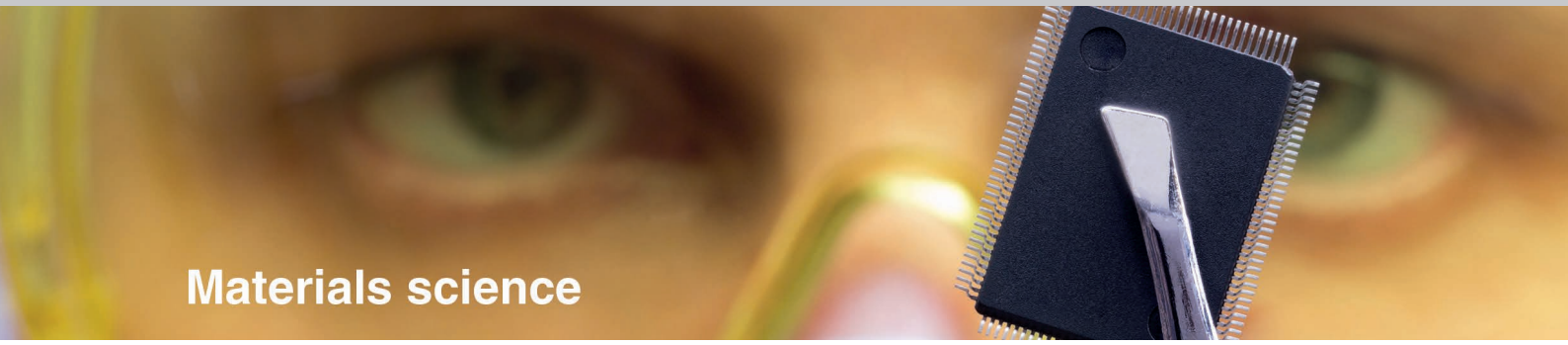
RENISHAW
apply innovation™

Analyse lithium-ion batteries with the inVia™ confocal Raman microscope



Materials science

Chemically characterise lithium-ion batteries with Renishaw's inVia Raman microscope. inVia is the ultimate system for studies ranging from fundamental research on the materials involved through to final product quality control and failure analysis.

The inVia confocal Raman microscope

- Provides unambiguous identification of all material types of interest:
  - organic and inorganic
  - crystalline and amorphous
  - solids (including polytype/allotrope differentiation), liquids, and gases
- Gives information on the spatial distribution of material, via depth profiles and 2D and 3D maps, and can resolve sub-micrometre features
- Allows *ex situ*, *in situ*, and *operando* measurements
- Can map uneven and rough surfaces
- Automatically maintains focus during dynamic analysis of expanding and contracting surfaces as batteries are cycled
- Uses a non-destructive, non-contact technique
- Can be coupled to atomic force microscopes for ultra-high resolution measurements

Identify lithium-ion battery components

- Carbon materials
- Metal oxides
- Polymers
- Electrolytes, ionic liquids

Correlation of composition and structure with performance

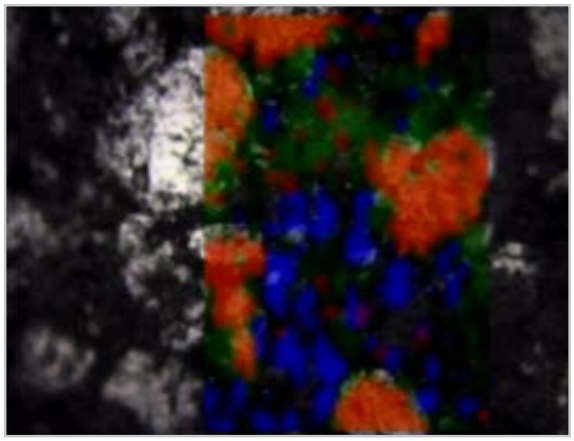
- Study the distribution of components on the electrode surface or in cross-section
- Discriminate between spatially close components
- Detect structural changes

Results can be quantified with metrics, such as fraction estimates and particle statistics

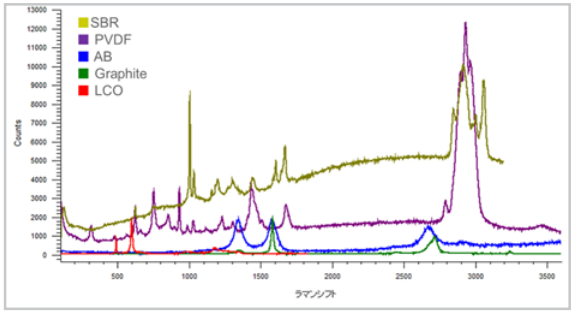
In situ electrochemical characterisation

Use inVia with a wide range of sample chambers and electrochemical cells. This, coupled with an ability to be triggered from devices such as potentiostats, enables *in situ* and *operando* measurements.

Custom systems for inert gas glove boxes are also available.



Raman map of an anode, superimposed on an optical microscope image. The map reveals graphite (red), acetyl black (blue), and hard carbon (green). Their relative abundances are, respectively: 13%, 10%, and 77%.



Detecting and identifying all the materials present, even at low concentration. Spectra taken in situ from: SBR (styrene-butadiene rubber, binder); PVDF (polyvinylidene fluoride, binder); AB (acetyl black, anode); graphite (anode); LCO (lithium cobalt oxide, cathode).

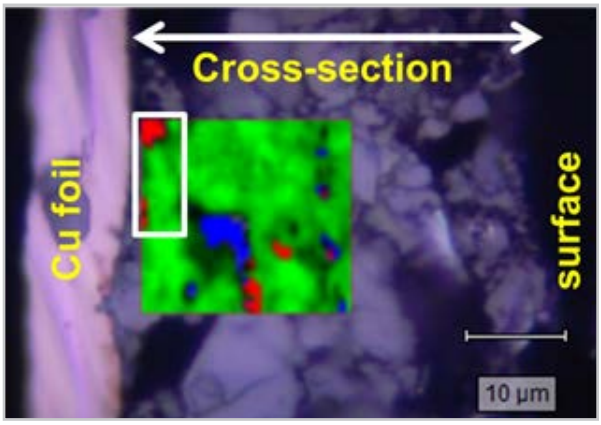
Renishaw plc

Spectroscopy Products Division
New Mills, Wotton-under-Edge,
Gloucestershire GL12 8JR
United Kingdom

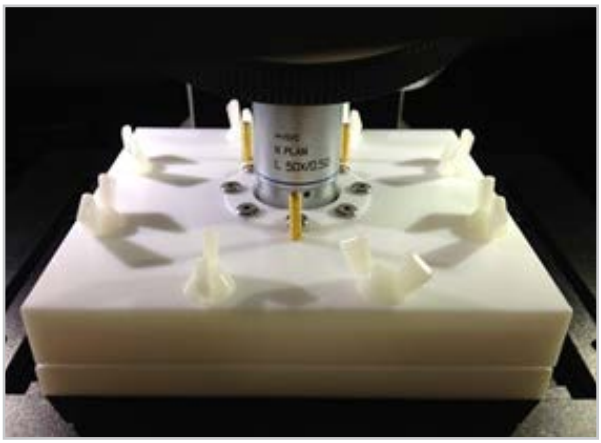
T +44 (0) 1453 524524
F +44 (0) 1453 524901
E raman@renishaw.com

www.renishaw.com/raman

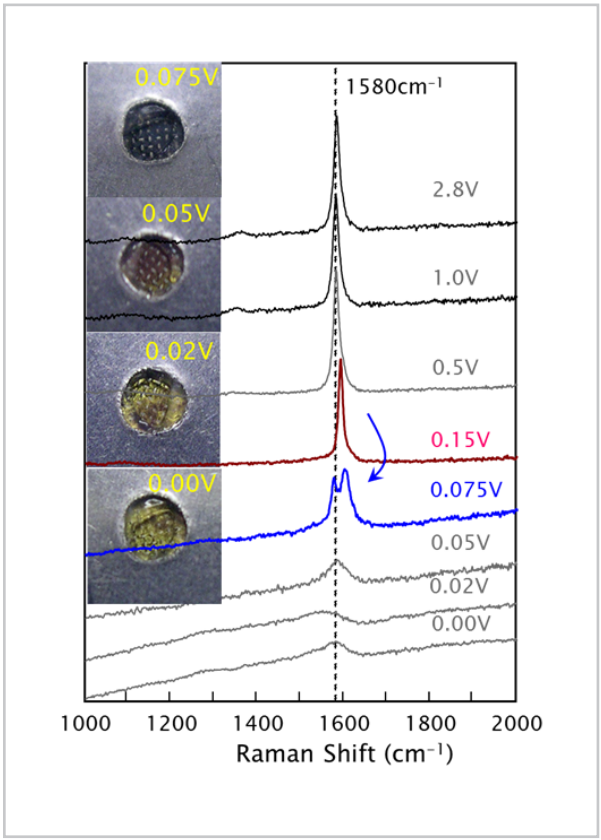
RENISHAW
apply innovation™



Detecting low concentrations of binder. Raman map of an anode (superimposed on an optical microscope image). The colours represent: SBR styrene-butadiene rubber binder (red); graphite (green); acetyl black (blue). The relative concentrations, as determined by the map, are, respectively: 1%, 97%, and 2%.



Using an electrochemical cell to perform operando measurements on a lithium-ion battery. Image courtesy of Mr. Hamura, Shimadzu Technoresearch, Japan.



Operando studies of an anode. As the potential is changed, the anode's appearance changes. The graphite G-band Raman peak also changes, indicating intercalation of lithium (shifting the peak to higher wavenumbers) and then a peak-splitting reflecting the intercalation penetrating to interior layers, rather than just the boundary layers. Data courtesy of Prof. Y. A. Kim, Shinshu University, Japan.

These results illustrate the ease with which you can use Renishaw's inVia confocal Raman microscope to study lithium-ion batteries.

inVia. The ideal lithium-ion battery analysis tool

- Research grade Raman microscope
- High sensitivity to detect traces of material
- High confocality to scrutinise small details
- A range of rapid mapping and imaging solutions
- Automation options, such as triggering of data acquisition by external systems (e.g. potentiostats)
- Raman-compatible electrochemical test cells available

The Renishaw inVia confocal Raman microscope.

Renishaw. The Raman innovators

Renishaw manufactures a wide range of high performance optical spectroscopy products, including confocal Raman microscopes with high speed chemical imaging technology, compact process monitoring Raman spectrometers, structural and chemical analysers for scanning electron microscopes, solid state lasers for spectroscopy and state-of-the-art cooled CCD detectors, for both end-user and OEM applications.

Offering the highest levels of flexibility, sensitivity and reliability, across a diverse range of fields and applications, the instruments can be tailored to your needs, so you can tackle even the most challenging analytical problems with confidence.

A worldwide network of subsidiary companies and distributors provides exceptional service and support for its customers.

Please visit www.renishaw.com/carbon for more information.