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Quality Assurance of Diamond Films OSD-105

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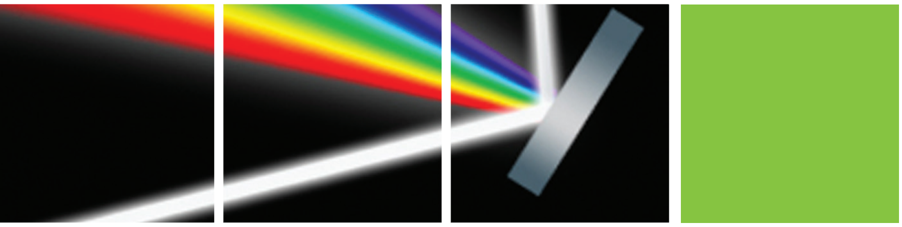


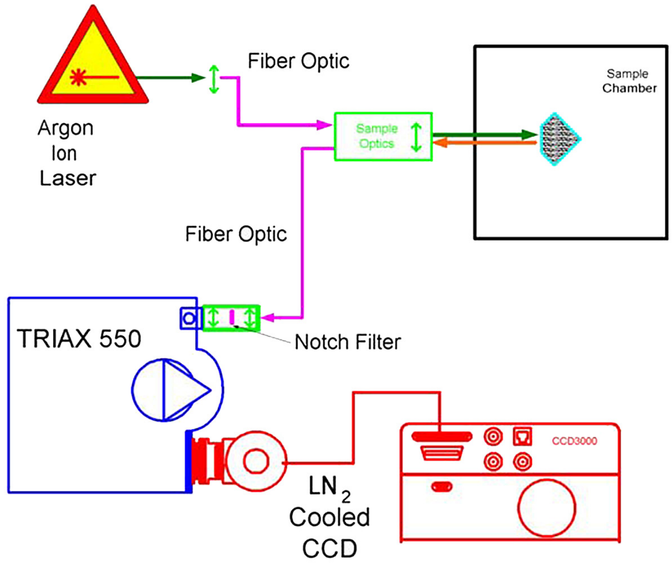
Raman spectroscopy for diamond characterization

Introduction

Because of their unique physical properties, diamond films find applications in protective coatings, cutting tools, and thermal and electronic devices. Most diamond films are grown by chemical vapor deposition, aiming for a high content of diamond and very little graphite. Raman spectroscopy can be used for diagnostic testing to determine the quality of the diamond films. Raman spectroscopy offers a quick, sensitive, non-destructive, and non-contact method to qualitatively test the resulting films.

Experimental setup

Because Raman spectra have low signal-levels compared to the inherent Rayleigh scatter, it is important to optimize the experimental setup. Several factors are responsible for the ultimate success of a Raman experiment: Excellent stray-light rejection, signal collection, and complete removal of the Rayleigh scatter. The HORIBA Scientific low-cost system (Figure 1) was based on a TRIAX550 spectrograph with a Spectrum-One liquid-nitrogen-cooled CCD camera. The excitation source was a 150 mW Ar^+ laser emitting at 514 nm. The laser beam was launched into a fiber and coupled via sampling optics to the diamond sample. The Raman signal was collected via the same sampling optics and transmitted through fiber optics to the spectrometer. The signal was coupled via fiber-optics into the spectrometer with an *f*/#-matching fiber adapter and Raman notch filter. The signal was acquired by the liquid-nitrogen-cooled Spectrum ONE CCD 1024 × 256 back-thinned VIS-AR detector. The system was completely controlled and all data managed using HORIBA Scientific's SpectraMax for Windows® software.



Features	Benefits
Fully-optimized high-throughput optical system	Maximizes collected Raman signal while minimizing stray light
Fiber-optics interconnects	Flexible configuration
Liquid-nitrogen-cooled CCD detector with ultra-low dark noise	Virtually unlimited acquisition length free of issues with dark noise

Figure 1. Experimental setup.

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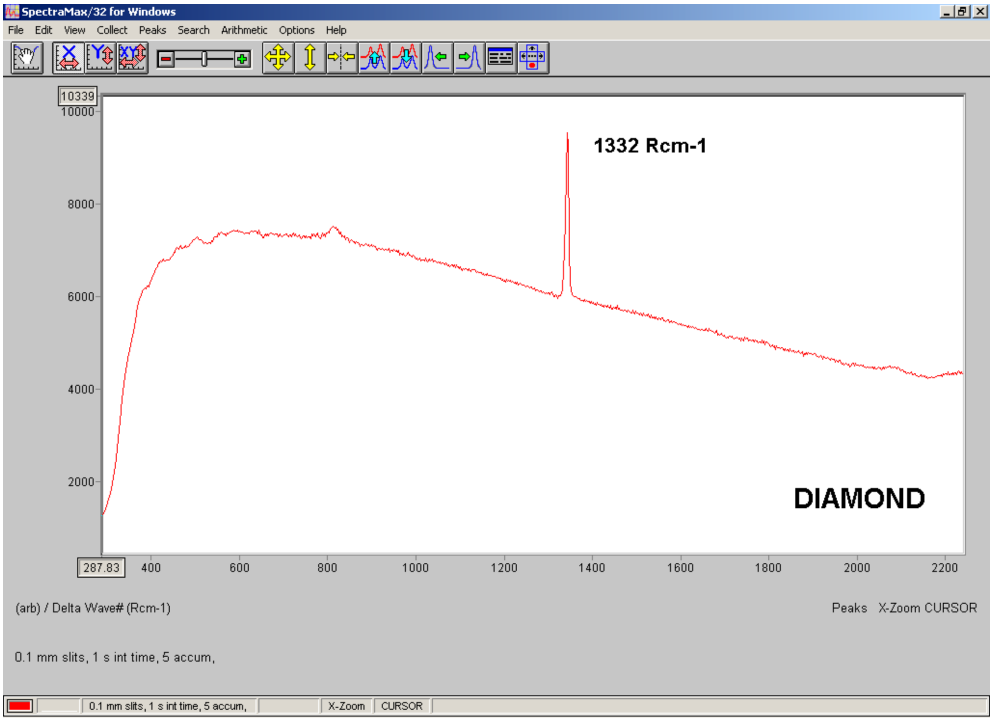
Results

Pure carbon can occur in several polymorphic forms, because the four valence orbitals of carbon can hybridize to *sp*^{2} and *sp*^{3} orbitals. Two well-known forms of elemental carbon are graphite and diamond. Graphite Raman lines occur at 1360 and 1580 Rcm^{-1}, and the ratio of their intensities determines the long-range order of the crystalline lattice. However, the main feature in a diamond Raman spectrum is a sharp peak at 1332 Rcm^{-1}, sometimes accompanied by fluorescence bands. Lately, engineered carbons such as fullerenes and carbon nanotubes also have become of interest to industry. An example of a typical Raman spectrum of diamond is shown in Figure 2. The data were collected using averaged accumulations and the result obtained in 5 seconds.



0.1 mm slits, 1 s int time, 5 accum,

Figure 2. Raman spectra of diamond.

A characteristic diamond line is found at 1332 Rcm^{-1}. Intensity of the line is proportional to the amount of diamond in the sample as compared to the other components in the spectrum. The sharpness of the band at 1332 Rcm^{-1}, along with the absence of side bands, demonstrate high diamond content without the presence of graphite and other impurities. The shape of the baseline at low frequencies is defined by the absorption of the notch filter. The notch filter and TRIAX550 spectrograph combination allows Raman analysis to 200 Rcm^{-1} of the excitation line.

Conclusions

The presence of the diamond band was observed with the low-cost Raman system. This and similar systems are suitable for characterization and quality assurance of diamond films.

For more demanding research measurements closer to the excitation line, the HORIBA Scientific Raman Division focuses on dedicated, fully-characterized Raman systems based on single-, double-, and triple-monochromator configurations. These systems allow analyses within 10 Rcm^{-1} from the Rayleigh excitation line with ultra-low stray-light rejection.

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