




[About Us](#) | [Our Publications](#) | [Contact Us](#)




OSI Optoelectronics
An OSI Systems Company
www.osioptoelectronics.com




STANDARD & CUSTOM PHOTODIODES




HYBRIDS



OPTICAL COMPONENTS & COATINGS



ASSEMBLIES



CERAMIC SUBSTRATES

Photonics.com
Spectra Home
Technology World
Innovative Products
Business World
Presstime Bulletin
Article Abstracts
Accent on Applications
Photonics Research
Subscribe

Microscopy Focus | November 2007

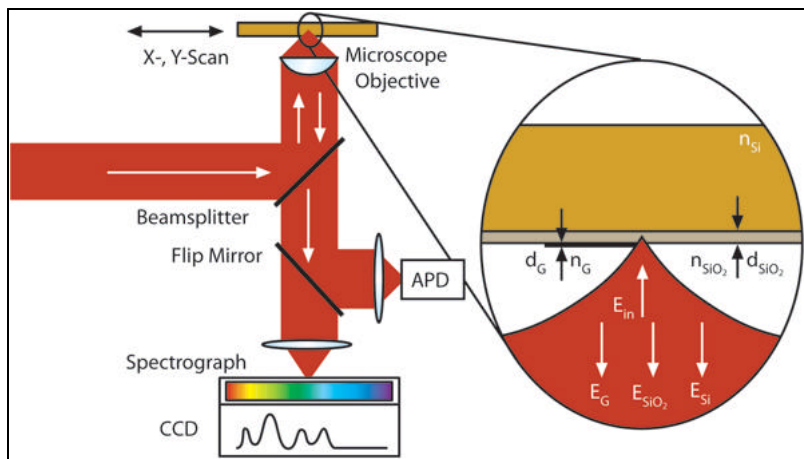
Rapidly Counting Graphene Layers, One by One

by Hank Hogan

Carbon someday could rival silicon in forming the basis for miniature electronics. Two-dimensional sheets of carbon called graphene are promising candidates because they are stable and they move electrons rapidly. Furthermore, graphene-based devices can be scaled down to nanometers.

-  [Email Article](#)
-  [Printer Friendly](#)
-  [Save Article](#)

Graphene typically is produced by cleaving graphite, which results in a few monolayer flakes among a welter of much thicker samples. From such piles, investigators would like to rapidly find the single-layer flakes, which are the best for research. However, this task has been difficult to accomplish. Now a team has discovered why standard Rayleigh imaging, which is based on simple light scattering, could do the trick.



In this setup, an incoming beam focuses on a sample of graphene. The back-scattered signal from the sample comprises Rayleigh scattering, which is detected by an avalanche photodiode (APD), and Raman scattering, which is detected by a spectrometer and a CCD. The inset shows the optical field interacting with graphene on silicon covered by silicon dioxide. Images reprinted with permission of the American Chemical Society.

"The main goal is a quick technique to identify and count graphene layers. This is badly needed in the field," said Andrea C. Ferrari, a lecturer at Cambridge University in the UK and a member of the research team. Others involved in the research were from Ludwig Maximilians University in Munich, from the University of Ioannina in Greece and from the University of Manchester, also in the UK.

The researchers combined Rayleigh imaging — used to count graphene layers — with Raman scattering — used to provide structural information. With the two techniques, they demonstrated quick and easy sample measurement and characterization.

In a homebuilt setup, they used an inverted microscope with either a HeNe laser at 633 nm or a collimated white-light beam as a light source. They generated coherent white-light pulses by pumping a photonic crystal fiber with the output of a Ti:sapphire laser operating at 760 nm.

Don't miss

BIOS 2008

Part of SPIE Photonics West

19–24 January 2008

BIOS Exhibition: 19–20 January 2008

San Jose, California USA

spie.org/pw

SWIFT GLASS

Company Inc.



Industrial and Technical
Precision Optical
Lighting and Appliance



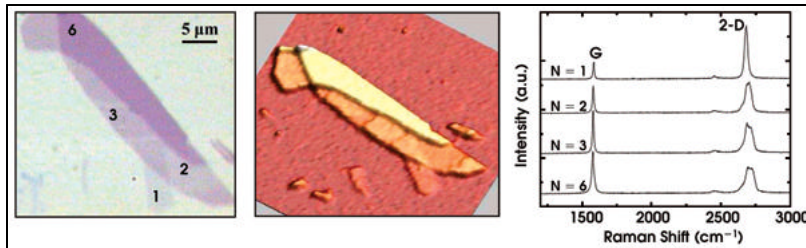
Micro Laser Systems, Inc.

Diode Lasers for Demanding Applications



www.microlaser.com

They focused the excitation light on a sample, which consisted of graphene flakes on a silicon wafer coated with SiO₂. They sent the backscattered light into an avalanche photodiode for Rayleigh measurements. Alternatively, they flipped a mirror and sent the light through a notch filter and into a spectrometer for Raman measurements, using a system from Renishaw plc of Wotton-under-Edge, UK.



In these images, one to six layers of graphene are visible. The left image is an optical micrograph, while in the center is a contrast-reversed 3-D confocal map of Rayleigh scattering from the sample. On the right are Raman spectra as a function of layer number.

The spatial resolution was 800 nm, with the Rayleigh images taking a few milliseconds of acquisition time per pixel. The Raman imaging, in contrast, required a few minutes.

The researchers compared the Rayleigh and Raman results with those obtained with an atomic force microscope from Veeco Instruments Inc. of Woodbury, N.Y. They found that the Raman spectra correlated with the number of layers, and they were able to distinguish between parts of a sample composed of one, two, three and six layers.

They also found the same to be true for Rayleigh imaging done with a 633-nm source. The contrast increased linearly with the thickness, an expected result.

The group knew before beginning research that thin layers of graphene are visible to the unaided eye when on an SiO₂-coated silicon wafer. For example, a single layer of graphene can be seen when it is on a 300-nm-thick layer of SiO₂. The challenge was to understand why this happened and to generalize it to any substrate.

In analyzing the situation, the researchers looked at the multiple reflections and at the presence of SiO₂, concluding that the graphene samples can be considered as the superimposition of single sheets, with the electrons in each layer acting independent of the others. The result is a change in contrast that tracks the number of sheets, up to six layers thick.

Consequently, Rayleigh scattering can determine graphene thickness quickly, and Raman imaging can be used for characterization. The group now plans to put the measurement tools to use. "The ultimate goal is to advance graphene research to become a viable industrial technology," Ferrari said.

Nano Letters, September 2007, pp. 2711-2717.

[Start a discussion on this article or any photonics topic in the Photonics.com Community Forum](#)

More Microscopy Focus

- [Rapidly Counting Graphene Layers, One by One](#)
- [Team Develops Electron Microscope with 0.5-Å Resolution](#)
- [Spotting Very Thin Graphite Layers](#)
- [Microscopy Used to Profile Refractive Index](#)
- [Scanning Light Microscopy Uses Nonlinear Properties of KNbO₃ Nanowires](#)

AUTOCOLLIMATORS



photonics.com COMMUNITY FORUM

Ask questions. Get Answers. Join the photonics community.

Most Active Topics

- [Wanted Someone to modify my DLP for payment photons](#)
- [Projector Builder WANTED for prototype construction.](#)
- [help with calcium flouride](#)
- [polishing si on pitch](#)



Photonics Spectra | November 2007

- [\\$100 Bill to Be Safeguarded with Photonics Technology](#)
- [Flexible and Freestanding Photonic Crystals](#)
- [Counting Atoms — and Defects — in Semiconductors](#)
- [Getting an Edgy View of the Rings of Uranus](#)
- [Moving Droplets of Liquid with Light](#)

photonics HANDBOOK


Now Available Online for Registered Users
Sign up today. Registration is FREE!

The Photonics Handbook is a unique collection of technical design and applications articles, as well as technology primers presenting the basics of the photonics technology.

- [Nd:YAG Lasers](#)
Standing the Test of Time
- [Materials for Optical Coating Deposition](#)
A Wide Selection Is Available
- [Vibration Control](#)
Dealing with Workplace Problems
- [Complete Table of Contents](#)

Most Emailed Articles

- [Light Bent the 'Wrong' Way](#)
- [Beam of Light Picks Up Cells](#)
- [Low-Temperature Flexible Sensors Use Ink-Jet Patterning](#)
- [Boeing Tests Humvee Laser](#)
- [Device Counts Single Photons](#)



THE PHOTONICS DIRECTORY

[Directory Home](#) | [Buyers' Guide](#) | [Corporate Guide](#)

Enter search term By Company

Search the online version of the most comprehensive directory in the industry.

[Subscribe to the Print Directory](#) | [Update Your Listing](#)

[Home](#) | [About Us](#) | [Advertising Info](#) | [News & Features](#) | [Photonics Spectra](#) | [Photonics Directory](#) | [Photonics Dictionary](#) | [Subscriptions](#) | [Contact Us](#) | [Top of Page](#)

Laurin Publishing provides comprehensive worldwide coverage of the photonics industry: optics, lasers, imaging, fiber optics, electro-optics, and photonic component manufacturing.

© 1996-2007 Laurin Publishing. All rights reserved.

Photonics.Com is Registered with the U.S. Patent & Trademark Office.

[Privacy Policy](#) | [Terms and Conditions of Use](#)
Reproduction in whole or in part without permission is prohibited.
webmaster@laurin.com