

Graphene-based Junctions for Electrical and Photoconducting Devices

Dr Wei Dacheng

Prof Andrew Wee

Department of Physics

The formation of graphene junctions with other materials can improve the properties of pristine graphene, opening up the possibility of new applications. Carbon nanotubes, which are rolled-up graphene sheets, are another type of carbon allotrope that has generated intense interest in the nanoscience field. However, few attempts have been made to form graphene-nanotube junctions at the molecular scale.

That was the case, at least, until a recent research breakthrough achieved by Lee Kuan Yew Postdoctoral Fellow Dr Wei Dacheng, Prof Andrew Wee and their team at the Surface Science Laboratory, working in collaboration with their Physics Department colleague Assoc Prof Sow Chorng Haur and researchers from the Chinese Academy of Sciences and Hunan University.

Dr Wei explains that carbon nanotubes, or what he describes as the “star material in nanotechnology”, have great potential for widespread application in the future. Yet, making that happen has proven to be difficult. Before the team’s research, graphene-nanotube junctions proved troublesome because existing methods could only unzip whole nanotubes into graphene ribbons. The team realised that “a more controllable unzipping method needed to be developed”, and devised a method to produce intramolecular junctions that combine graphene nanoribbons and carbon nanotubes in one-dimensional nanostructures.

Critical to this process was the way in which the team achieved control over the unzipping process. Dr Wei comments that “we produced poly-methyl-methacrylate (PMMA) patterns by electron-beam lithography to cover parts of the nanotubes”. Following zinc/acid sputter etching, “only the uncovered parts were unzipped into graphene nanoribbons”. As PMMA patterns can be designed with existing software, the method will be relatively easy to replicate.

The research team successfully unzipped single-walled carbon nanotubes into sub-5-nm graphene nanoribbons to produce nanoribbon/nanotube junctions displaying typical gate-dependent rectifying behaviour and excellent photoconducting properties. They then demonstrated the use of these junctions in prototyping directionally dependent field-effect transistors, logic gates and photodetectors. An impressive photocurrent as high as -11.6 nA and photovoltage as high as 270 mV were achieved.

Dr Wei remarks that aside from potential uses in high-performance photodetectors and nanoscale photovoltaic power sources, these junctions will also be beneficial in sensors and logic circuits. The team is currently working to “further improve the quality of the junction”, he says, “which could result in higher performance” when these applications are realised.

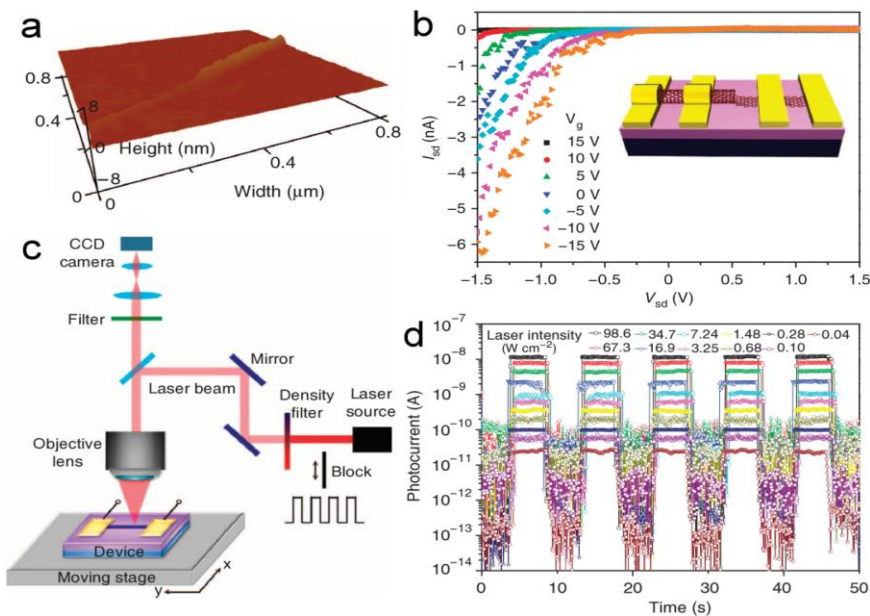


Figure 1. (a) 3D AFM image of nanoribbon/nanotube junction; (b) gate voltage-dependent rectifying curves of the junction; (c) photoelectric measurement system; and (d) the junction's photocurrent response when the laser is switched on and off.

Publication:

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