ANFF

ACT Node & WA Node NEWS

Providing nano and microfabrication facilities for Australia's researchers

Australian National Fabrication Facility

ACT Node & WA Node

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Plasmonic Nanowires - a Better Nanowire!

Researchers at the Department of Electronic Materials Engineering (EME) at ANU have been working on III-V semi-conductor nanowires that offer the possibility of achieving even higher density integration of optoelectronic devices (such as LEDs, lasers and photo-detectors) than current planar devices via the use of their inherent 3-dimesional type architecture.

High quantum efficiency (QE) in semi-conductors is essential for making efficient optoelectronic devices (QE is defined as the ratio of the radiative recombination rate and total recombination rate (both radiative and non-radiative)). A large surface area to volume ratio results in very poor quantum efficiencies in the nanowires due to non-radiative surface recombination, despite very good material quality. High quantum efficiencies in nanowires can be achieved by either reducing the non-radiative rate or by increasing the radiative rate. The non-radiative recombination rate can be reduced by quenching the surface states through surface passivation and this approach is actively being pursued for nanowire opto-electronic devices. The EME researchers approach for making opto-electronic device quality nanowires is to increase radiative recombination rate by coupling the nanowires to plasmonic structures.

Dr Sudha Mokkapati and her colleagues have been successful in integrating plasmonic structures with nanowires. Figure 1 (above, right) shows three different configurations of coupled nanowire-plasmonic structures created from the deposition of silver (Ag) using the E-Beam Evaporator and Sputter Deposition System at the ANFF ACT Node facility. Depending on the deposition conditions, a conformal layer of nano-particles can be deposited on the nano-wires. Such structures support surface plasmon polaritons (SPPs) at the nanowire-metal interface. The discrete metal nano-particles support localised

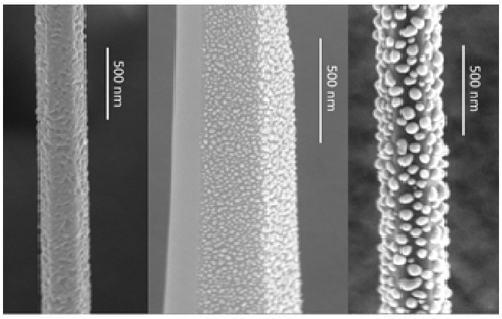

Figure 1: Different configurations for integrating nanowires with plasmonic structures.
Left: Continuous film of Ag deposited on a nanowire surface using thermal evaporator;
Centre: Ag nanoparticles deposited on selected facets of the nanowire using sputter deposition system without substrate rotation and
Right: Ag nanoparticles deposited on all facets of a nanowire using sputter deposition system with substrate rotation.

surface plasmons (LSPs) and the plasmon modes can increase the radiative recombination rate in the semi-conductor by concentrating electro-magnetic fields in the nanowire. This is analogous to the Purcell effect observed in dielectric resonant cavities. Nanowires coupled to plasmonic structures emit light much more efficiently compared to bare nanowires - Figure 2 (below) shows light emission from GaAs core-AlGaAs shell nanowires. Bare nanowires show a single peak at 870nm from the GaAs core, however there is no emission from the AlGaAs shell in bare nanowires due to very low quantum efficiency of the shell. In nano-wires coupled to plasmonic

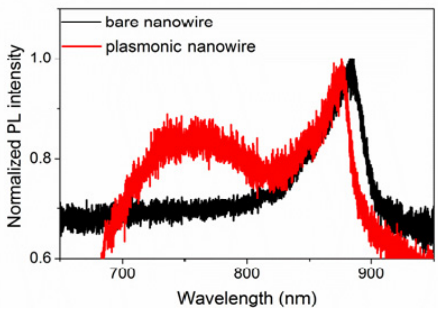

Figure 2: Plasmonic nanowires show distinctly different optoelectronic characteristics, where enhanced light efficiency due to coupling of the nanoparticles to the nanowire shell is observed.

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In this issue we have a feature article on some exciting work integrating plasmonic structures and nanowires by Dr Sudha Mokkapati from EME at ANU, and we also get to congratulate Dr Victor Pantano and his team from Digitalcore Pty Ltd. Digitalcore recently won the Australian Museum 2012 Eureka Prize for Commercialization of Innovation.

Digitalcore has been a long-term user of the facilities at the ANFF ACT Node and it is terrific to be associated with their success!

Also recently, we conducted our annual User Satisfaction Survey and the results were particularly pleasing. Conducting this exercise has given me a new-found appreciation of the efforts people put in to responding to surveys. The full survey report is now available on our website 'News & Links' page if you care to read it.

Last, but not least, the ACT Node said farewell to our well-respected FIB engineer, Dr Jie Tian, in August. Jie has moved to the sunny and warmer climes of southern Queensland to be with her husband and focus on family matters.

I'm sure all of you who benefitted from Jie's expertise will join us in wishing her all the best for the future.

Next Issue:
due December 2012

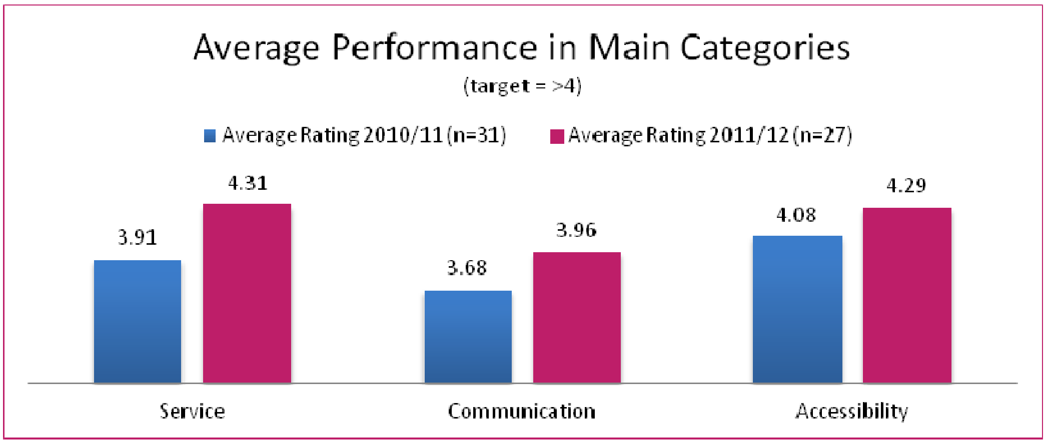
ACT Node & WA Node info:

- 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 2011/12

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 third year the survey has been conducted and, while the first year had limited participation, the last two 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 115 users – these were people who physically accessed the facility during the previous 12 months from 1 July 2011 through to 30 June 2012. Of these, 27 responded to the survey (~24%) and this compares to 79 users and 29 responses (37%) from 2011. While percentage participation numbers were down the actual number of responders is similar.



The chart to the left shows the results in the three broad categories. The complete survey report is available on our website at: http://anff-act.anu.edu.au/htm/main/news.htm

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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structures the emission from AlGaAs shell is clearly seen at 730nm due to enhanced quantum efficiency. Devices have now been successfully fabricated from nanowires coupled to plasmonic structures by electrically contacting the nanowires through platinum (Pt) deposited using the FIB system at ANFF-ACT, as shown in Figure 3 . These devices are currently being characterised and are expected to show superior performance compared to devices fabricated from bare nanowires.

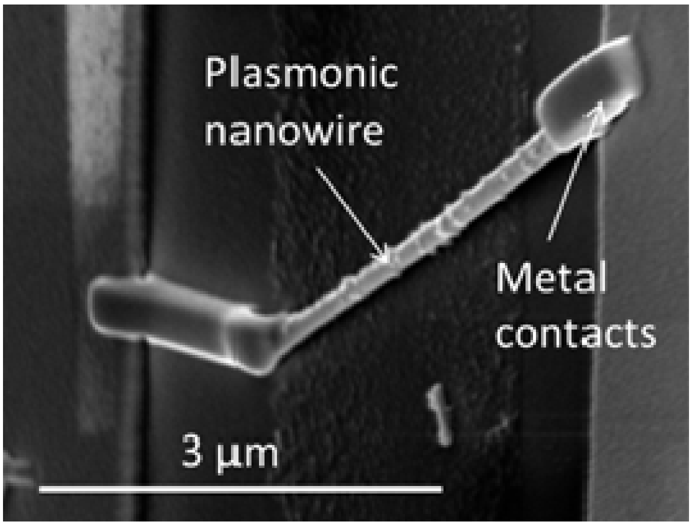

Figure 3: Plasmonic nanowires contacted using Pt electrodes deposited by FIB for electrical measurements.

Digitalcore – Eureka!

The ability to rapidly and efficiently analyse core samples for prospective oil and gas exploration operations using micro and nanotechnology is enabling more effective extraction of hydrocarbons.

Digitalcore Pty Ltd has won the prestigious 2012 Eureka Prize for Commercialisation of Innovation for their efforts bringing this technology to the international oil and gas industry.

Digitalcore, a long time client of the ACT node, provides 3-dimensional analysis of core samples, primarily using x-ray CT scanning. For some samples, such as shales and tight gas, CT scanning does not have the resolution to see the nanoscale features required for a meaningful analysis. Using the Focused Ion Beam (FIB) system and expert staff at the ACT Node, Digitalcore has developed a nano-scale 3D imaging technique. The technique uses a focused gallium ion beam to mill a small hole in the sample. Using the scanning electron beam integrated into the FIB system the edge of this hole can be imaged. Images of subsequent slices milled from the edge of the hole can be combined to create a single 3D image with nanoscale resolution.

"Together with ANFF, we have been leading the application of these (FIB) systems on rock samples to produce nanoscale 3D images of tight unconventional geological systems such as shales and tight gas." said Dr Victor Pantano, CEO of Digitalcore.

"This work is important as these geological samples cannot be analysed using traditional means, and thus the work with the ANFF provides a means of characterising these increasingly important oil and gas bearing formations."

See also ANU News - http://news.anu.edu.au/?p=16861

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