Integrated Circuits

Designing integrated circuits depends on understanding the electronic properties of the materials used in the manufacture of the devices. In order to create devices such as transistors, diodes, and capacitors there has to be patterning on the silicon which is achieved by doping or by depositing an amorphous layer and by coating with dielectric and metal films. As well as engineering the electronic properties of the materials, there are important materials compatibility issues which can be addressed with Raman spectroscopy.

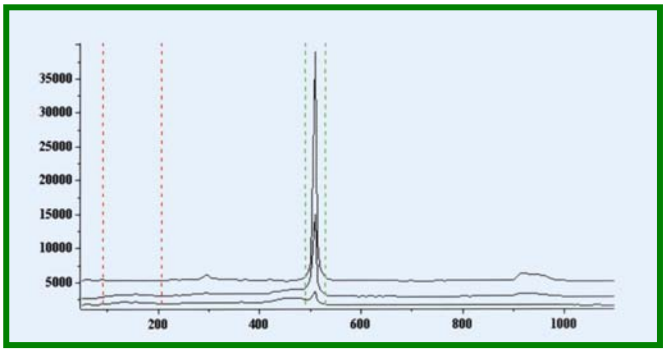
Raman spectroscopy is often the technique of choice for studying the materials in an integrated circuit. It provides information on interatomic bonding, crystallographic phase, and strain, and it does all this with better than 1 µm spatial resolution.

In this note, we illustrate these capabilities by creating a detailed map of a feature on an integrated circuit with feature sizes between 3 and 10 µm.

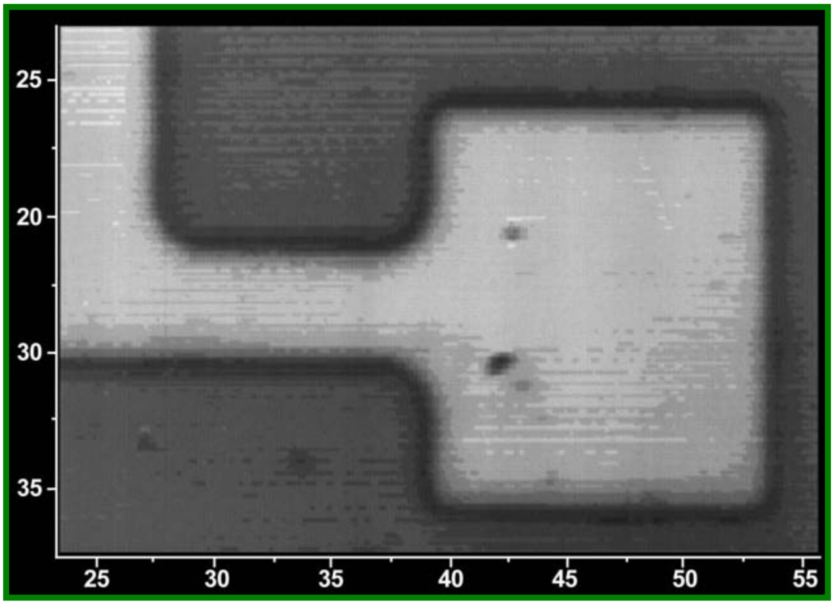
Image of Device Feature Composed of Amorphous Silicon

The LabRAM's patented line-scanning capabilities were used to collect spectra from the area of the device illustrated in the video image.

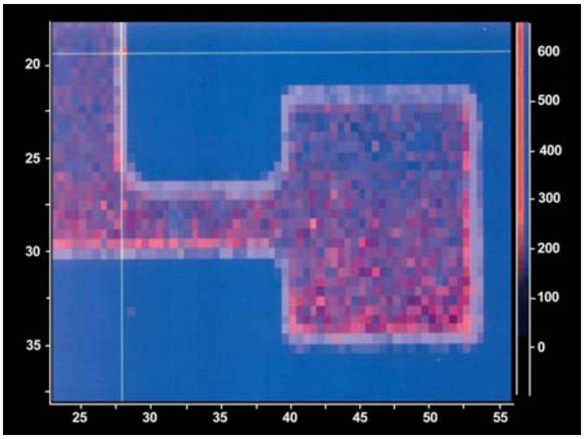
In this case, the Raman Map will show areas of the crystalline silicon substrate and amorphous silicon deposited on it.



Raman spectra of the crystal and amorphous phases are quite easy to distinguish. This figure shows spectra acquired from the substrate (the darker material in the video image, top spectral trace), from the amorphous feature (the bright 15 µm square and L-shaped connector, bottom spectral trace), and from the dark line between the two (middle trace). The spectrum of the amorphous layer shows a small residual signal from crystalline silicon at 521 cm^{-1} because the amorphous layer is semi-transparent to 633 nm excitation, the wavelength used in this study. The spectrum from the dark line has a higher crystalline-to-amorphous intensity implying a thinner amorphous layer. The dotted red and blue lines span the wavenumber regions that were bracketed to reconstruct the Raman map.

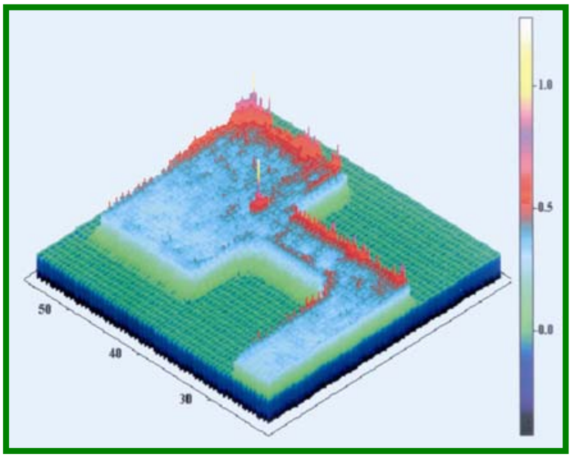


This figure is the Raman map where the same colour-coding was employed. The red area is the deposited amorphous material; the blue background is the crystalline substrate. At the edge of the amorphous region the pink/purple colour corresponds to the narrow edge where the contributions from the two phases are somewhat different than in the centre. The overlap of the red and blue creates the different colour.



In order to illustrate more clearly the variation in the relative intensities of the two bands, we have also mapped the intensity ratio. In this figure the map is shown as a three-dimensional intensity projection in order to be more sensitive to differences in relative intensities at the edge.

What is apparent is that the intensity ratio does peak at the edge - however this peaking is not equivalent on all edges. This phenomenon could be a result of the manner in which the feature was manufactured.



Conclusion

The simple measurement made here illustrates the facility with which one can map species on integrated circuits. Note that no optical resolution is lost in the map; it is determined only by the spacing between the points on the sample from which Raman signals are collected. The flexible capabilities of the mapping software provide information on the sample treatment that might not be apparent before data processing.

HORIBA JOBIN YVON

France : HORIBA Jobin Yvon S.A.S., 231 rue de Lille, 59650 Villeneuve d'Ascq. Tel : +33 (0)3 20 59 18 00, Fax : +33 (0)3 20 59 18 08. Email : raman@jobinyvon.fr www.jobinyvon.fr
USA : HORIBA Jobin Yvon Inc., 3880 Park Avenue, Edison, NJ 08820-3012. Tel : +1-732-494-8660, Fax : +1-732-549-2571. Email : raman@jobinyvon.com www.jobinyvon.com
Japan : HORIBA Ltd., JY Optical Sales Dept., 1-7-8 Higashi-kanda, Chiyoda-ku, Tokyo 101-0031. Tel: +81 (0)3 3861 8231, Fax: +81 (0)3 3861 8259. Email: raman@horiba.com
Germany: +49 (0) 6251 84 75-0 **Italy:** +39 02 57603050 **UK:** +44 (0)20 8204 8142
China: +86 (0) 10 6849 2216