MId- to NEaR infrared spectroscopy for improVed medical diAgnostics

MINERVA
improved medical diagnostics

MINERVA project newsletter #1

July 2013

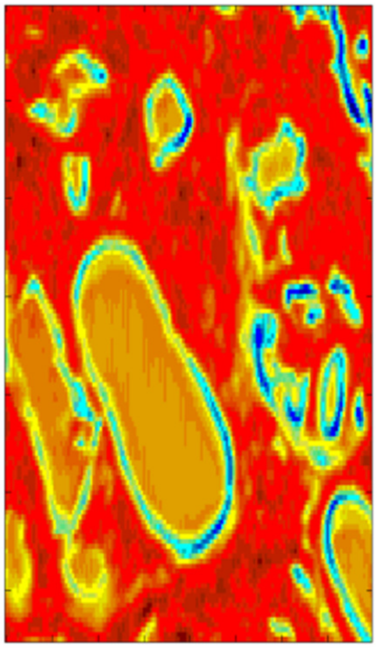

Image of prostate tissue using mid-IR. [Courtesy of University of Exeter.]

Welcome to the first MINERVA project newsletter!

MINERVA is a project funded by the European Commission through its Seventh Framework Programme (FP7). It brings together thirteen partners from across Europe with the common objective of developing mid-infrared (mid-IR) technology to improve the early diagnosis of cancer.

The MINERVA mid-IR range (1.5 to 12 μm) is rich in spectroscopic absorption peaks of biomolecules such as fats, proteins and carbohydrates. In particular it has been shown that, through the latest data analysis techniques, this spectral region can be used to identify the presence of early cancer.

Currently there is a lack of practical sources and components for this spectral region, and so these mid-IR diagnostic techniques are restricted to laboratory demonstrations.

MINERVA aims to develop fibre, lasers and broadband sources, components, modulators and detectors to access this important part of the spectrum. In parallel it will identify analytical techniques using the new photonic hardware to improve early skin cancer diagnosis and the rapid and automatic assessment of biopsy samples using a microscope.

These newsletters will be issued twice a year, and there is much more information available from the project website (www.minerva-project.eu). Further contact info is given below.

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Vivid Components
University of Exeter
LISA
NKT Photonics – the power of light
DTU
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Seventh Framework Programme

MINERVA
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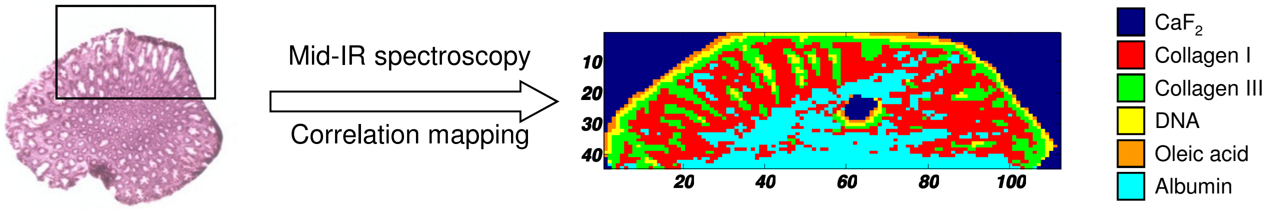
Mid-IR spectroscopy: a new tool for pathologists

The spectral region studied in MINERVA (1.5-12 μm) includes the so-called "fingerprint region" in which many biomolecules have tell-tale absorption peaks. By studying the pattern of absorbed radiation it is possible to deduce details of the type and distribution of these molecules, which in turn provides important information for disease diagnosis.

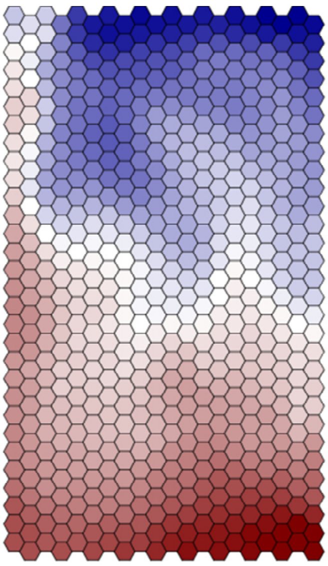
It is emphasised that this process is not as straightforward as simply spotting certain chemicals, or "cancer markers." The information is buried in the inter-related distribution of species and subtle biochemical changes. It requires a powerful mathematical technique known as multi-variate analysis to extract useful information from the reams of spectral data in order to spot the warning signs of cancer.

One form of multi-variate analysis is correlation mapping, which enables the visualisation of diseased cells or regions from spectral data. MINERVA combines novel mid-IR spectroscopy with correlation mapping and hopes to lead to a breakthrough diagnostic technology.



MINERVA will develop a suite of mid-IR photonic hardware to improve access to this information. Working in the mid-IR is extremely challenging, and MINERVA will need to break new ground in several technical areas:

- The project coordinator (G&H) will develop mid-IR components such as fused combiners (glass devices used to combine or separate signals into different optical fibres), and acousto-optic modulators (to switch the signals and separate wavelengths at high speed).
- These AO devices will need new types and sizes of calomel crystals from BBT.

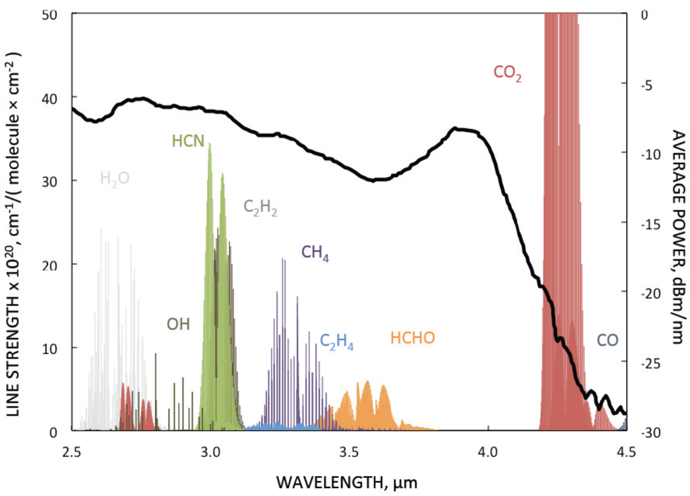


Images courtesy of Gloucestershire Hospitals NHS Foundation Trust

- Mid-IR glass fibre to carry the radiation efficiently and conveniently is being produced at University of Nottingham.
- Novel pump lasers at 2.9 μm and 4.5 μm from LISA Laser will be used by DTU and NKT to generate a range of supercontinuum sources in ZBLAN, indium fluoride and chalcogenide glasses, spanning the MINERVA range from 1.5 μm to 12 μm.
- Xenics and IRnova are advancing the state-of-the-art in Type II superlattice detectors, which offer a cost effective route to highly efficient detection in the mid-IR.
- University of Exeter and Gloucestershire Hospitals NHS Trust will develop the multivariate algorithms and techniques for high volume screening of human samples.
- WWU Muenster will develop a skin cancer diagnostic process.
- UPVLC (Valencia) is working on the user interface and visualisation.
- The project is managed and administrated by Vivid Components.

MINERVA supercontinuum sources from NKT

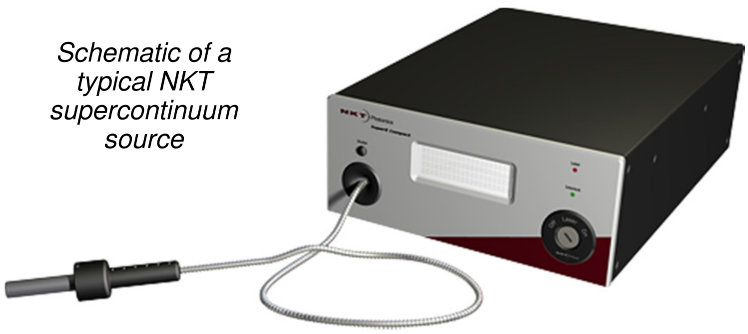
It has been mentioned that the mid-IR region contains a wealth of spectral data which can yield important information on the chemical composition of samples from gases and liquids to living cells. However, the investigation of this topic has been limited by the available photonic sources. Researchers had to choose between a very low intensity broadband source such as a "globar" thermal source, or a high intensity but narrowband source, such as a laser diode.



Graph showing absorption spectra of some key bio-molecules in the lower end of the "fingerprint region."

NKT Photonics is dedicated to providing flexible sources of high intensity light in an easy to use format. It has already established commercial supercontinuum systems which can deliver any wavelength from 400 to 2000 nm on demand. It has recently launched the EXTEND-UV accessory which can extend the wavelength coverage to cover the 270-400 nm UV region. The company would now like to push the limits of supercontinuum sources at longer wavelengths, reaching into the mid-IR region.

Schematic of a typical NKT supercontinuum source



For more info contact Peter Moselund
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In MINERVA NKT is developing zirconium fluoride (ZrF_4) glass fibre supercontinuum sources to cover the 1.5-4.5 µm spectrum. Subsequently it will investigate even longer wavelengths by utilising newly developed indium fluoride (InF_3) fibres to extend the spectrum beyond the transmission band of ZrF_4 glasses. These sources could detect changes in cells by monitoring absorption in the 2.6-3.8 µm region which relates to the balance between lipids and proteins. The increase in wavelength from 4.5 µm up to >5 µm would make it possible to interrogate additional important gas absorption lines such as carbon monoxide.

NKT expects that the first applications for these new sources will be previously unobtainable or impractical spectroscopic techniques. They will allow long range or high resolution measurements which were previously only possible with much more expensive and bulky instruments such as optical parametric oscillators (OPOs) or synchrotrons.

As these mid-IR supercontinuum sources become available and known in the field the MINERVA consortium expects the emergence of new markets. For example, an important spectroscopic application in the petrochemical industry is to monitor single wavelengths in the 3-3.5 µm band in order to optimise the refining processes. Monitoring the whole spectrum simultaneously would allow a full real-time chemical analysis of the output chemicals.

First steps with MINERVA fibres at University of Nottingham

Prof. Angela Seddon leads the Mid-Infrared Photonics Group at the University of Nottingham (George Green Institute for Electromagnetics Research), which has world-class facilities for mid-IR glass fibre optics and mid-IR planar devices: design, fabrication and testing. The main objective of the group is the development of new chalcogenide mid-IR fibres based on ultra-low loss materials and innovative fabrication techniques to provide robust fibre media for both mid-IR fibre lasers and mid-IR fibre supercontinuum sources.

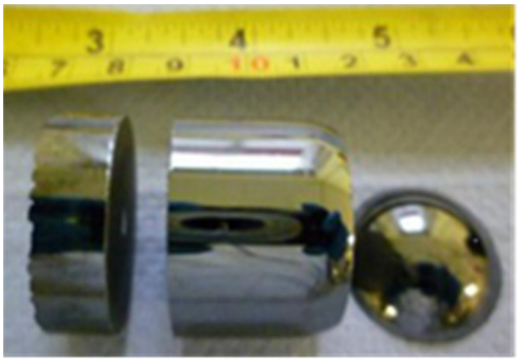
MINERVA will study the 1.5-12 µm wavelength range. As has been seen in this newsletter, mid-IR radiation is an exciting new area for real-time molecular-sensing, for example:

- Medicine and healthcare (e.g. early cancer detection: the MINERVA application space)
- Environment and energy (e.g. monitoring exhaust gases)
- Security (e.g. detection of narcotics or explosives; food security)
- Chemical, and industrial manufacturing (e.g. process control and quality assurance.

Three dedicated laboratories for the manufacture and assessment of mid-IR materials contain:

- Facilities for the manufacture of bulk glass mid-IR materials in controlled atmospheres
- Customised fibre drawing tower for advanced processing techniques
- Optical characterisation systems (e.g. photoluminescence, refractive index studies, optical loss and near-field imaging)
- Thermal characterisation equipment (e.g. viscosity, glass transition, thermal-mechanical and differential thermal analysis (TMA & DTA).

Workers at the University of Nottingham Mid-IR Photonics Group in action!



Sections of mid-IR preforms: these glass rods can be pulled into hair-thin optical fibres

The group also has access to the University's comprehensive range of state-of-the-art microscope and analysis equipment and expertise.

In addition to its experimental facilities, the group has considerable expertise in the modelling of mid-IR fibre lasers and the doping of glasses.

In MINERVA, it will model various fibres and laser configurations, and fabricate a range of solid and photonic crystal fibres. More details will be reported in the newsletters and on the website as well as at conferences and in journal publications.

For more info contact Angela Seddon: Angela.Seddon@nottingham.ac.uk