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Nanocarbon-based Material Platform for the Manufacturing of Multifunctional Materials

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Introduction

CVD Materials Corporation, a subsidiary of CVD Equipment Corporation launches internet business portal to facilitate the commercialization of Nanomaterials.

www.cvdmaterialscorporation.com

CVD Materials Corporation will engage with its customers on 3 levels :






The Nano-to-Macro missing bridge for nanomaterials :

Manufacturing ?

CVD Materials Corporation masters the production of graphene through the ***Chemical Vapor Deposition (CVD)*** of carbon precursors cracked onto catalysts substrates - mainly Cu and Ni alloys - at temperature ranging from 450 to 1000°C.

Scale-up ?

The ***versatility of the CVD method*** offers :

- high potential for scale-up
- an ***easy route to mass production*** of graphene products

But ***high throughput*** production necessarily implies :

- ***Rapid*** *Quality Control*
- ***Integrated*** *Techniques*
- ***Automated*** *Methods*

Standard characterization techniques available for Graphene :

Scanning Electron microscopy
+ performed on ***as-grown*** samples
- tedious protocol
- cannot clearly give the number of graphene layers

Optical microscopy
- requires ***transferred*** samples
- elementary observation

Fluorescence Quenching Microscopy
- requires ***transferred*** samples
+ scalable

Raman spectroscopy
+ allows to qualify doping, strain, disorder and chemical modifications levels
+ unambiguous, high-throughput, nondestructive identification of the number of graphene layers
+ information-rich experimental data on defects
+ can be performed on both as-grown and transferred samples

Problem raised for a rapid, integrated and automated quality analysis of CVD Graphene:

Quality analysis is usually performed **AFTER TRANSFER** of CVD graphene onto an optically Raman signal enhancing substrate (285nm SiO_2 layer is the standard)

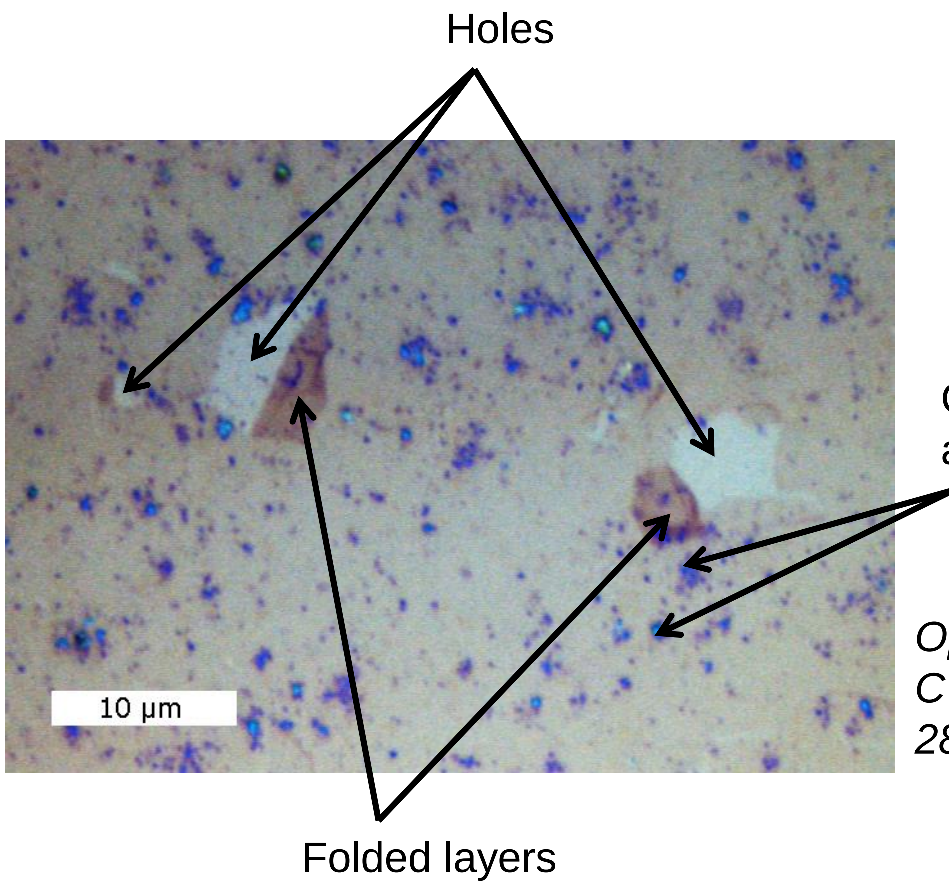
Analyzing the quality of CVD Graphene after transfer involves :

- Etching of the deposited graphene on one side of the Cu foil
- PMMA film deposition and curing
- Cu foil etching
- Plasma treatment
- Etc.

=> TIME CONSUMING

=> HIGHER CHANCES TO DAMAGE THE GRAPHENE

Problem of rapid transfer : higher chances to damage the graphene



Optical microscopy (x100) of CVD Graphene transferred on 285nm SiO_2 wafer

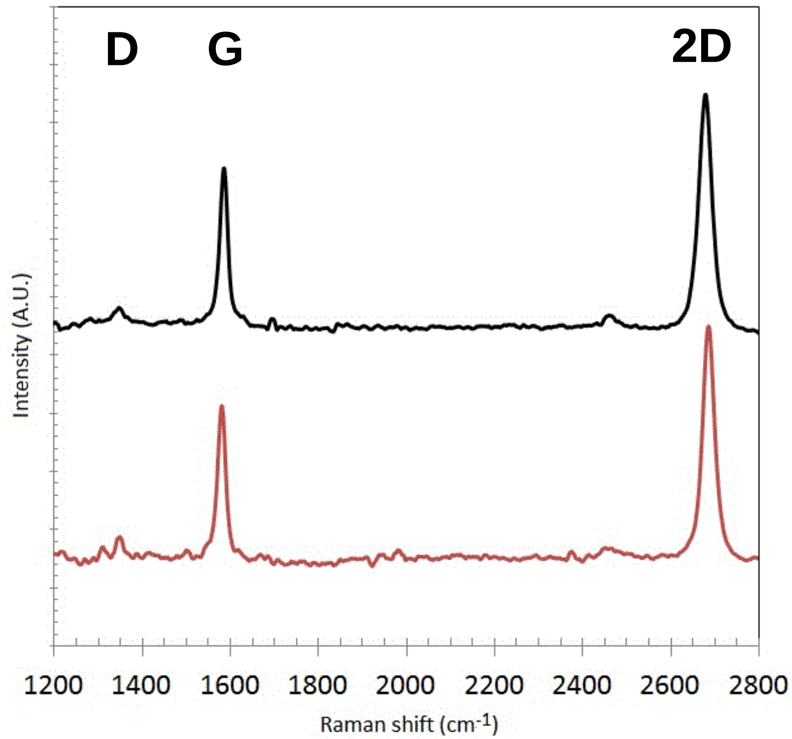
How to prevent any *misinterpretation* on the quality of graphene here, without making graphene transfer a time consuming task ?

Proof of concept :

as-grown CVD Graphene, base-line corrected

vs.

same CVD Graphene, transferred



baseline corrected signal obtained for as-grown graphene on Cu foil

raw signal obtained for the same CVD graphene transferred to 285nm SiO_2 / Si substrate.

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Solution for a rapid, integrated and automated quality analysis of CVD Graphene:

WHAT WE PROPOSE :

DIRECT analysis on as-grown CVD graphene on substrate

AUTOMATED standard Raman sampling

QUANTITATIVE analysis

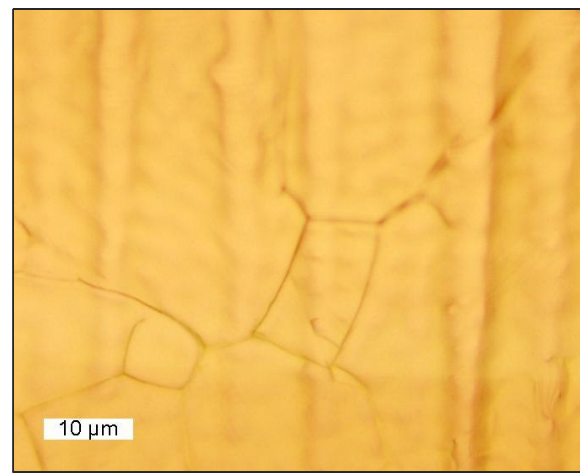
SCALABLE method

COMPLEMETARY to optical microscopy versatility

Experiment :

Here, Raman plots of the sixteen raw spectra.

2"x2" Cu foil (Alfa Aesar, 99.8% purity), 25 µm thick



Automated spectral analysis steps :

1. Establish the **exclusion windows** (input the start and end of the spectral window).

2. Curve fit with a polynomial curve the extracted spectra (6 to 12 order depending on shape of background).

3. Use the fitted parameter to establish a **calculated polynomial background curve** for the total spectral window

4. Subtract the calculated background from the total raw spectra to get the **background corrected spectra.**

5. Use a **Lorentzian or Gaussian fit** to fit the spectra inside each of the three selected peak windows to find the **center peak, peak width** of each of the three spectral peaks (D, G, 2D).

6. Use the fitted spectral peak curves to calculate the **area of each peak** on the background corrected spectra.

7. Normalize all the areas under each peak by one peak area (in the Graphene on Cu case we chose the G peak)

8. Calculate the **FWHM for each peak**.

9. Present the results in a **report** format showing raw data, corrected spectra, extraction windows, and **peak info (center, amplitude, FWHM, peak fitting quality, Area and normalized Area ratios)** for all three extraction windows.

Experiments (I) :

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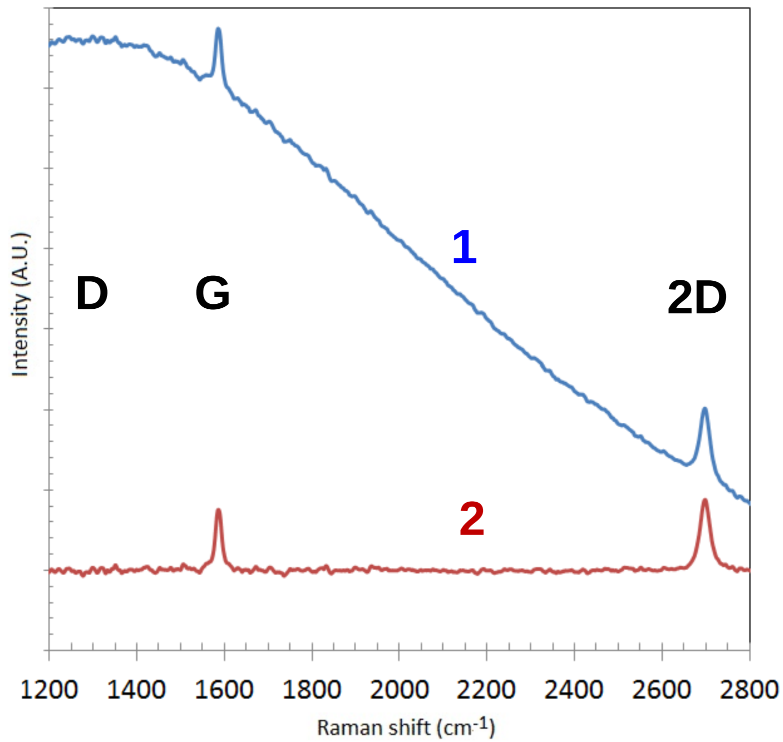
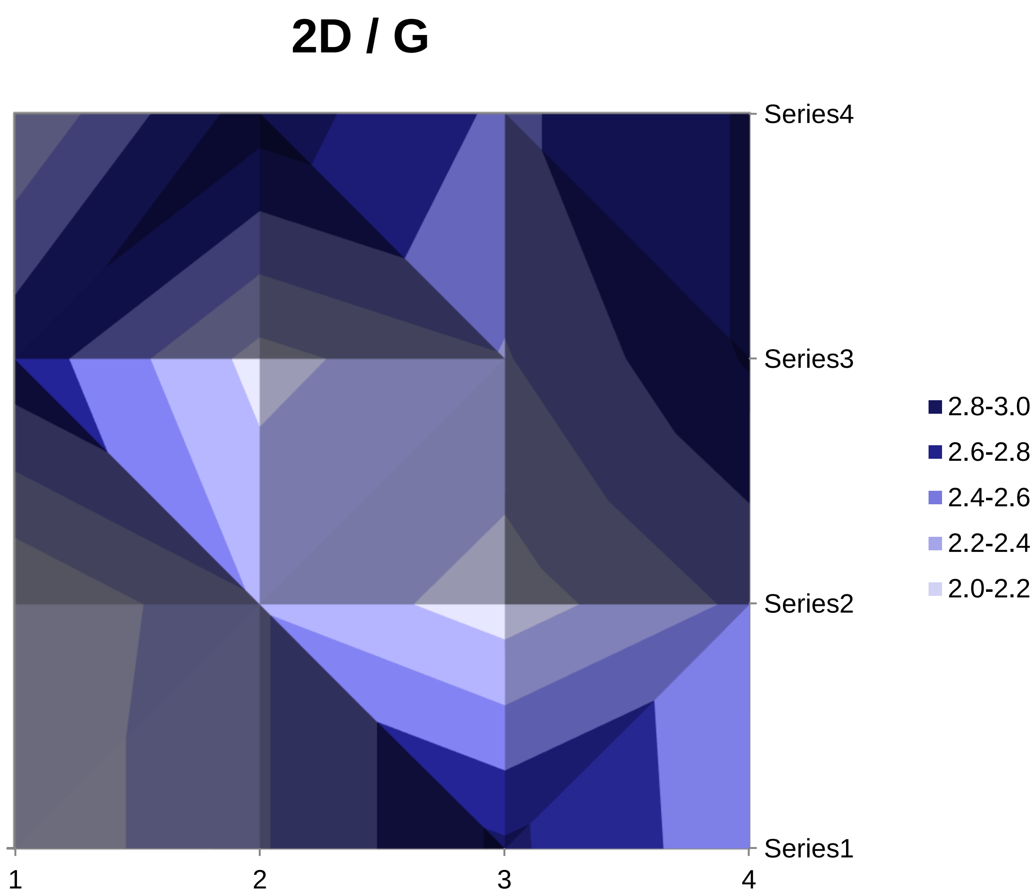
Base-line corrected raman signal of as-grown CVD graphene



raw signal on as-grown CVD Graphene with important background owing to Cu fluorescence

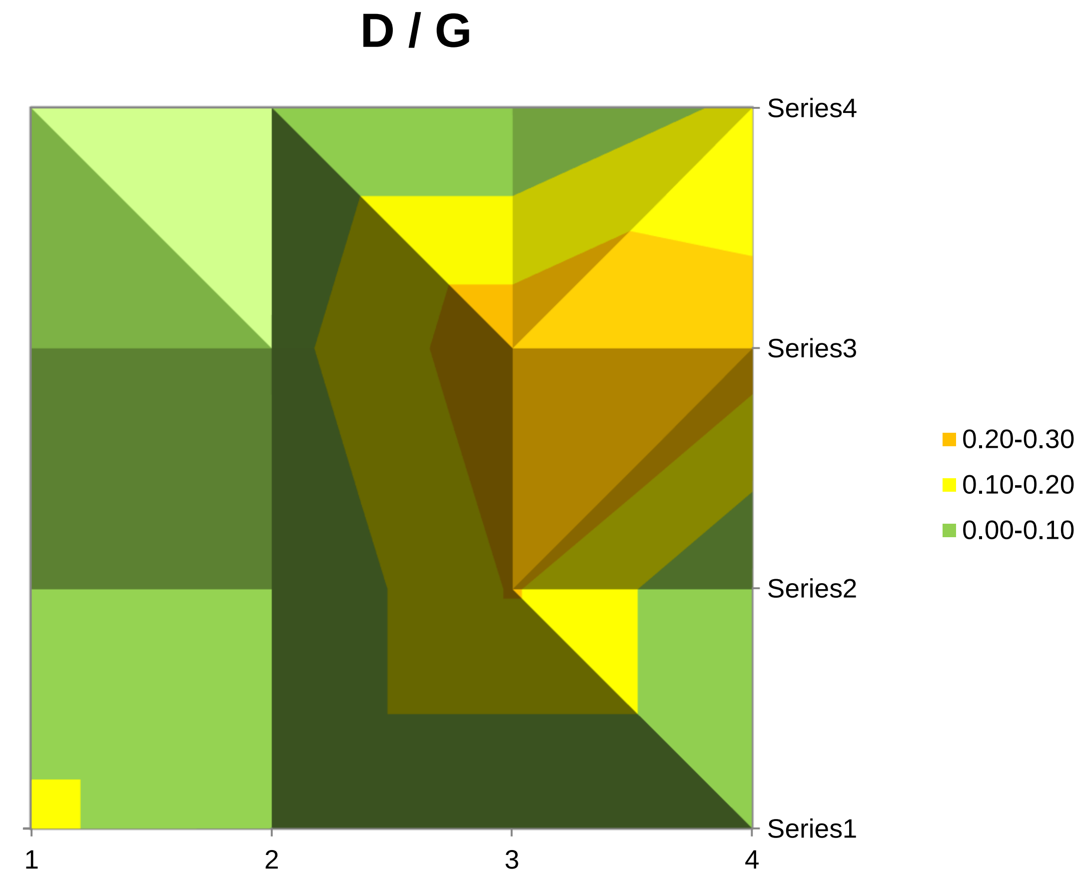
baseline corrected signal

Results (I) :



2D/G	1	2	3	4
1	2.1	2.4	2.8	2.5
2	2.0	2.4	2.1	2.4
3	2.7	2.1	2.4	2.8
4	2.2	2.9	2.6	2.8

Results (II) :



D/G	1	2	3	4
1	0.13	0.00	0.00	0.00
2	0.00	0.00	0.21	0.00
3	0.06	0.06	0.27	0.25
4	0.05	0.00	0.00	0.12

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