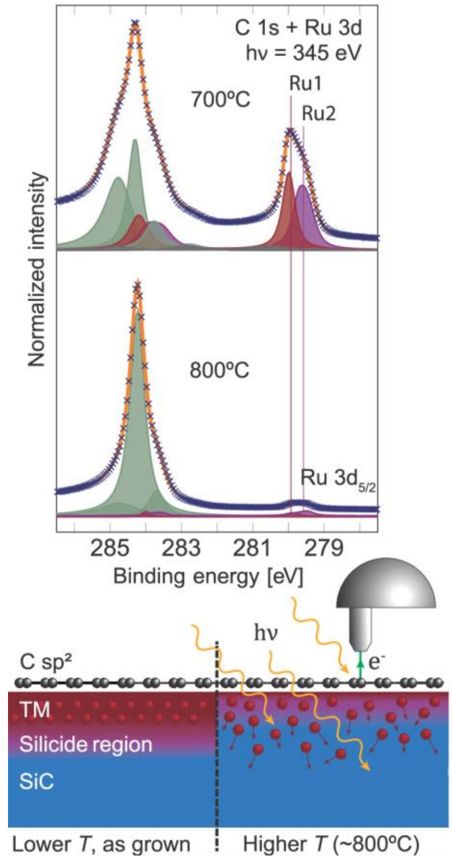
The growth and incorporation of graphene into semiconductor device architectures has been limited by challenges related to the quality, reproducibility, and high process temperatures required to grow it on suitable substrates. In this study, device grade graphene on silicon carbide was synthesised through a transition-metal mediated reaction occurring at an industrially compatible temperature. The growth method is ideal for further large-scale processing into graphene-based devices structures.

Research & Outcomes

Since its experimental discovery in 2004, graphene has attracted significant attention for device applications because of its exceptional electronic, thermal, optical, and mechanical properties. Despite this, challenges exist with the production of large-scale high-quality graphene layers on industrially compatible semiconductor substrates such as silicon carbide (SiC). Graphene must either be grown *ex-situ* and transferred to the semiconductor surface, risking the introduction of contaminants and imperfections, or grown via high temperature annealing of pristine SiC. The latter method, although producing high quality graphene, occurs at temperatures 1200°C, far in excess of industrially compatible processes.

In this study, researchers from the Soft X-ray Beamline and the Norwegian University of Science and Technology (NTNU) used soft x-ray spectroscopy to demonstrate that thin layers of Fe or Ru deposited on SiC cause carbon from the substrate to crystallise in an adjustable number of graphene layers at the surface. Importantly, this is shown to occur at significantly lower temperatures than that required for "conventional" epitaxial growth on SiC.

By subsequent annealing of the sample (again at relatively low temperatures), the transition metal and an underlying silicide layer formed during fabrication can be removed via bulk diffusion into the SiC.



Synchrotron photoemission data of carbon and ruthenium at the surface of silicon carbide. Annealing to 800C results in the formation of a single layer of graphene and removal of ruthenium via diffusion into the bulk of the crystal, illustrated in the lower panel

Benefits & Impact

The ability to grow high quality, defect-free graphene directly on a semiconductor substrate is crucial for harnessing graphene's unique electronic properties in next generation electrical devices such as field effect transistors and sensors.

This study demonstrates that transition metal-mediated graphene growth on SiC is a promising methodology for realizing graphene-based devices within the pre-existing framework of large-scale device processing.

<u>Reference:</u> Røst *et al*, JPPC **125**(7), 4243-4252 (2021)