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RAMAN ANALYSIS REPORT
20 Aug 2009

JOB NUMBER C09Z5796
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for

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RAMAN ANALYSIS REPORT

Requester:	Less Wright
Job Number:	C09Z5796
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Purpose:

To detect the presence of a diamond like carbon (DLC) coating on a zirconia gem.

Summary:

DLC was detected by Raman spectroscopy on the gem coating. The DLC was of high quality, having probably up to 85% *sp3* content, typical for a tetrahedral amorphous carbon.

Experimental:

The Raman measurements were performed with a “Dilor” J-Y spectrometer (“LabRam”) equipped with a “BX40 Olympus” microscope using the backscattering geometry (180^0). A HeNe laser (632.8 nm wavelength) and a 600 gr/mm grating were used in these measurements, which were repeated with an Ar^+ ion laser (514.5 nm wavelength) and an 1800 gr/mm grating.

Results and Discussion:

Spectrum 1 was acquired from the top face of the gem with a HeNe laser. In addition to the Raman bands from cubic zirconia at 604 and 296 cm^{-1}, a broad band was present at ~1552 cm^{-1}, with a shoulder band at ~1363 cm^{-1}. These bands are typical of the G and the D bands of *sp2* carbon found in DLC. The results were repeatable at other locations.

The results were also consistent when the measurements were performed with the Ar^+ ion laser, which also showed the presence of DLC (Spectrum 2). The unmarked peaks in Spectrum 2, which appear only with the Ar^+ ion laser, are most probably fluorescence peaks. The bands at 286 and 609 cm^{-1} present with both lasers are cubic zirconia bands. The broad feature at ~1588 cm^{-1} is due to the DLC.

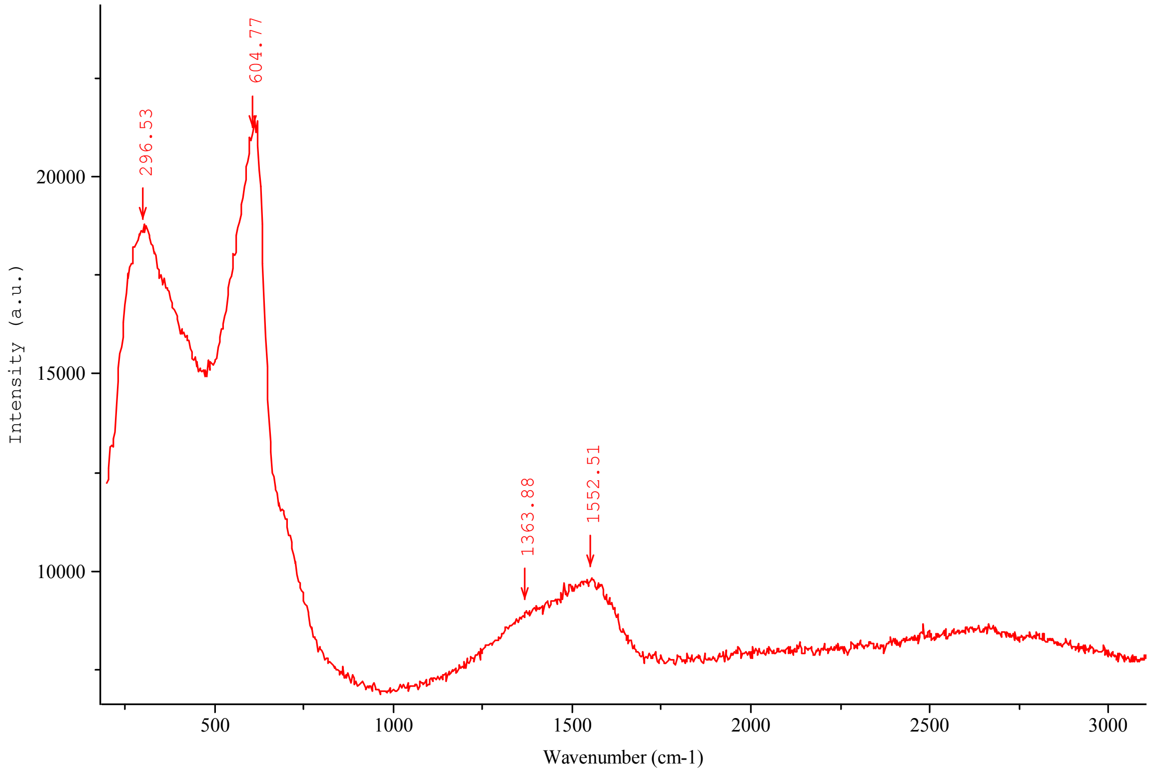
A reference spectrum of an industrial DLC acquired with an Ar^+ ion laser is shown in Spectrum 3. It shows the G band at 1565 cm^{-1} and a weak shoulder band at 1367 cm^{-1} (the D band). The weaker the intensity of the D band, the higher the quality of the DLC. For DLC with an *sp3* content as high as 85%, the D band has practically a zero intensity (height).

A spectrum from the gem coating, acquired with an Ar^+ ion laser, in the region of the DLC bands only (1300-2000 cm^{-1}) is shown as Spectrum 4 and its baseline corrected as Spectrum 5. Since Spectrum 5 can be band-fitted with only one band at ~1584 cm^{-1} (the G band), while intensity of the D band is negligible, it can be stated that the coating was good quality DLC with an *sp3* content as high as 85%, typical for the tetrahedral amorphous carbon films.

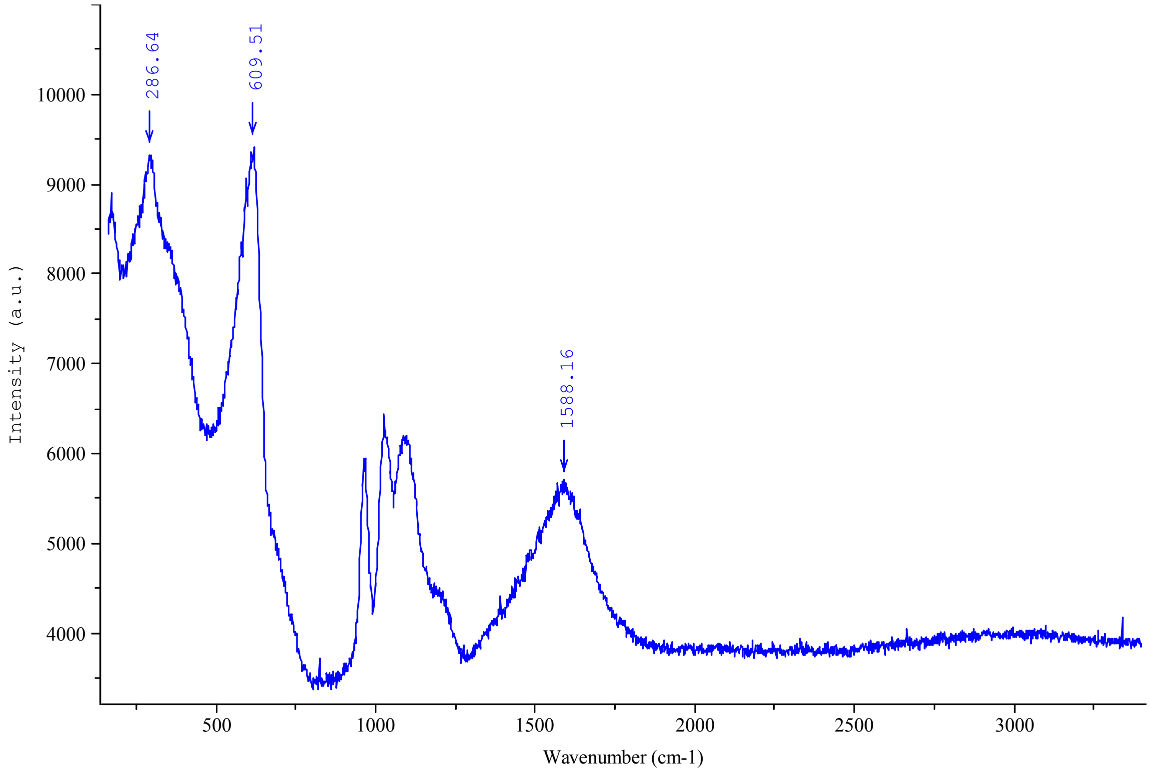
Raman spectroscopy is often used for the qualitative identification of functional groups or for the identification of entire organic compounds, typically with the aid of spectral databases. Assignment of spectral features to functional groups or the identification of a compound can be made with relative certainty, in some instances. However in many cases the presence of spectral features and functional groups cannot be traced unambiguously to one specific compound, especially in the analysis of mixtures.

Appendix 1

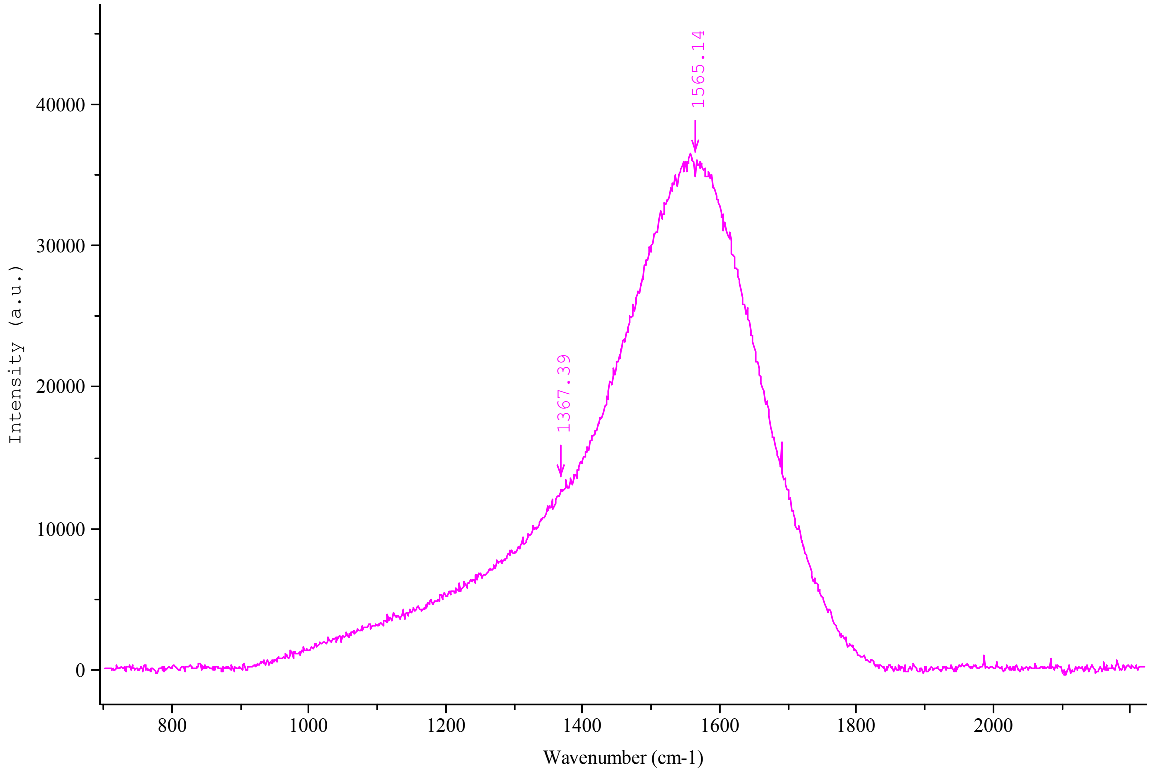
Raman spectroscopy is the collection of light inelastically scattered by a material or compound. When a light of known wavelength strikes a material, the light is shifted according to the chemical functionalities of the material. The intensity of this shifted light depends on both molecular structure and macrostructure. As a result of these phenomena, the collection of the shifted light gives a Raman spectrum that can provide direct information regarding the molecular vibrations of the compound or material. We can then interpret this information to determine chemical structure, organization, and in some cases, non-covalent intermolecular interactions.


604.77
296.53
1363.88
1552.51
20000
15000
10000
Intensity (a.u.)
500
1000
1500
2000
2500
3000
Wavenumber (cm-1)

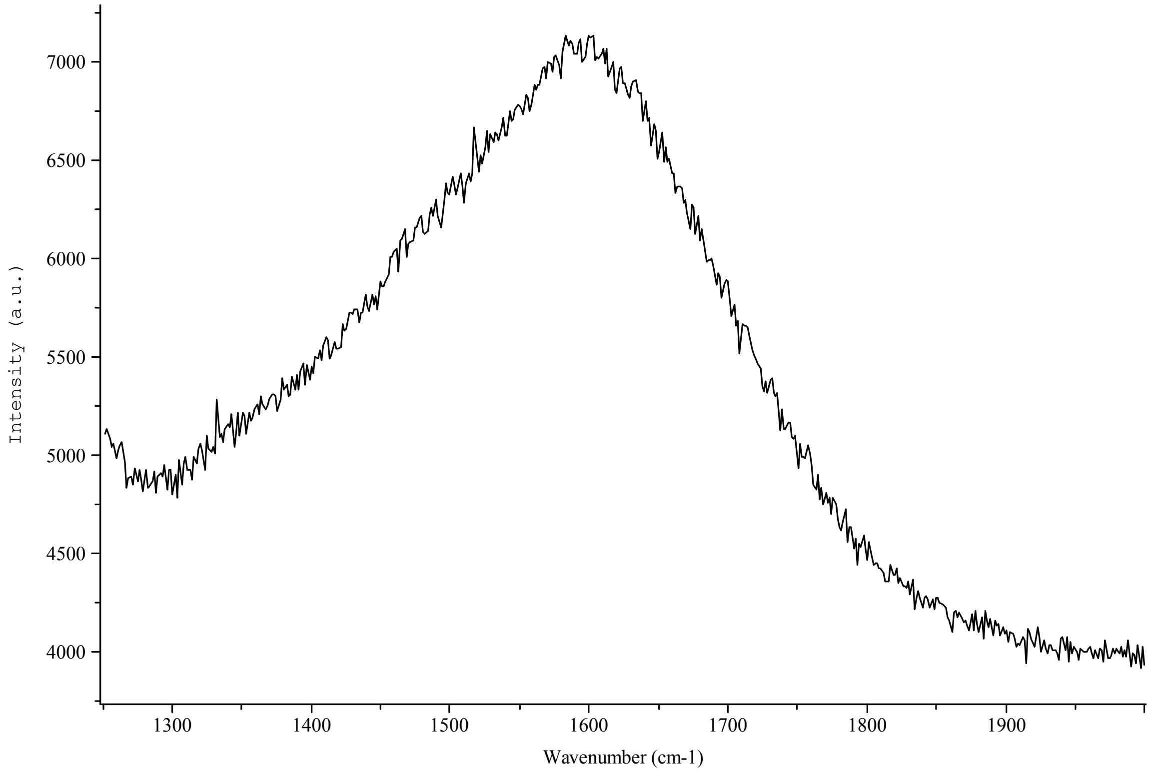
Spectrum 1


286.64
609.51
1588.16
10000
9000
8000
7000
6000
5000
4000
Intensity (a.u.)
500
1000
1500
2000
2500
3000
Wavenumber (cm-1)

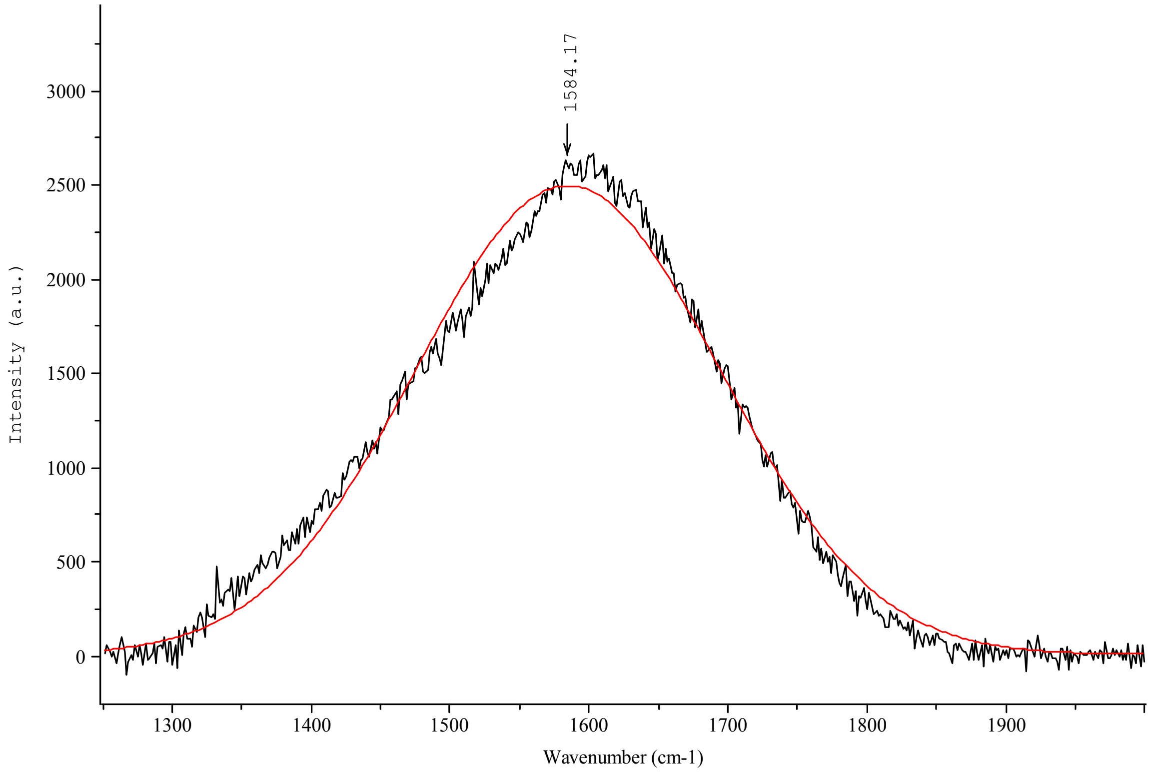
Spectrum 2


1565.14
1367.39
Intensity (a.u.)
40000
30000
20000
10000
0
800
1000
1200
1400
1600
1800
2000
Wavenumber (cm-1)

Spectrum 3


Intensity (a.u.)
7000
6500
6000
5500
5000
4500
4000
1300
1400
1500
1600
1700
1800
1900
Wavenumber (cm-1)

Spectrum 4


1584.17
Intensity (a.u.)
3000
2500
2000
1500
1000
500
0
1300
1400
1500
1600
1700
1800
1900
Wavenumber (cm-1)

Spectrum 5