Raman Spectroscopy

MANCHESTER 1824
The University of Manchester

STRESS & DAMAGE CHARACTERISATION UNIT

Laser light, focussed to a small spot size on the surface of the material, is scattered back, producing a light spectrum with particular frequencies corresponding to specific bond types. When the material is strained, the vibration frequencies change, and this is realised as a shift in the corresponding peak positions. In this way elastic strains can be measured, with high spatial resolution, in the surface of materials showing Raman shifts. These include many natural materials, nylon, carbon fibres, nanotubes and others. Fluorescent peaks or alumina can be analysed in a similar way.

Facilities

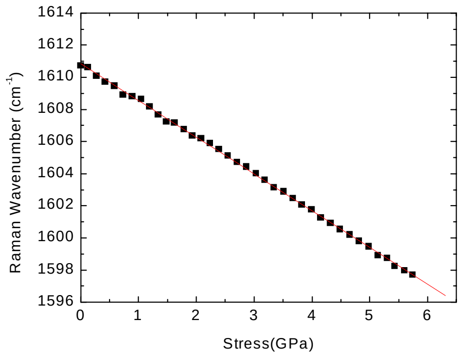
Renishaw 1000

Renishaw system 1000 with a 632 nm HeNe laser.
A dual Renishaw system 1000 with a 632 nm HeNe and 514 nm Ar laser.
A Renishaw system 1000 with a 780 nm near infrared laser.
A portable Renishaw Raman system for use on industrial equipment and larger specimens.
Spex 1403 Double monochromator (HeNe laser).
Spex 1000M single monochromator (HeNe laser).

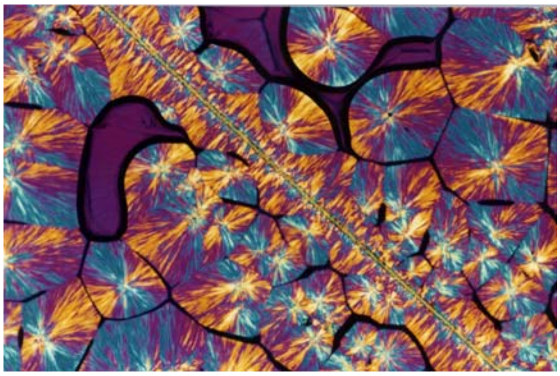
Deformation rigs (1 N, 25 N, 2 kN+) are available, and the portable system can be coupled to an INSTRON tensile tester. Materials which can be studied include aramid, carbon, polyethylene, silicon carbide and alumina fibres, resins and natural fibres. Polarisation and confocal mode spectroscopy are also possible.

Case Study (1) - Fibre Deformation

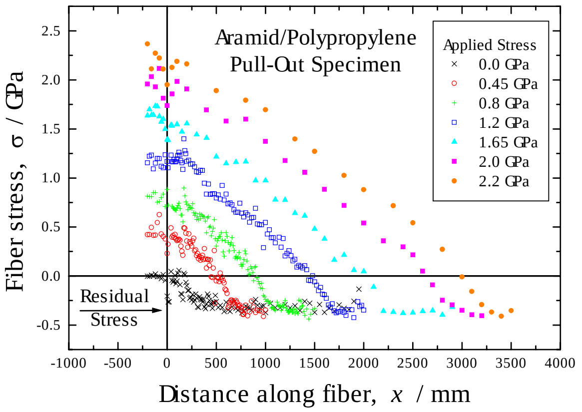
In aramid fibres under load, Raman bands shift towards a lower wavenumber due to molecular straining/stressing. Shifts can be calibrated allowing point-to-point variations to be measured giving us insight into fibre structure, as well as strain/stress within a composite material.



Case Study (2) - Composites

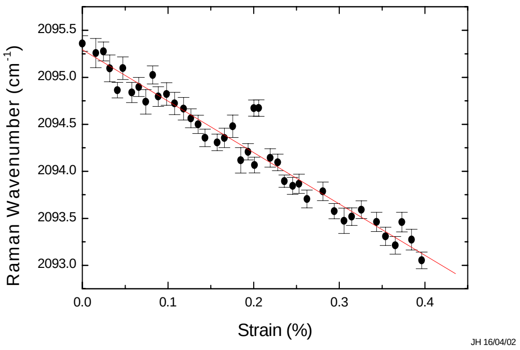


Optical micrograph of aramid fibre (indicated by arrow) embedded in crystallised polypropylene film, surrounded by a transcrystalline layer.
Raman spectroscopy measured the residual stress in the system, and also solved the debate over whether the layer benefits the fibre/matrix interface (it has little effect). The stress distribution in the fibre was measured during a pull-out test, and the results of axial fibre stress for different levels of applied stress are shown in the graph:



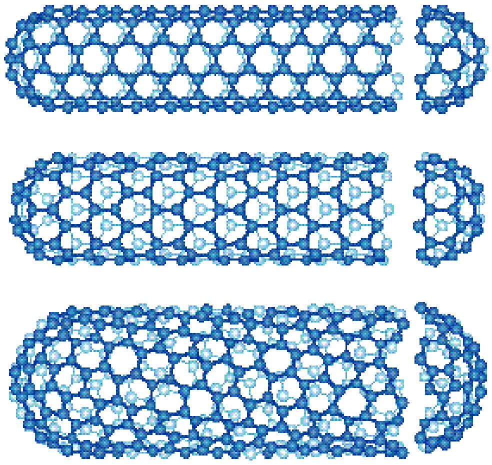
CASE STUDY (3) - SMART STRAIN-SENSITIVE COATINGS

Diacetylene co-polymers have been developed in the Manchester Materials Science Centre, which can be applied to metals and alloys that are otherwise insensitive to Raman. An example of a Raman band shift with strain for a coated aluminium substrate is shown in the figure,



giving valuable insight into the local deformation:

Similar results can be obtained by making dispersions of carbon nanotubes:



These materials can be dispersed into a matrix and are highly effective as nano-strain sensors.

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