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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Taking Glass Nanowires to the Max

All-optical processing in highly non-linear waveguides is currently a subject of considerable interest as it enables the single channel data rate in a tele-communications network to far exceed those imposed by the limited bandwidth of electronics. All-optical processors utilise nonlinear optical phenomena in waveguides to manipulate light using processes such as four-wave mixing (FMW). FWM can be used for wave-length conversion; demultiplexing; performance monitoring; dispersion compensation; etc in an optical network.

To achieve efficient processors, optical nanowires made from highly nonlinear materials, like silicon or chalcogenide glass, are required since these structures provide a strong nonlinear response because the optical field is confined with a sub-micron waveguide "core" which enhances the light intensity. Furthermore, the small transverse profile can reduce the foot-print of the device and also allows the optical dispersion to be engineered to achieve devices with THz bandwidth. However, whilst there has been a lot of interest in using silicon waveguides as the nonlinear material, its strong two-photon absorption (TPA) and free carrier absorption (FCA) degrade performance.

As a result, Xin Gai, a PhD student supervised by Prof. Luther-Davies, working within the Centre for Ultra-high bandwidth Devices for Optical Systems (CUDOS) at the Laser Physics Centre, ANU has developed devices based on chalcogenide glasses because they offer extremely high optical non-linearities without TPA and FCA.

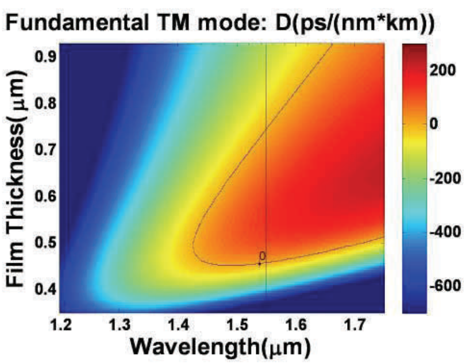

Figure 1. Dispersion parameter as a function of wavelength and film thickness. The blue curve represents zero-dispersion.

In the work reported here, the LPC designed and fabricated highly non-linear nanowires from a new $Ge_{11.5}As_{24}Se_{64.5}$ chalcogenide glass. In order to achieve nonlinear processing over the widest bandwidth, the nanowires need to be designed to achieve near zero optical dispersion. Using a finite-difference time-domain (FDTD) mode solver, the dispersion parameter was calculated as a function of wavelength and film thickness as shown in Figure 1. The zero-dispersion point is indicated by the blue curve. Finally, a structure 630nm wide and 500nm thick was selected for fabrication.

To fabricate the nanowires, 500nm thick $Ge_{11.5}As_{24}Se_{64.5}$ was deposited onto silicon oxidized substrate by thermal evaporation, and PMMA was spin-coated onto the film as a resist. E-beam lithography, using the Raith 150 machine at the ANFF ACT Node facility, was used to transfer the waveguide pattern into the resist. Using the special fixed beam moving stage (FBMS) capability of this machine allowed for stitching errors between different write fields to be eliminated, reducing optical loss in the nanowires. The pattern was then transferred into the glass film using ICP dry etching with CHF_3. A 5nm layer of Al_2O_3 was deposited by atomic layer deposition to enhance the adhesion and passivate

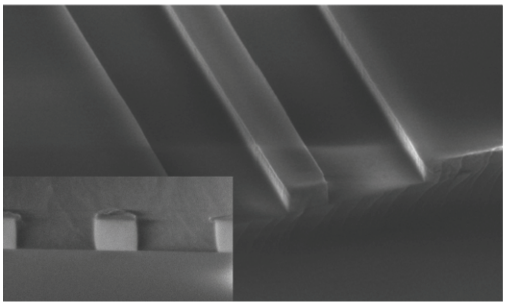

Figure 2. SEM pictures of nanowires. Inset shows hybrid glass top cladding.

(Continued on page 2)

***Welcome to the New Year** - and, depending on how you view things, a new decade!*

In this issue our main story focuses on an oral presentation given at COMMAD 2010, held just as our last newsletter was released. The presentation was titled: 'Ge$_{11.5}$As$_{24}$Se$_{64.5}$ chalcogenide glass nanowires with a nonlinear parameter of 136,000W^{-1}km^{-1} at 1550nm' and given by Xin Gai, a young PhD student from the Laser Physics Centre at ANU. Xin Gai's efforts were rewarded with him being presented with one of the two awards for the best oral presentation for the conference (there were two poster awards as well). The awards, sponsored by the ANFFL and ARCNN, consisted of $300 cash, a choice of book from Pan Stanford Publishing and a certificate.

Xin Gai has accessed facilities at the ACT Node for over 12 months now and we are happy to be associated with his success.

Other COMMAD winners were Laurence Deam (Uni. of Melbourne), Jason Chen (Uni. of NSW) and Anna Podolska (UWA). Congratulations to all.

Other news in this issue:

Next Issue: due June 2011

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.

Official opening of the WA Node

UWA Pro Vice-Chancellor (Research) Professor Alistar Robertson opening the WA Node of the Australian National Fabrication Facility at The University of Western Australia.

Although operating for many years now, the ANFF facility at The University of Western Australia was officially opened on 1 March 2011, becoming the eighth node of the ANFF.

Previously the UWA facility operated in partnership with the ACT node at The Australian National University. The facility at The University of Western Australia will continue to enable the development of unique technologies that will revolutionise daily life in fields as varied as health, agriculture, mining, automotive industries, communications, data storage and defence.

The WA node of the Australian National Fabrication Facility in the University's School of Electric, Electronic and Computer Engineering, was opened by UWA Pro Vice-Chancellor (Research) Professor Alistar Robertson. Other people in attendance included ANFFL's Chief Executive Officer, Ms Rosie Hicks; WA Node Director, Prof. Lorenzo Faraone; ACT Node Director, Prof. Chennupati Jagadish; Access Committee Chair, Prof. Jim Williams, Facility Managers, Res. Prof. Mariusz Martyniuk (WA) and Dr Fouad Karouta (ACT), and about 20 other invited guests.

In his opening speech Professor Robertson said "The launch was a proud day for the University in its aim to make a difference to the wellbeing of local, national and international communities".

The node would enable collaboration and facilitate the transfer of research into applications in industry. The WA node provides, via the ANFF, access to state-of-the-art semiconductor device technology and micro-electromechanical systems (MEMS) fabrication processes for industry and the broader Australian and international research communities. These UWA-based capabilities are in high demand and unique in Australia, (and in some areas, such as MEMS/HgCdTe infrared (IR) technology, unique in the world), and are already being accessed locally and internationally.

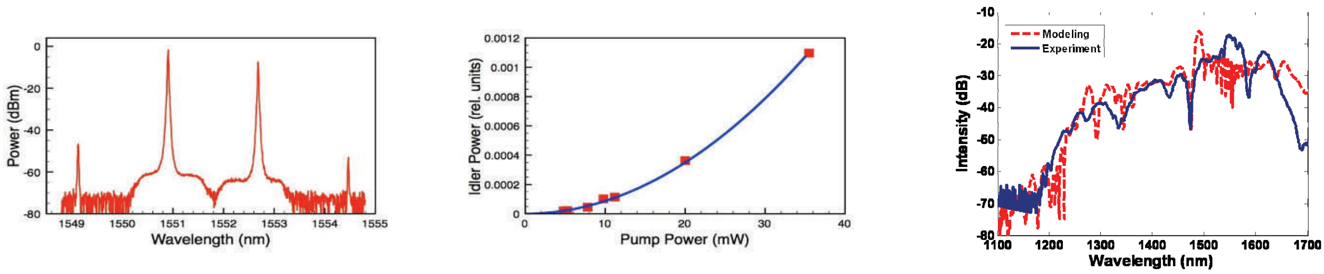

Figure 3. (a) The CW FWM spectrum, (b) Square law between pump power and conversion efficiency, (c) Spectrum of supercontinuum generation in 18mm nanowires.

(Continued from page 1)

the etched surfaces. At the end of the processes, a hybrid glass was spun onto the structure as a top cladding. The SEM picture of nanowires is shown in Figure 2 on page one.

To test the design, researchers measured the non-linear parameter of the nanowire using continuous wave FWM (Figure 3a). The conversion efficiency from signal to idler was measured with an optical spectrum analyser and confirmed to vary with the square of the pump power in the nanowires (Figure 3b). A value for the non-linear parameter of 136,000$(Wkm)^{-1}$ was obtained - this is the highest value ever achieved in a glass waveguide!

To demonstrate the effectiveness of the nanowire as a nonlinear device LPC researchers used it to generate supercontinuum requiring only an 18mm long nanowire driven with 20W peak power pulses 1ps long. This confirmed the strong nonlinear response and that correct dispersion had been obtained in the design (Figure 3c).

Devices such as these will find wide application in high speed and all-optical nonlinear processing in the future.

Story courtesy Xin Gai and Prof. Barry Luther-Davies, Laser Physics Center, ANU.

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