NANOBIOPSY

Interrogating single cells

ACS Nano http://doi.org/qhq (2013)

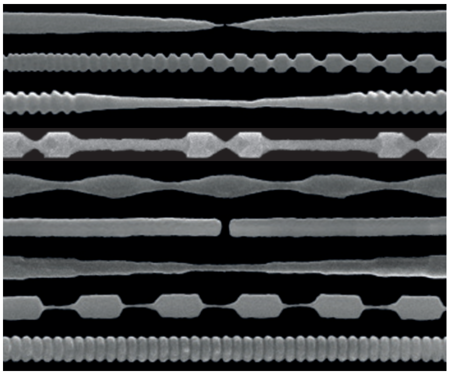
The ability to study the heterogeneous nature of cells in, for example, tumours has been useful in gaining insights into cell–cell interactions and the pathology of disease at the single-cell level. Intially studies focused on dead cells, which prevented their dynamic investigation, but more recently nanoendoscopes have been developed to interrogate living cells and extract information from organelles. Nader Pourmand and co-workers at the University of California, Santa Cruz have now taken this approach further by using a scanning ion conductance microscope, which consists of a nanopipette probe, to extract cellular material without causing cell death, and then to analyse the contents using high-throughput sequencing technology.

The researchers use a technique known as electrowetting to generate a force and flow solution in and out of the nanopipette. When directed, the nanopipette pierces the cell membrane and aspirates the contents; this process is minimally invasive and can be repeated several times in the same cell without causing cell death, allowing the study of molecular dynamics. To demonstrate the sensitivity of the technique, contents were extracted from the mitochondria of a single cell and analysed using next-generation genomic sequencing. Mutant mitochondrial genomes were identified that would have been missed when analysing pooled mitochondrial data. This increased exclusivity of sample selection could in turn elucidate mutations and mechanisms involved in cellular dysfunction. *SB*

NANOFABRICATION

Engraving nanowires

Nano Lett. **13,** 6281–6286 (2013)



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Semiconductor nanowires have electronic and optical properties that are intrinsically linked to the one-dimensional motion of electrons. Therefore, the ability to control the diameter of nanowires during growth could lead to both complex nanostructures and tailored devices. James Cahoon and colleagues at the University of North Carolina at Chapell Hill have now developed a fabrication technique that can modulate the diameter of silicon nanowires and create features as small as 10 nm.

The phosphorus-doped silicon nanowires were grown using the vapour–liquid–solid (VLS) mechanism. Previous work has shown that the level of phosphorus-doping affects the growth rate of the nanowire and the etch rate in a KOH solution. Cahoon and colleagues calibrated these phosphorus-doping dependences and then used the calibration to predict the exact phosphorus content that would allow the design of very precise and complex structures. With the approach they were able to fabricate a range of structures including bowties, nanogaps, and nanowires with periodically modulated cross-sections (see the scanning electron microscopy image).

The technique, which is termed ENGRAVE (encoded nanowire growth and appearance through VLS and etching) by the authors, was also used to create two proof-of-principle devices. In the first, a nanowire with a gap was used as a template to fabricate metal nanostructures with precise surface plasmon resonances. In the second, nanowires with constrictions were used to demonstrate resistive memory elements. The next step will be to extend the technique beyond silicon, and to demonstrate devices on a larger scale. *FP*

CARBON NANOTUBES

Mapping electrochemistry

Nano Lett. http://doi.org/qhp (2013)

The electrochemical activity of carbon nanotubes is not well understood. Some researchers have reported high conversion efficiencies, which suggest that the nanotubes could be useful in sensing and energy applications, but others are more sceptical and are not ready to discard subtle side effects. To shed light on the situation, Patrick Unwin and colleagues at the University of Warwick have now developed a microscopy technique that can map the electrochemical response of individual carbon nanotubes.

The microscope uses a tip at the bottom of which a tiny meniscus of redox-active solution is formed. The tip is scanned across a carbon nanotube while a potential is applied to the nanotube. The electrochemical activity of the carbon nanotube is then recorded as a function of tip position by measuring the current generated by the redox reaction that occurs in the meniscus. The resolution of the technique is around 6 nm, which means that the role of defects can be accounted for because they are more widely spaced than this.

With the approach, the researchers show that, under the right amount of bias, the sidewalls of both metallic and semiconducting nanotubes are electrochemically active towards simple, one-electron transformations, a result that has previously been disputed. *AM*

SEMICONDUCTOR NANOWIRES

Measuring barrier height

Nano Lett. **13,** 6183–6188 (2013)

The electrical contact between a metallic electrode and a semiconductor in electronic devices creates an energy barrier for the injection or extraction of electrons. The barrier height determines the ease of electron transfer and affects device performance. It can be estimated by analysing the current–voltage characteristics. However, in the case of semiconductor nanowires, this method has limited applicability due to complications that arise from the small dimensions of the devices. Lincoln Lauhon and colleagues at Northwestern University and Tel-Aviv University now show that the height of the barrier between a metal contact and an n-doped silicon nanowire can be measured by spectrally resolved scanning photocurrent microscopy.

The researchers shine sub-bandgap light on the metal–nanowire junction. Electrons in the metal are photoexcited and can cross the energy barrier in a process called internal photoemission. This generates a photocurrent that is collected by the microscope. The barrier height can then be extracted by analysing the dependence of the photocurrent on the energy of the photoexcitation. Lauhon and colleagues find that the height is lowered compared with the case of metal/bulk silicon interfaces as a consequence of doping and geometric effects. Nanowires with enhanced surface doping or smaller diameters exhibit reduced barrier heights. The method could also be used to characterize the barrier height in other nanoscale heterojunctions. *ED*

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