Australian Government

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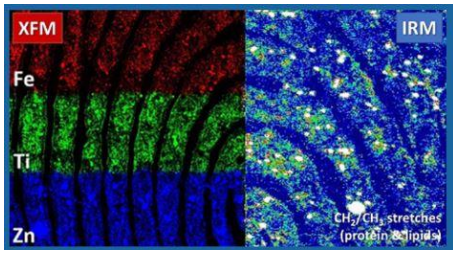


Virtual XFM & IRM Microscopy Workshop at the Australian Synchrotron

20th & 21st May 2021

FUTURE DEVELOPMENTS OF THE INFRARED MICROSPECTROSCOPY BEAMLINE

Mark Tobin

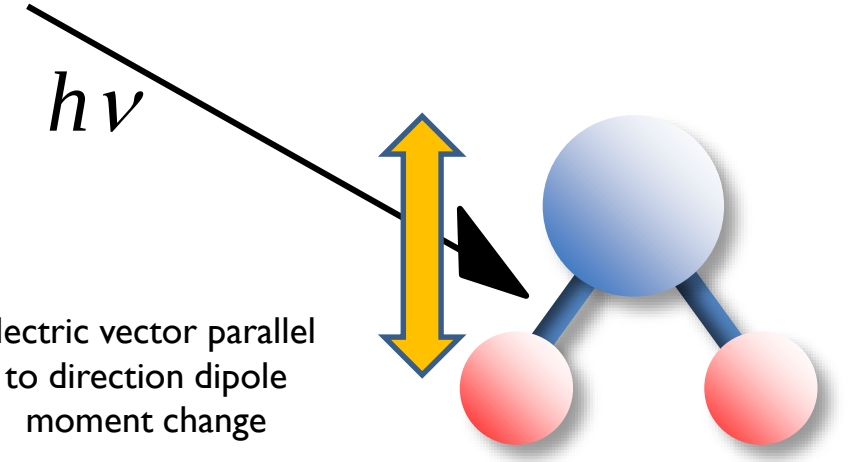
Australian Synchrotron

Science. Ingenuity. Sustainability.

OVERVIEW

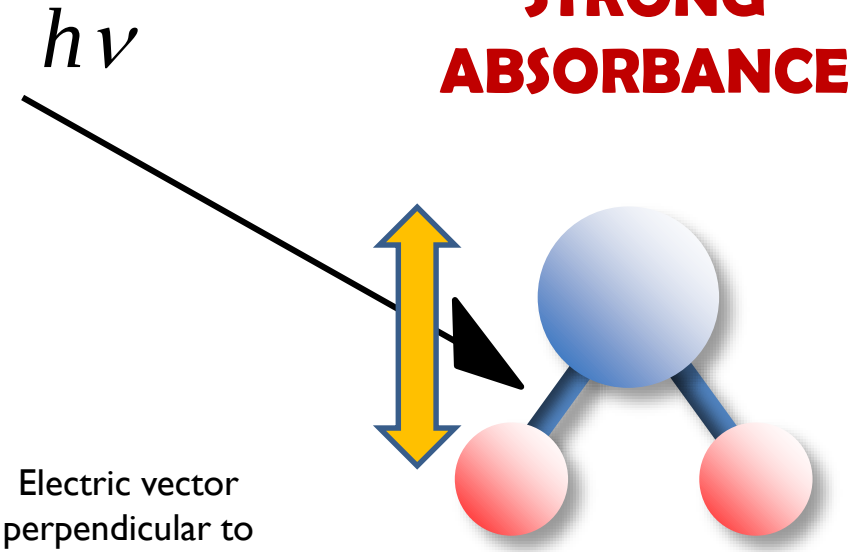
- Polarisation-resolved IR mapping
- Far-IR microspectroscopy
- Inverted ATR for live cells
- Second beamline branch for technique development
- Nano-FTIR

POLARISED INFRARED SPECTROSCOPY



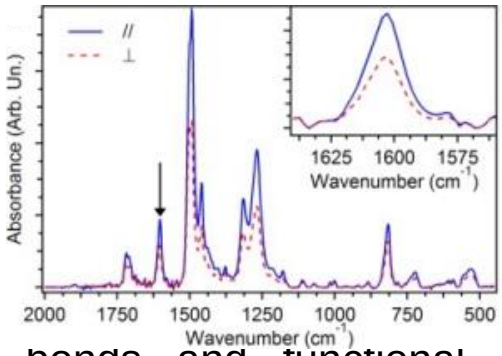
Electric vector parallel to direction dipole moment change

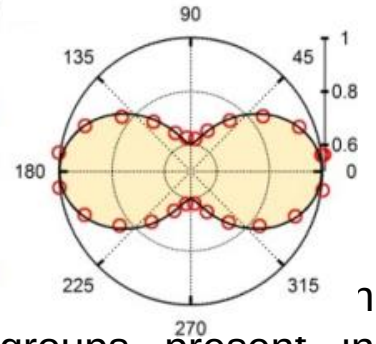
STRONG ABSORBANCE



Electric vector perpendicular to direction dipole moment change

WEAK ABSORBANCE





From Fasano V, Polini A, Morello G, Moffa M, Camposeo A, Pisignano D. Macromolecules 46(13): 5935-5942 (2019)

Absorbance of oriented PFO-PBAB electrospun fibres

Ring stretching mode of the fluorene unit, associated with vibrations prevalently directed along the molecular axis

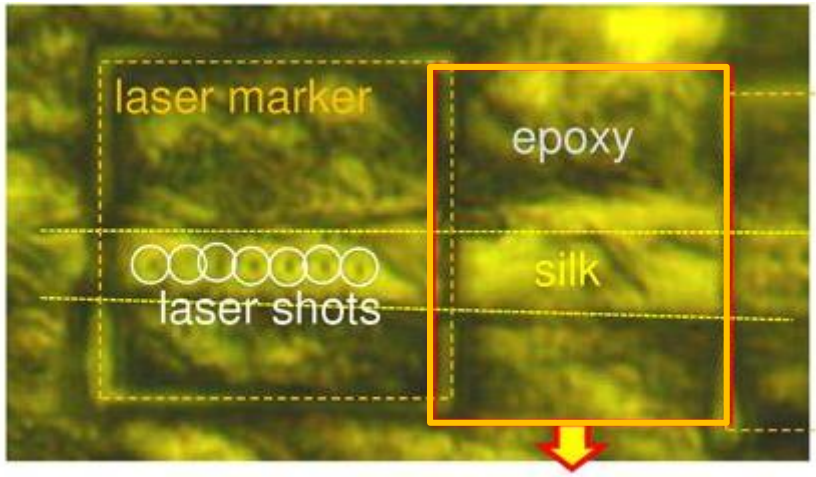
Infrared spectroscopy can therefore be used to probe the orientation of molecular bonds and functional groups

bonds and functional groups present in materials

- Frequency of bond vibration depends on mass of atoms and strength of bond
- Frequency is influenced by surrounding bonds and atoms
- For IR absorption to occur, vibration must result in a net change in a dipole moment.

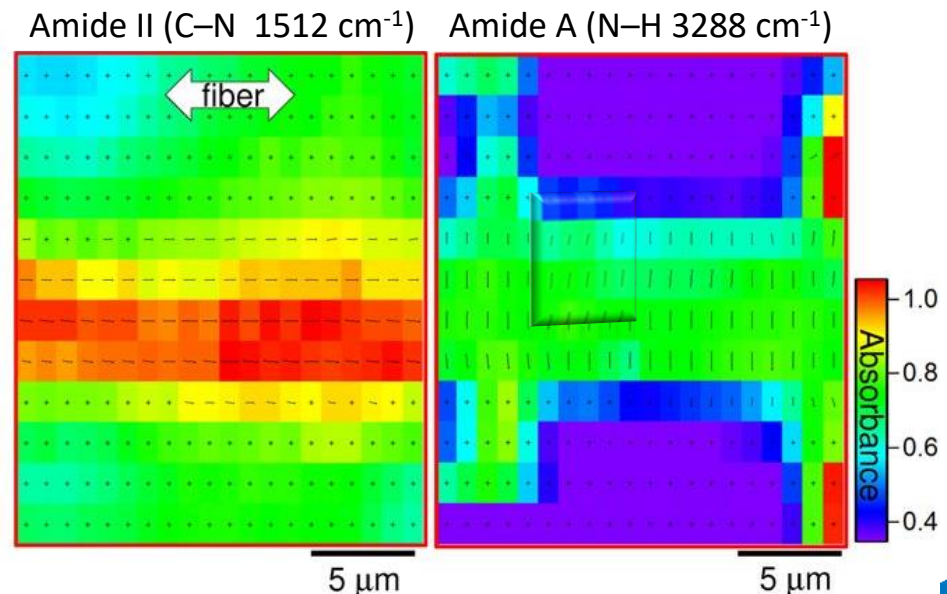
ORIENTATION ANALYSIS OF SILK-DERIVED BIOCOMPATIBLE MATERIALS

Prof. Saulius Juodkazis (Swinburne University) and Prof. Elena Ivanova (RMIT)
Prof. Junko Morikawa, Dr Miguya Ryu and Dr Reo Honda (Tokyo Institute of Technology)



Laser modification of silk protein for tissue scaffold printing

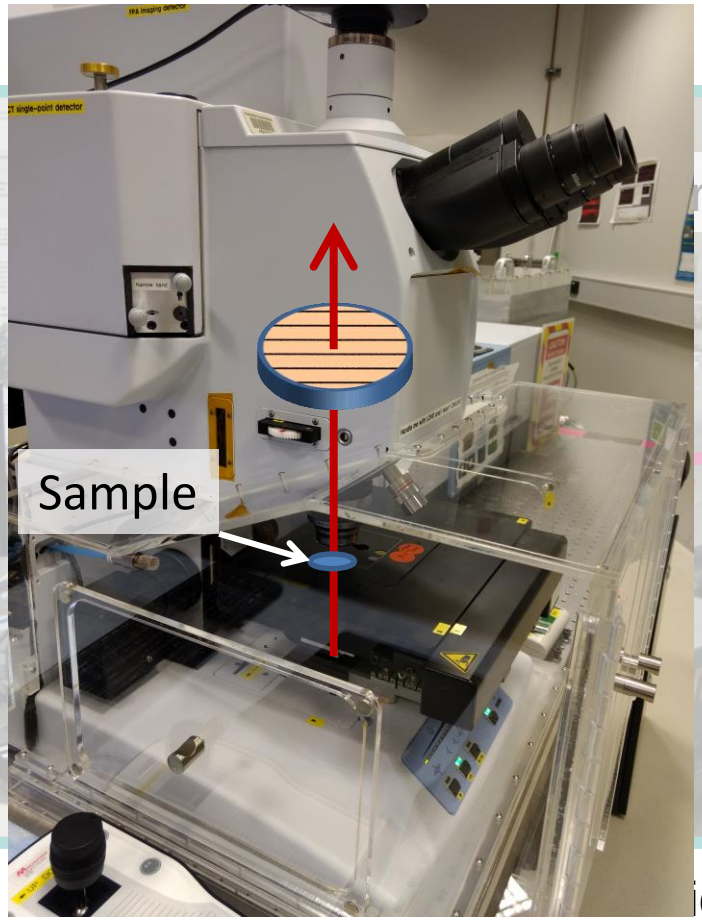
Mimicking the nanomorphology of insect wings to prevent bacterial colonisation.



Bar direction = Orientation function angle θ

POLARISED SYNCHROTRON INFRARED MICROSPECTROSCOPY

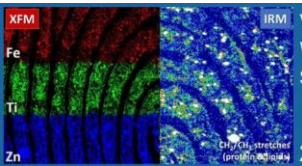
By coupling an FTIR spectrometer to an IR microscope, high signal-to-noise data can be collected from microscopic samples



Synchrotron Beam

- SR source, single element detector
- **High spatial resolution, down to a few microns**
- Mid-IR range, 750-3850 cm^{-1}

icroscope



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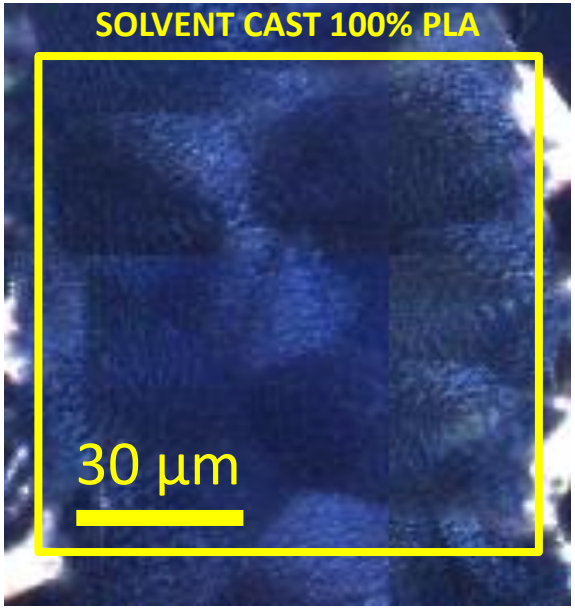
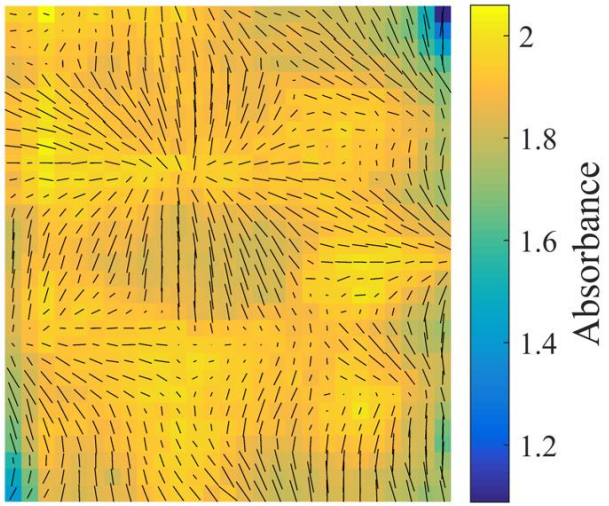
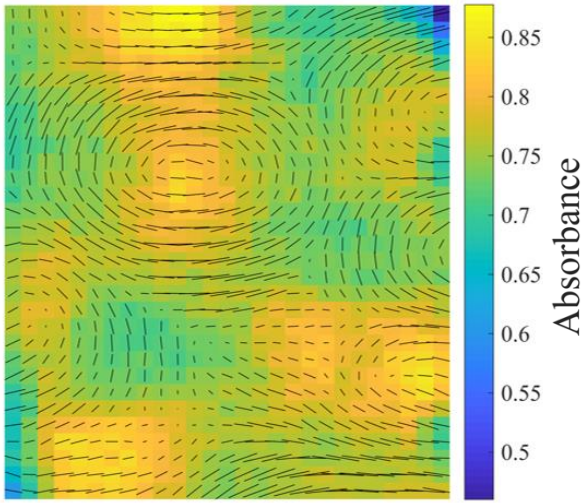
POLARISED IR MAPPING OF POLYLACTIC ACID (PLA)

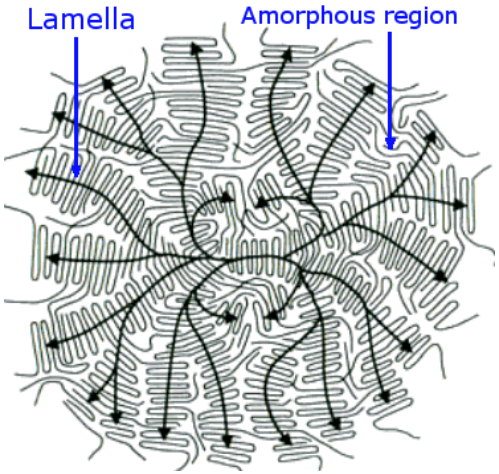


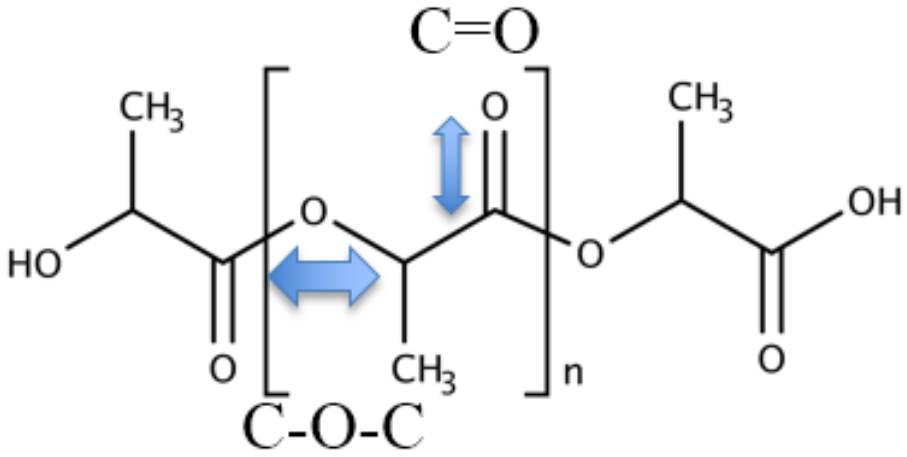
C=O Sidechain



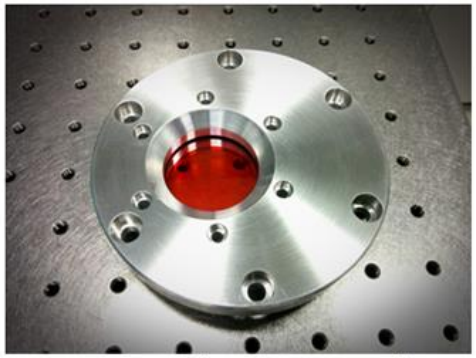
C-O-C Backbone



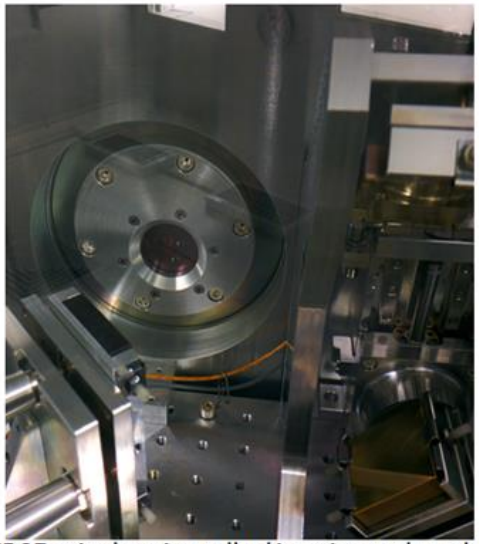




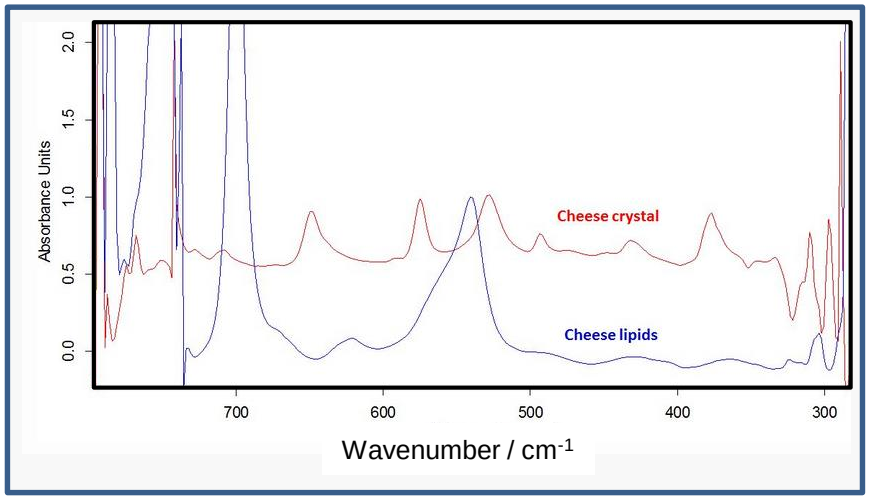
FAR INFRARED MICROSCPECTROSCOPY



KRS5 window (to 250 cm^{-1})



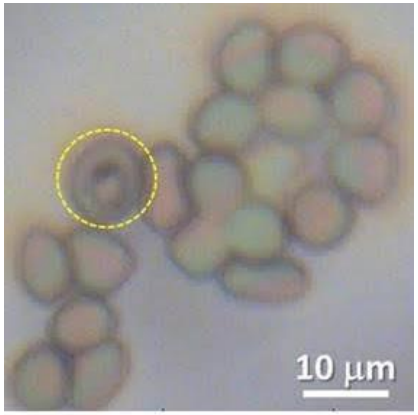
KRS5 window installed in mirror chambe



- Lipids and lactate crystals from aged cheese recorded to 300 cm^{-1}
- Reflectance spectra of polished geological samples recorded to 260 cm^{-1}
- Focus spot size scales with wavelength

ATR MICROSCOPY OF LIVING CELLS

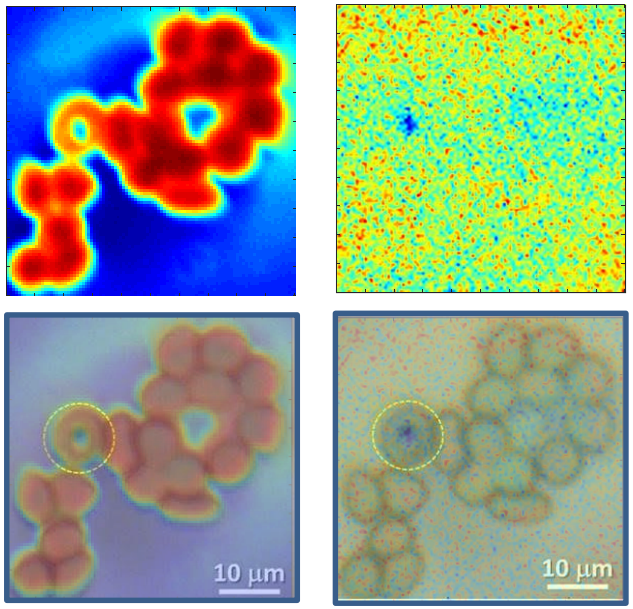
Macro-ATR mapping of fixed malaria infected blood cells



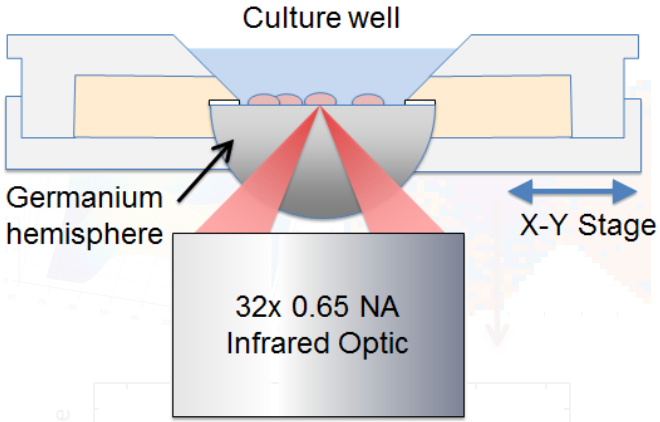
Cluster of erythrocytes with single malaria infected cell

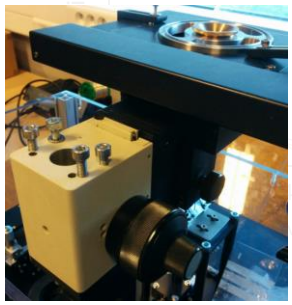
Amide A

Hemozoin band at 1713 cm^{-1}



Plan to develop liquid ATR chamber for live cell biology As demonstrated at SOLEIL





Pimm Vongsvivut – Australian Synchrotron (ATR mapping)
Bayden Wood, Phil Heraud and David Perez-Guaita –
Monash Biospectroscopy (sample preparation and data processing)

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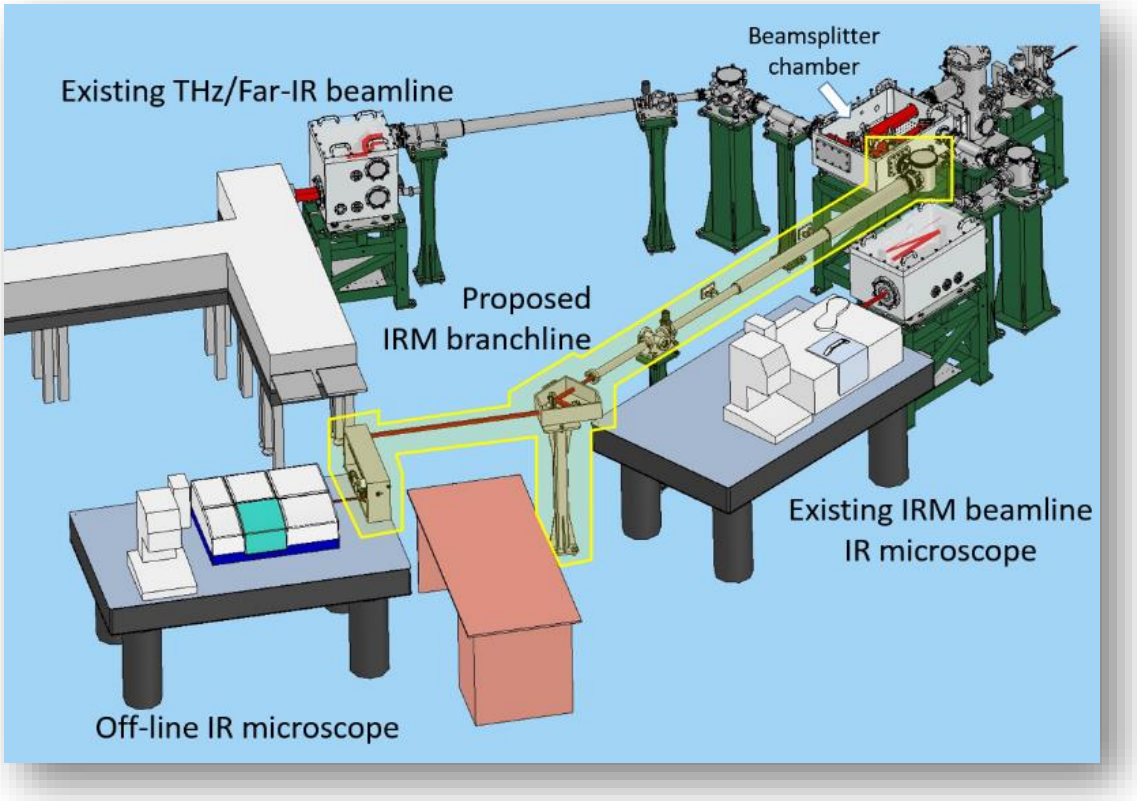
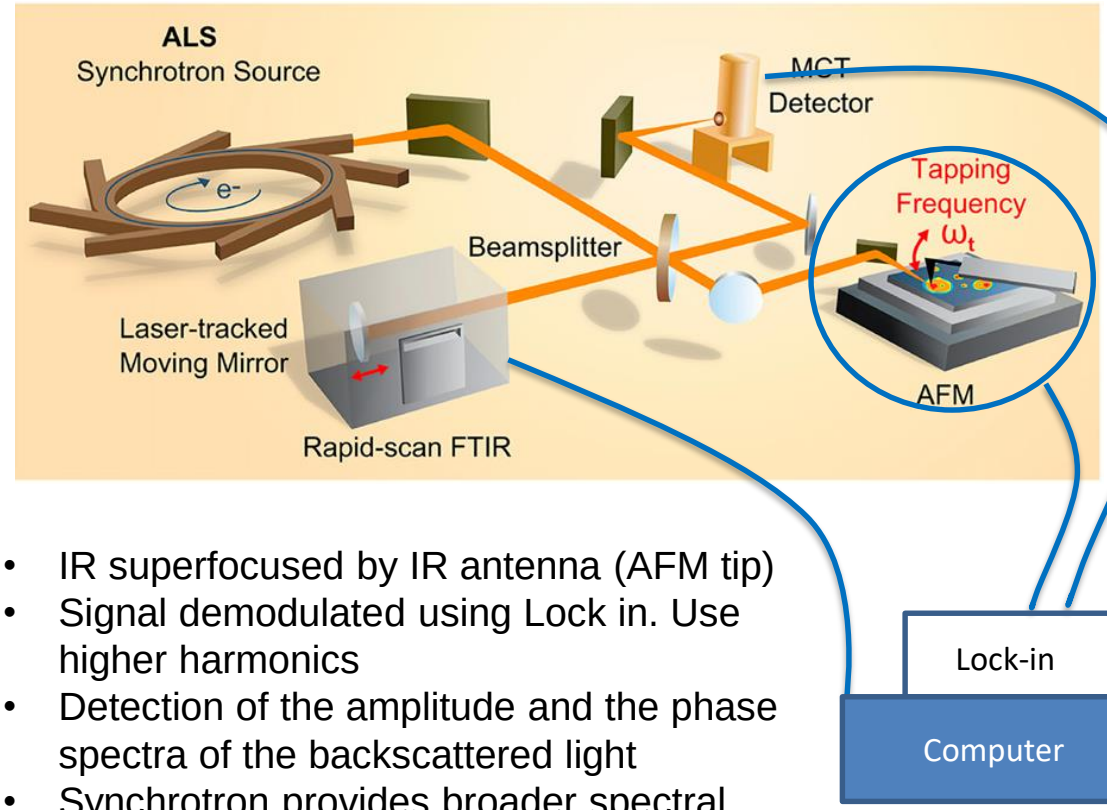
SECOND BRANCHLINE FOR IRM



To facilitate the testing and development of the techniques described in previous slides using the current off-line IR microscope – but with synchrotron beam.

Synchrotron beam will therefore be switchable between the two IR microscopes.

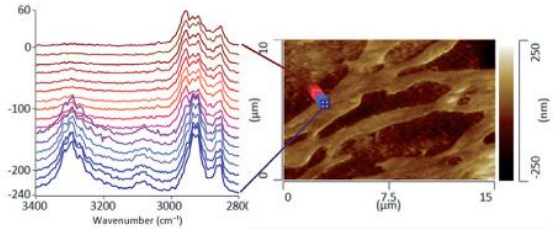
AFM-BASED NANO FTIR WITH BROADBAND SYNCHROTRON BEAM



- IR superfocused by IR antenna (AFM tip)
- Signal demodulated using Lock in. Use higher harmonics
- Detection of the amplitude and the phase spectra of the backscattered light
- Synchrotron provides broader spectral range than is available from lasers

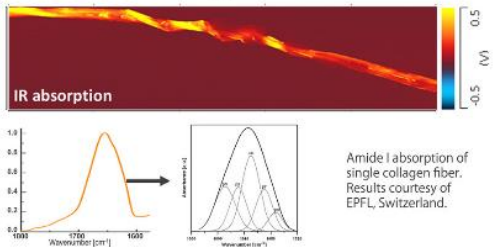
H.A. Bechtel E.A. Muller R.L. Olmon M.C. Martin and M.B. Raschke
PNAS (2014) vol. 111 7191–7196

Polymer interface chemistry



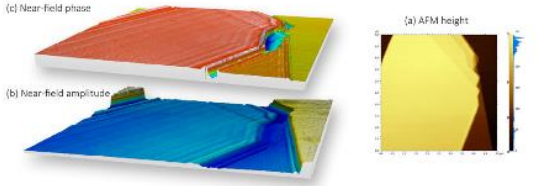
AFM-IR spectra (left) and morphology (right) of a polymer blend across a rubber/nylon interface.

Protein secondary structure single fibril



Amide I absorption of single collagen fiber. Results courtesy of EPFL, Switzerland.

hBN phonon-polaritons



Nano imaging of surface phonon polaritons (SPhP) on hexagonal boron nitride (hBN). (a) AFM height image shows homogeneous hBN surface with different layers on Si substrate; (b) s-SNOM amplitude shows strong interference fringes due to propagating SPhP along the surface on hBN; (c) s-SNOM phase shows a difference phase with layer thickness. From the image b and c, we can also see the wavelength of the SPhP changes with the number of layers.

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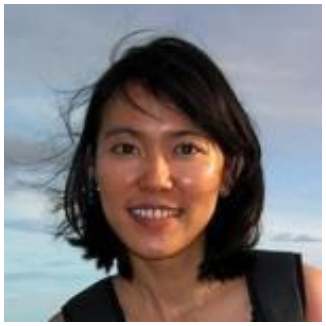
WHAT OTHER DEVELOPMENTS WOULD BE OF INTEREST AT THE IRM BEAMLINE?...

CONTACT THE BEAMLINE TEAM WITH YOUR ENQUIRIES!

Mark Tobin
Principal Scientist – IRM



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Microscopy Group Manager

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ANSTO

Thank you

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