ACT Node & WA Node
NEWSLETTER
ANFF
Providing nano and microfabrication facilities for Australia's researchers

Australian National Fabrication Facility
ACT Node & WA Node
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Selective Area Epitaxy of Indium Phosphide Nanowires

Semiconductor nanowires are currently of great research interest due to their unique properties. Axial and radial heterostructure nanowires (NWs) have been proposed as nano-building blocks for next generation electronic and photonic devices.

These devices are expected to revolutionise our technological world in the way of new devices and components. The unique properties stem from their large surface to volume ratio, very high aspect ratio, and carrier and photon confinement in two dimensions. Most semiconductor nanowires are grown by catalyst-assisted vapour-liquid-solid (VLS) process due to its versatility. However, precise site control of nanowires using this technique is difficult.

Also, incorporation of the metal catalysts into the nanowires may create deep level traps which could degrade their optical and electrical properties. Selective-area metal-organic vapour-phase epitaxy (SA-MOVPE) has the advantages that the nanowires can be grown without any catalyst, and allows the controlled positioning of the nanowires.

Qian Gao, a PhD student working at the Department of Electronic Materials Engineering (EME), Research School of Physics and Engineering, ANU has successfully grown high quality indium phosphide (InP) nanowires using SA-MOVPE. Various facilities of the ANFF ACT Node have been used in fabricating these InP nanowires and characterising their properties.

To fabricate the patterned substrate for growing nanowires, 30 nm thick SiO_x was deposited on an indium phosphide substrate by Plasma Enhanced Chemical Vapour Deposition (PECVD), and ZEP was spin-coated onto the film as the electron beam resist.

Using the electron beam lithography (EBL) at the ANFF ACT Node, followed by wet chemical etching, a series of patterns with holes of various diameters and pitches was transferred to the resist and then onto the SiO_x layer.

The substrate with the pattern was then cleaned and loaded into the MOVPE system for nanowire growth. Figure 1 (below) shows a typical scanning electron microscopy (SEM) image of the patterned substrate (a) and InP nanowires after the epitaxial growth (b-d). The images show that nanowire diameter increases with increasing pitch for the same window diameter. This is due to the larger collection area around the openings which allows for more adatoms to diffuse towards the NWs and contribute to lateral growth.

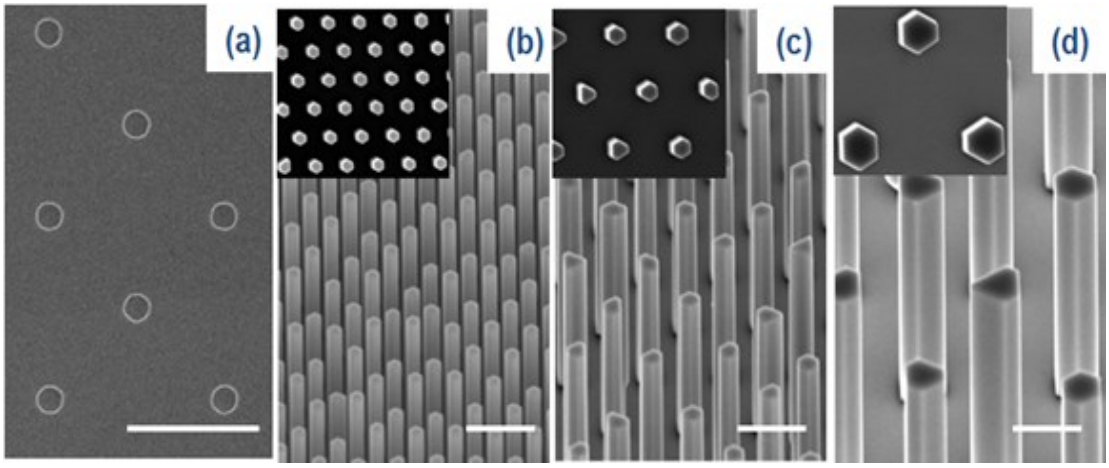

Figure 1: SEM images of (a) patterned substrate and InP nanowires with the spacing of (b) 500 nm, (c) 1 µm, (d) 2 µm. The designed diameter is 170 nm. The scale bars are 1 µm.

To further study the crystal structure of the nanowires, transmission electron microscopy (TEM) was employed. The Focused ion beam (FIB) at ANFF ACT Node was used to prepare TEM lamella with a thickness less than 100 nm. These nanowires were first planarised by BCB for support. Figure 2 (overleaf) shows a lamella after the FIB milling and polishing processes. High resolution TEM images and diffraction patterns of the InP nanowires indicates the nanowires have a wurtzite crystal structure without any stacking faults.

With these high quality InP nanowires, we will be fabricating high efficient devices such as photo-detectors and solar cells. These devices are exciting because of the large

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***"Spring has sprung,** the grass has ris', I wonder where my mower is?"*

Not quite classic haiku poetry I know - but I try hard. Just like everyone else at the ACT & WA Nodes.

It has been a busy past three months with the Annual Business Plan and finance reports being submitted, the upgrade of the Ion Implanter at ANU completed and now up and running again and work continuing on the installation of the two new MOCVD's and the re-commissioning of the old MOCVD. Maybe we'll have an article on these new capabilities next newsletter.

The WA Node has been busy with new upgrades, fitting an automatic sample stage to their XRD, the MBE upgrade producing top-of-the-line single crystal CdTe and the ICPCVD producing a-Si layers.

*The ACT Node also held their first User Workshop in late June and the results are in on this years User Satisfaction survey - more on these stories can be found overleaf. One suggestion from the user survey was to include journal publications that have accessed our facilities - this has now been done for 2012 and 2013 (to be updated as new publications come in). Check it out via the **'News & Links'** drop-down menu and click on **'Publications'**.*

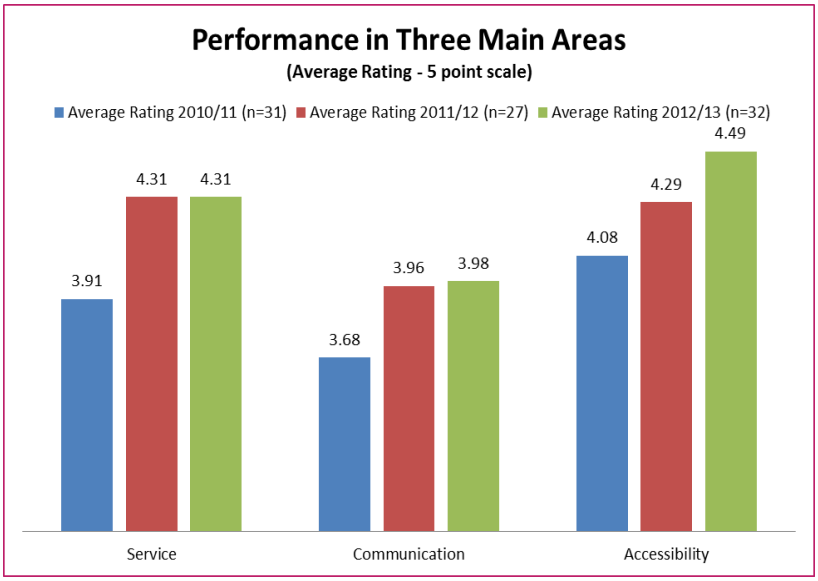
And finally, I'm sure we can look forward to adding to our publications listing soon with the work being carried out by Qian Gao who has provided the main article for this newsletter. As you will read she has utilised many of our tools and services in carrying out her research.

ACT Node & WA Node info:

- The ACT Node specialises in III-V compound semi-conductors.
- The WA Node specialises in II-VI compound semi-conductors and MEMS.
- We can provide full support with the use of the equipment available.
- Full pricing policy and rates are available on the ANFF website at www.anff.org.au or contact us direct for more information - see contact details overleaf.

ANFF ACT - User Satisfaction Survey 2012/13

Each year we invite users of our facility to participate in a User Satisfaction Survey to gauge our effectiveness in three key areas – service, communication and accessibility. It also provides an opportunity for users to give valuable feedback through additional comments and suggestions to improve the overall experience of accessing this valuable research facility.



This is the fourth year the survey has been conducted and, while the first year had limited participation, the last three years are directly comparable with a similar number of participants and response rates. Our target is to achieve an average rating of four (4) or higher (on a five-point scale, 1 = poor, 5 = excellent) in each of the three key areas identified above, and ideally achieve this average rating for each of the 15 questions. This year the survey was sent to 146 users – these were people who physically accessed the facility during the previous 12 months from 1 July 2012 through to 30 June 2013.

Of these, 32 users responded to the survey (~22%) - this compares to 115 users and 27 responses (24%) for 2012 and 79 users and 29 responses (37%) from 2011. While percentage participation numbers were down slightly the actual number of users responding is similar.

The chart to the left shows the results in the three broad categories. The complete survey report is available on our website:

(see http://tinyurl.com/kcpqabg).

Many thanks to all those who took the time to participate - we had some very valuable feedback that we will use to continue to improve our services.

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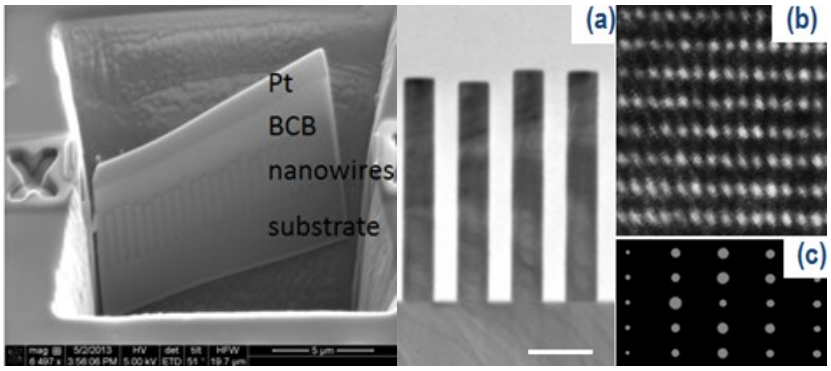

Figure 2: (above left) SEM image of a TEM lamella.

Figure 3: (above right) (a) TEM image of InP nanowires. (b) High-resolution TEM image and (c) selected area electron diffraction (SAED) pattern are shown in the right side of the figure.

surface area of nanowires to absorb light and efficient carrier transport properties that could improve device efficiency.

Since nanowires are inherently non-planar structures, the fabrication processes can be challenging and new processes have to be developed and optimised using ANFF facilities and with the assistance from the highly skilled ANFF staff.

Story courtesy of Qian Gao,

Department of Electronic Materials Engineering,
Research School of Physics & Engineering,
The Australian National University.

ANFF ACT Node Workshop

The ACT Node held their first User Workshop on Tuesday, 25 June - only a couple of weeks after the last newsletter was sent out. It was a well attended event, with close to 60 people, held in the Leonard Huxley Lecture Theatre with a total of eleven presentations - a full digest of the abstracts is available on our website:

(see http://tinyurl.com/m7yqk7l).

Two prize draws were made they went to Pawel Sajewicz and Mykhaylo Lysevych, both from Electrical Materials Engineering, ANU and they each received an official ANFF polo shirt. The event concluded with an in-house Turkish banquet and the biggest ANFF chocolate cake you have ever seen!

ANFFL CEO, Rosie Hicks, cutting the largest ANFF cake EVER! (above) and the line-up of workshop presenters with Node Manager, Fouad Karouta and Rosie Hicks bringing up the rear (below).

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