MINERVA project newsletter #2

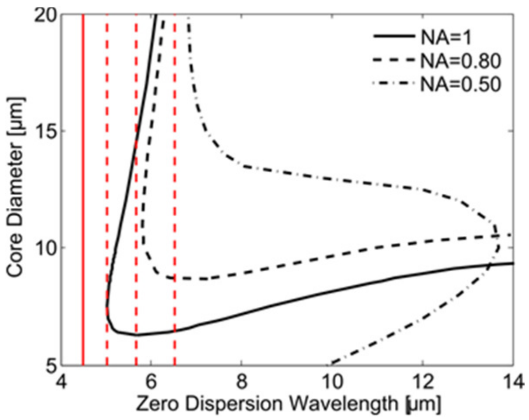
November 2013

Welcome to the second MINERVA project newsletter!
The project is entering its second year, and there has been excellent progress so far. This newsletter presents T2SL detector technology from IRnova, image segmentation work from UPV and supercontinuum modelling work at DTU.

There is much more information available from the project website (www.minerva-project.eu). For any other questions, further contact info is given below.

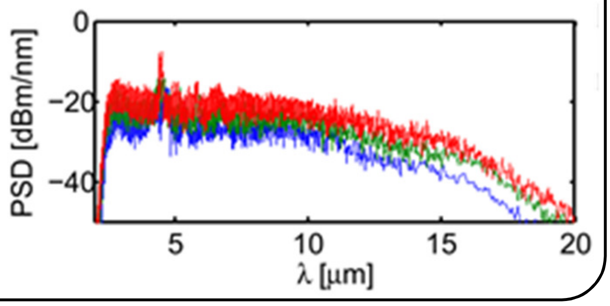
Extreme IR supercontinuum modelling at DTU

Prof. Ole Bang's team at the Technical University of Denmark (DTU) has the task of fibre modelling in MINERVA in close collaboration with the fibre manufacturing group at University of Nottingham (see previous newsletter). The DTU group also models dynamic super-continuum generation along the fibres using both measured material data and calculated fibre properties. This advanced modelling requires extensive computational resources in order to accurately follow the rapid spectral broadening, which covers over four octaves (from 1 µm to 16 µm); made possible by the strong non-linearity of chalcogenide glasses and the extremely high numerical aperture (NA) of the Nottingham fibres.



Zero dispersion wavelengths versus core diameter for step-index fibres (based on fibres fabricated at the University of Nottingham) with NA as given in the legend.

Modelling shows that a fibre with core diameter 10 µm and NA = 1.0 exhibiting no second zero- dispersion is optimum. Super-continuum generation beyond 12 µm is observed numerically.



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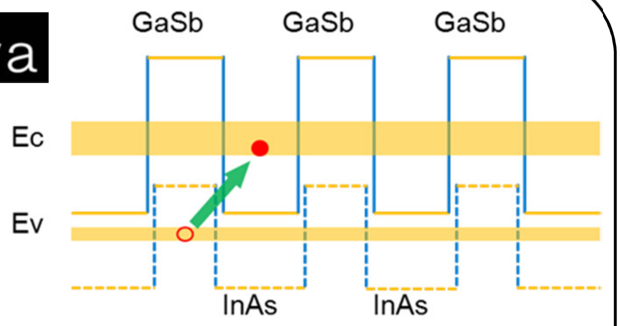
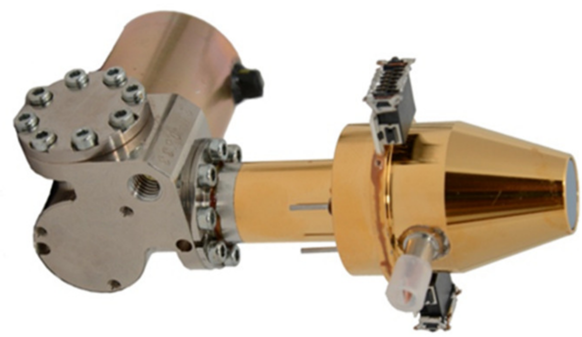
Seventh Framework Programme

MINERVA type-II superlattice IR detectors from IRnova



Schematic of T2SL band-gap structure

Type-II superlattice (T2SL) is a material/ technology that can be used for high quality cooled photon detectors, with tailorable bandgap from 2 µm and upwards. The name comes from the fact that the conduction and valence bands display a so-called “broken type-II” (sometimes also called “type-IIb” or even “type-III”) alignment between the constituent materials, which can be InAs/GaSb/AlSb, or alloys thereof (see above right). In contrast to typical quantum well devices, e.g. the active regions of semiconductor lasers, the superlattice layers in the T2SL material are so thin (typically ≤3 nm) that mini-bands are formed in the material. These mini-bands resemble the conduction and valence bands of a bulk semiconductor material. By carefully selecting the superlattice layer thicknesses and compositions, novel materials can be defined to meet widely different needs.



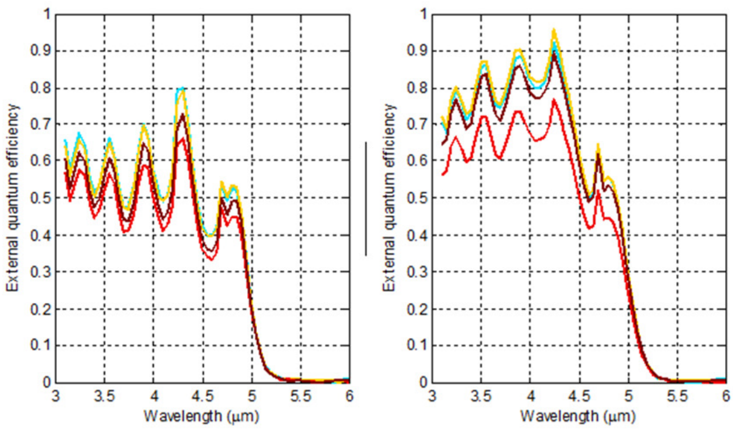
Detector/ Dewar/ cooler assembly for T2SL from IRnova

Compared with a traditional bulk material for the 3-5 µm range, such as InSb, T2SL requires less cooling and thus draws less power, which allows for longer cooler lifetime and consequently lower life-cycle cost. For the 8-12 µm range, the traditional alloy bulk material HgCdTe (or “MCT”) is difficult to fabricate with high yield, partly due to the extreme sensitivity of the bandgap to composition (particularly the HgTe: CdTe alloy ratio). Here T2SL materials have distinct advantages in fabrication.

Focal plane arrays comprising hundreds of thousands of T2SL detector pixels are flip-chip bonded to a CMOS read-out-circuit and then mounted on a ceramic carrier, which in turn is glued to a cold finger in a vacuum Dewar housing, complete with an IR window. The cold finger is cooled to detector operating temperature by a Stirling rotary cooler. IRnova’s detector-Dewar-cooler assembly for T2SL can be seen in the figure above.

IRnova has recently worked on improving the quantum efficiency (QE) of the detection by applying anti-reflective coatings to the detector surface. By this method, the QE was increased from approximately 50% to 80% in the wavelength region of interest (see graphs on right). This improves the signal-to-noise ratio and allows a reduced integration time for each image frame.

Apart from MINERVA applications, IRnova plans to use T2SL technology for gas detection of key greenhouse gases with absorption lines in the atmospheric transmission bands, such as methane and perhaps also sulphur hexafluoride (SF6).



Showing effect of AR coating on QE

MINERVA improved medical diagnostics

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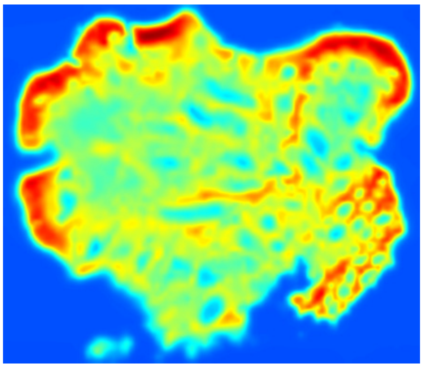
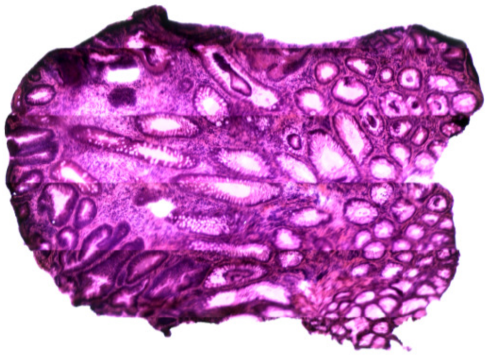
First steps with MINERVA image processing at UPV

Prof. Valery Naranjo leads the image and signal processing group at Universitat Politècnica de València (Labhuman Research Institute). The group's first objectives in MINERVA are focused on segmentation and registration of different kinds of images: infrared spectral images (IR), white light (WL), and those most used by clinicians at present, the haematoxylin and eosin stained images (H&E). The latter is the current "gold standard" used to distinguish between a healthy or pathological patient sample.



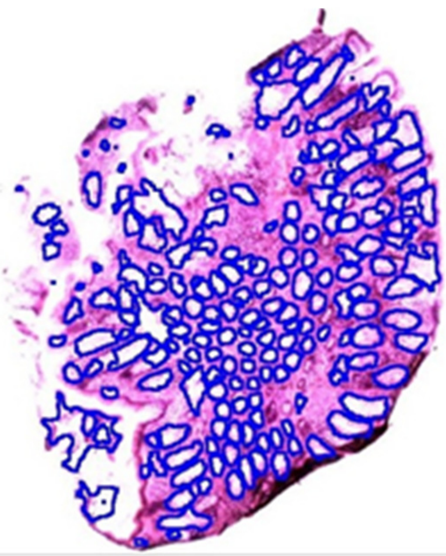


Left: IR image. Centre: WL image. Right: H&E image

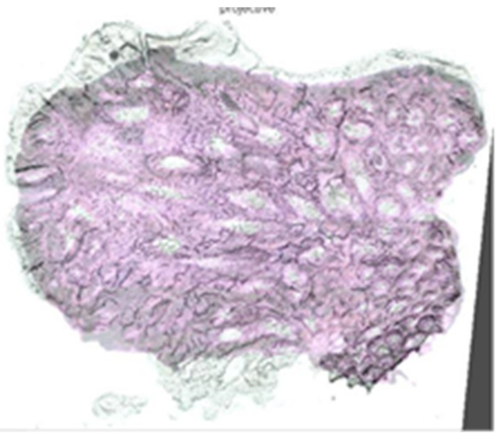
The objective within MINERVA is to automatically segment regions of interest (healthy and pathological) in the H&E images and look for their features in the infrared spectrum. To achieve this goal the H&E image must be registered with the WL image (which is already registered with the infrared volume). So, the work is focused on two interactive steps: registration and segmentation.

Registration allows the matching of elements that clinicians considered important in the H&E images with the spectral images. A successful registration task would allow users to learn, and later identify, the areas from which diseased and healthy cells and patients can be distinguished.

Segmentation concerns the accurate extraction of the cell contours. This would reduce the huge amount of data to be analysed looking for subtle biochemical changes ("cancer markers"). Once the contours have been identified, the regions must be classified as healthy or cancerous depending on subtle features including shape, texture and clustering. This is an extremely difficult task, but the use of the spectral information in the mid-IR should eventually aid clinicians to improve on the current gold standard.



Segmentation sample test



Projective registration test

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