Epitaxial growth of Graphene and Graphene Nano Ribbons (GNRs) over Silicon Carbide (SiC) substrate

ESR 10 - Naveen Shetty, Chalmers University, Sweden

Graphene is a single layer of carbon atoms arranged in a two-dimensional honeycomb lattice arrangement. It exhibits numerous fascinating properties such as ballistic charge transport over a larger range, massless Dirac fermions, exceptionally high tensile strength, high electrical conductivity etc. This wonder material can be synthesized in multiple ways, such as by pealing graphite using scotch tape, chemical vapor deposition, epitaxial growth. Within the QuESTech project, graphene over SiC is grown by a thermal sublimation technique at Chalmers. This technique could be optimized to obtain 99.5% monolayer (ML) and the goal is to achieve the same on wafer scale.

Even with such incredible properties, it is hard to implement graphene in the modern electronics. Due to its semimetalic nature, it does not have a bandgap so that it cannot be used in the electronics that utilizes conventional switchable transistors. Nevertheless, it was theoretically shown that a band gap can be engineered into graphene by quantum confinement. To do this, one-dimensional ribbons of graphene can be created, which are called graphene nanoribbons (GNRs).

In this project, GNRs were fabricated using bottom-up epitaxial growth over SiC. The quality of the ribbons were assessed using scanning tunneling microscopy and Raman spectroscopic techniques. It was identified that the contact resistance (R_c) between metal and GNRs were the limiting factor in performing transport measurement, hence a comprehensive research has been conducted to reduce the R_c. A tri-layer edge contact recipe has been developed using which the contact resistance is reduced to as low as 50 Ωµm. This value is in near agreement with the quantum limit to the contact resistance $R_c^{min} = h/(2e^2k_f) = 0.026/\sqrt{n_{2D}} \approx 30\Omega\mu m$. The quality of the contacts and scalability is further investigated by fabricating largest most accurate quantum Hall array ever! Here, we were able to quantize all the 236 Hall elements proving that the scalability and reliability of this approach could be further utilized to improve the transport measurements on GNRs.

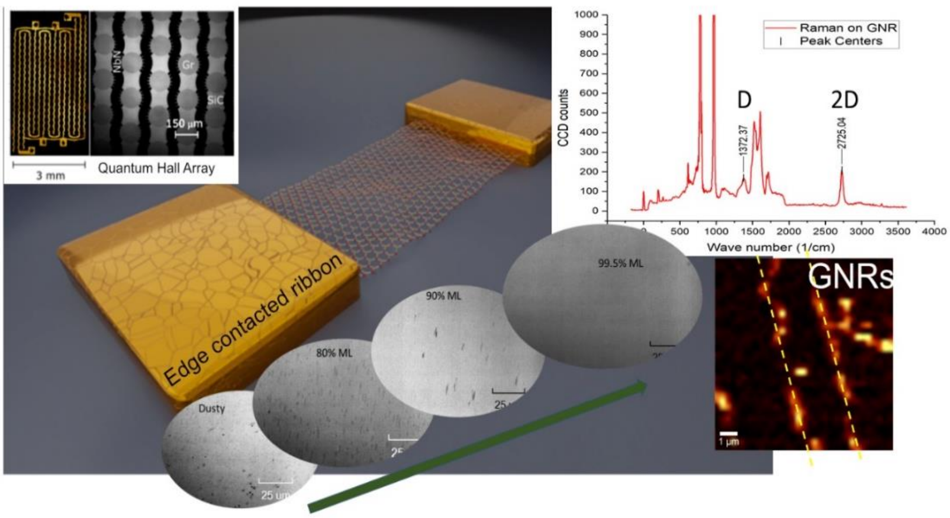

Figure 1: Edge contacted graphene (rendered image), ML growth progress of epitaxial graphene. Top left: Hall bar array fabricated using edge contact technique. Top right: Raman spectroscopy on graphene nanoribbon, bottom right: Raman mapping of 2D peak for graphene nanoribbon

Chalmers University of Technology, Microtechnology and Nanoscience Lab, Quantum Device Physics group, Sweden.