Australian National Fabrication Facility
ACT Node & WA Node
NEWSLETTER
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Supplanting the Synchrotron for Micro-Spectroscopy

The thermal glowbar has been the default wideband source used in Fourier Transform Infra-Red (FTIR) spectroscopy for many years, but suffers a major limitation in source brightness. The impact of this is most felt when used for example in FTIR microscopes under diffraction limited conditions at high magnification, where the signal to noise ratio suffers greatly compared to the situation in a large beam FTIR measurement. In response to this, critical experiments and investigations particularly in the life sciences have migrated to synchrotron sites where the IR brightness of the synchrotron beam is several orders of magnitude higher and enables almost diffraction limited observations. Whilst this is a solution of sorts, synchrotrons are neither compact nor “low” cost turnkey benchtop laboratory instruments! With this in mind, the question of whether a better source might be possible has stimulated CUDOS researchers at the Laser Physics Centre in ANU’s Research School of Physics and Engineering to apply their Chalcogenide IR waveguide technology to generate a wideband IR supercontinuum (SC) in a similar manner to the plethora of visible and NIR SC sources available commercially today. There are two key aspects to the problem.

Firstly low loss highly nonlinear waveguides with transmission covering the 2-12 micron band must be available, and additionally with suitable dispersion characteristics to enable the wideband SC to be generated. Secondly, a suitable femtosecond pump source is required. Research carried out at LPC identified that a pump source in the 3.5-5 μm band is essential to generate the long wavelength end of the spectrum.

The solution to the first part of the problem lay in utilising ANFF supported modelling tools and ANFF supported fabrication facilities for waveguide processing. After much experimentation and modelling, a waveguide was designed that supports only a single polarisation supercontinuum and that could be fabricated with available materials and tools. Before this could be tested however, a pump source was required. The requirements for the pump source were not met by any existing commercial product, and consequently, a new source had to be developed. Based upon prior research, an Optical Parametric Amplifier approach was chosen where an industrially available 1 μm femtosecond laser is used and converted to the required IR wavelength in a periodically poled crystal. In the process of researching this, a new operating mode was discovered that is currently undergoing patent examination, this new mode providing extremely high conversion efficiency in a single pass cavityless architecture. This is important in that it enables a much simpler and more robust device to be built, allowing true alignment free turnkey operation as desired in a practical instrument. Hotlight Systems (www.hotlightsystems.com), an ANU pre-spin out commercial entity, has been formed to exploit the IP and to develop a productionised version of the tunable OPA.

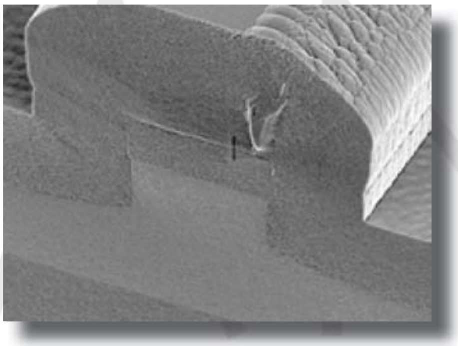

Figure 1 - Scanning electron Microscope cross section photograph of 4 μm wide (4.4 μm high) all chalcogenide rib waveguide structure with a cladding layer (Core-Clad index difference is 0.35).

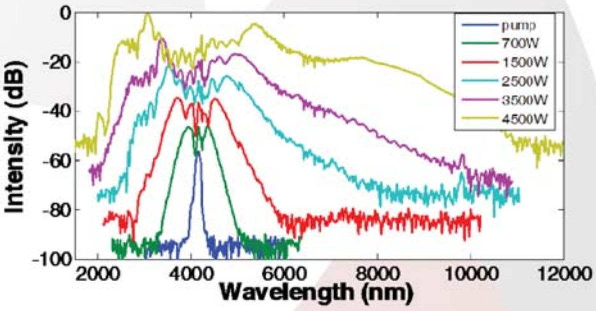

Figure 2 - Supercontinuum spectra as a function of coupled peak power at waveguide launch facet,

The waveguide has also been built in the ANFF supported waveguide fabrication facilities by a lithography/etch process, and a scanning electron microscope cross section of the device is shown in Fig. 1. Losses around 0.5dB/cm were measured across the 3.6-5 μm band, and the device was then used in conjunction with the OPA to generate the supercontinuum. A 1.8 cm long waveguide was pumped at 4.18 μm in the quasi-TM mode, and for a 130 mW pump input we obtained 26 mW of supercontinuum at the output. The polarisation extinction ratio of the SC exceeded 20 dB and the spectrum spanned 2.2 to 10.2 μm at the +/-15dB points relative to the pump wavelength, and is shown in Fig. 2.

The SC source is found to be low noise and offers slightly better dynamic range, but the real gain is when the measurement area is shrunk to a one wavelength sized spot as the SC source measurement loses no dynamic range whereas the glowbar source is significantly affected. In comparison to synchrotron and glowbar sources, the SC is extremely bright and it is plotted in comparison with a number of synchrotrons and a thermal glowbar in Fig. 3. As can be seen a brightness increase exceeding 105 has been achieved over a glow bar and > 100x that of a typical synchrotron heralding great possibilities for high resolution microspectroscopy. Work is now starting to integrate the SC waveguide and optics into the OPA case to provide a true turnkey MIR SC source capable of replacing a synchrotron at a tiny fraction of the price!

ANFF ACT node congratulates Dr. Steve Madden and his team at ANU-RSPE-LPC and wish Hotlights Systems a great success in their (ad) venture experience.

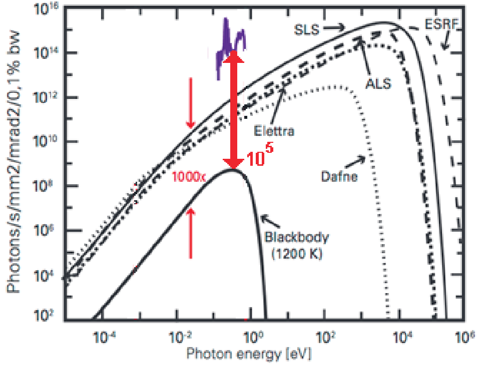

Figure 3 - comparison of SC source brightness with a glowbar and a number of international synchrotron sources

ICP RIE System: Plasma Therm Versaline

Continuing our series of articles focusing on tools available at the ACT Node, this quarter we look at the ICP-RIE tool.

The Plasma Therm Versaline, inductively coupled plasma (ICP) reactive ion etching (RIE) tool has been running since 2010. The system can process up to 4” wafer size and has the He backside cooling feature (common to many ICP tools). We have available three possible chemistries:

> CH_4-H_2 chemistry: this chemistry is widely used in InP-based integrated optics due to its high selectivity to dielectric mask and to its low damage and low etching rate enabling etch control for waveguide applications. A drawback of this chemistry is the formation of polymers associated with the C-atoms which requires a cleaning process after every booking using CH_4.
>
> F-based chemistry: We have two gases under this category SF_6 and CHF_3. In plasma conditions both gases supply F (radicals) responsible of the chemical etching of Si-based materials like silicon oxide and nitride. We have many users mainly from ANU who etch such materials as well amorphous and crystalline Si, Ge, TiO_2 and W-Si. We also have users who etch polymeric materials in SF_6:O_2 chemistry to contact planarised InP nanowires for solar cell application as shown in Fig. 1.
>
> Cl-based chemistry: this is an aggressive chemistry and can be used to etch various materials and metals. With the availability of BCl_3 along Cl_2 our users have been etching III-V semiconductors like InP, InGaAs, GaAs, GaN to cite a few. Fig. 2 shows a dense array of InP nanopillars fabricated using Cl-Ar-H_2 process top down approach. We also have some users using BCl_3 to etch Al-containing mixtures of pure Al.

Weekly the reactor chamber is cleaned using O_2 plasma

Having all these chemistries in one reactor brings some risk of contamination between processes and memory effect. In the semiconductor world usually industry does not mix these chemistries in one reactor. University institutes may use such combinations due to budget or lab space factors. As our tool will require a thorough investment to address various minor issues we are considering the possibility of purchasing a new tool that offers new capabilities to our users but restricting the chemistries by removing the F-based chemistry from the new tool. Still the node will be able to offer F-based chemistry opening access to the ICP-RIE tool of the ANU-RSPE Laser Physics Group, a tool that is partially supported by ANFF.

Kaushal & Fouad

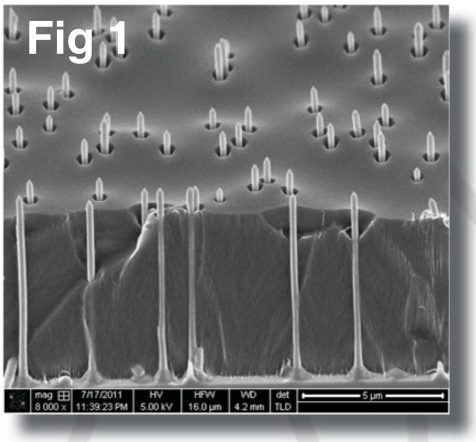
Fig 1

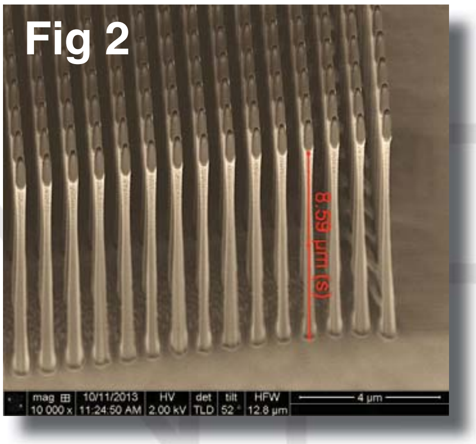
Fig 2

Welcome to our autumn issue

Lots has happened since last issue but first we want to congratulate our Node Director Prof. Chennupati Jagadish for his award on Australia Day of the Companion of the Order of Australia, the highest civilian honour in Australia.

Our casual Node Admin Ms. Gemo Virobo left the node to complete her study in Melbourne, we wish her good luck. Our recruitment process has been finalised and Ms. Shelly Song took the position since late January. She is taking care of the Node administrative tasks. Please welcome her warmly.

Fouad Karouta

Mark Lockrey, our SEM-CL engineer presented a talk at the ACMM24 held in Melbourne early February and he was awarded the Proscitech Trans-Tasman bursary that will fund him to attend the New Zealand Microscopy Conference in Auckland next year.

The photograph below shows Mark receiving the award from prof. Martin Saunders, president of the Australian Microscopy and Microanalysis Society.

Congratulations Mark!

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