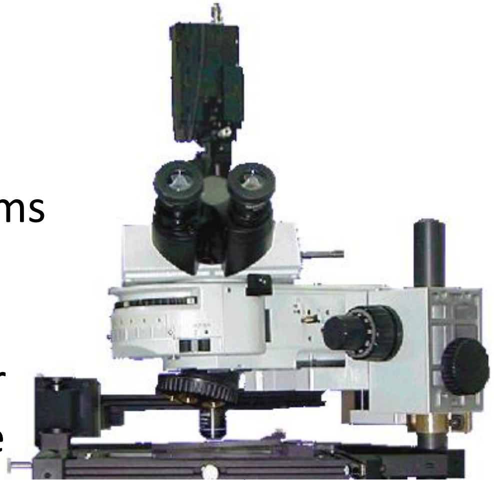
NANONICS IMAGING

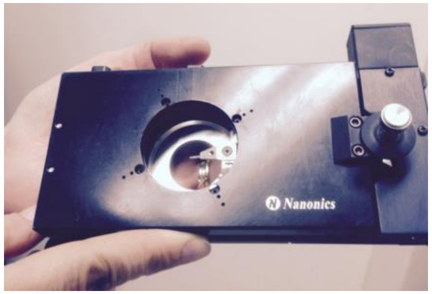
Background Free NanoPhotoconductivity Correlated With Topography of Photovoltaics & 2D Material Devices

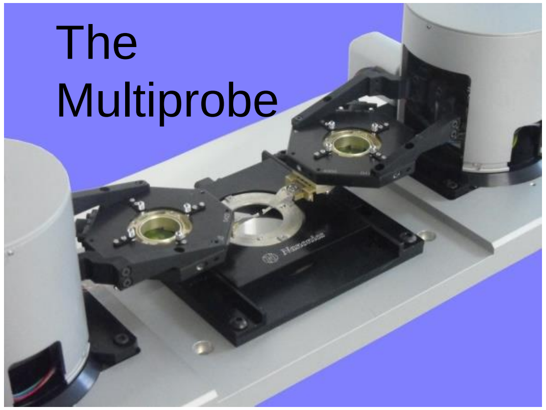
http://www.nanonics.co.il/applicationscontent/photovoltaics-photoconductivity

The System
A Variety of Different Possibilities From Simple to Sophisticated

Single Probe Systems With Nanonics Microscope Solutions or Your Own Microscope

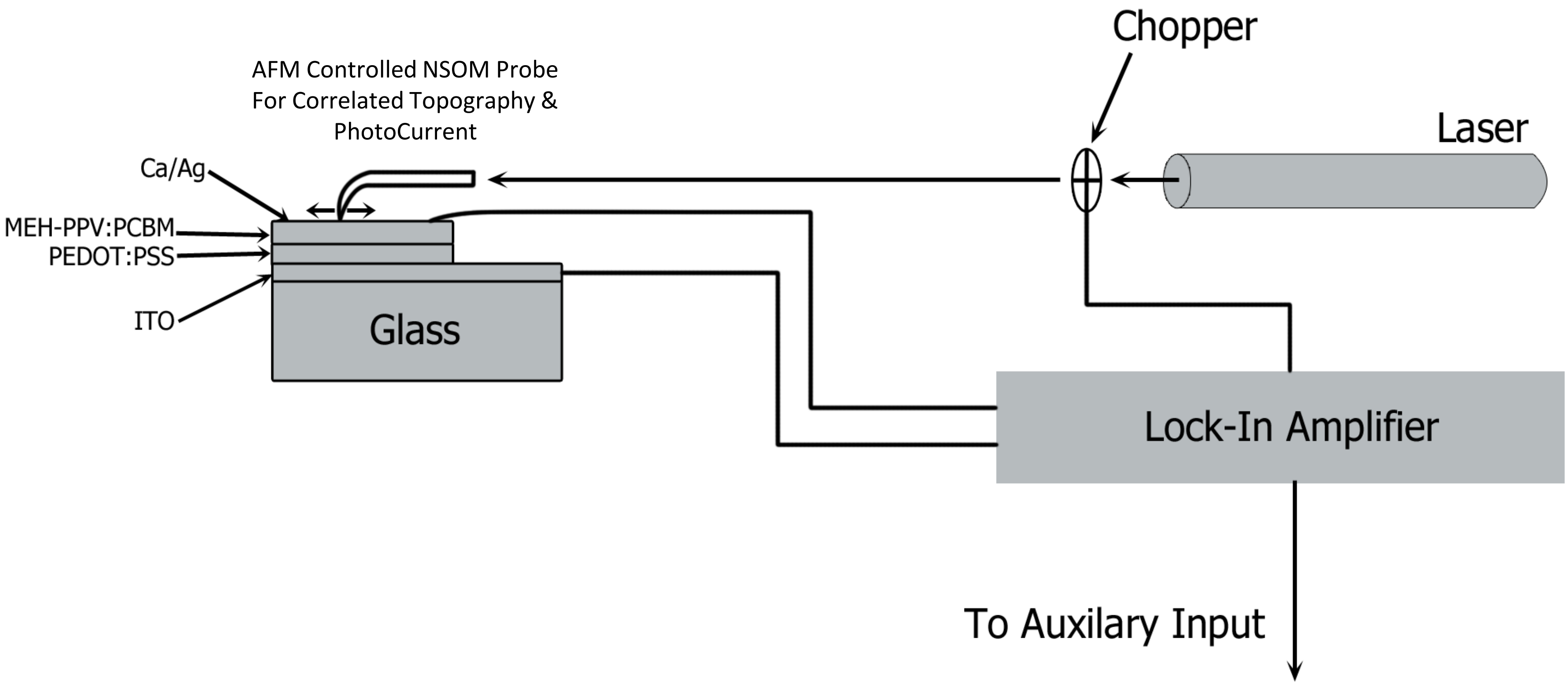






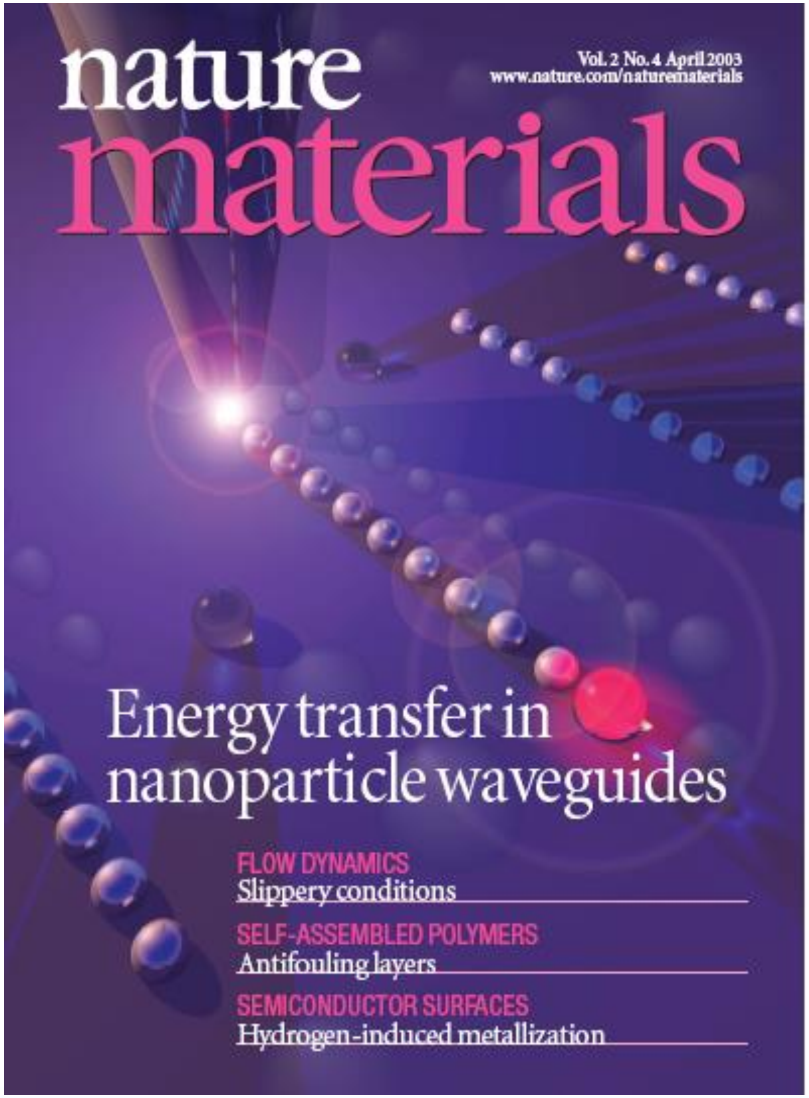
Multiprobe Systems

An Exemplary Photoconductivity Measurement Layout As Provided by Nanonics



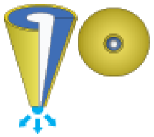
NANONICS
IMAGING

Over Two Decades Nanonics Has Provided Point NanoIllumination Sources With No Background For Optical NanoCharacterization Corelated With Topography

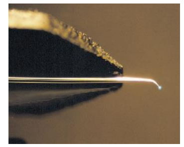


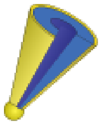
Over 1800 Citations

A NanoToolKit™ of Exclusive Functional Probes

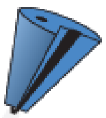


NanoOptical Light Source

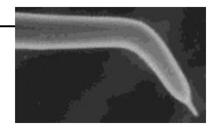


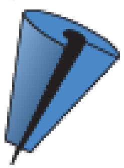


Plasmonic NanoProbes with Single Gold NanoParticles But Other Nanoparticles Also Possible Such As Co Possible

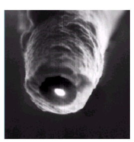


NanoProbes for Thermal Conductivity & Thermocouples

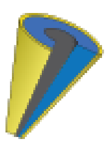




Glass Insulated Coaxial NanoElectrical

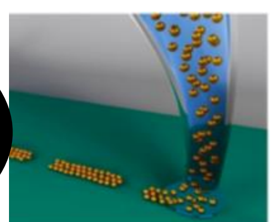


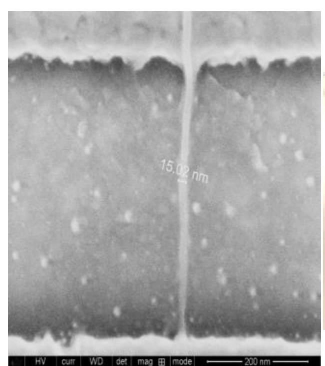
Cantilevered AFM/SECM NanoElectrochemical Probes

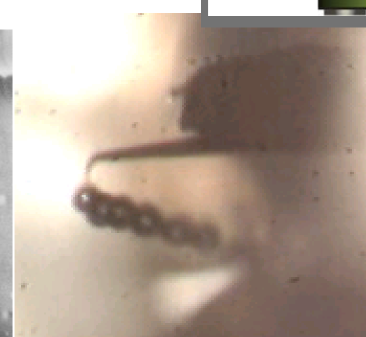


Nanopipettes for: Ionic Conductance, NanoFountain Pens for Liquid & Gas Delivery & Deposition, NanoEvacuation

Nanolithography





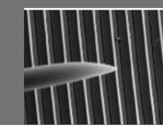


All probes patented & nano-fabricated By Nanonics

Optically Friendly

Unobstructed Optical Axis

- Non-Obscuring Non-Interfering Cantilevers
- Probe Tips Exposed To The Optical Axis
- All Probes Allow On-line Raman



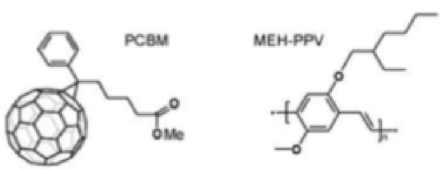
Nanonics Probes are MultiProbe Friendly

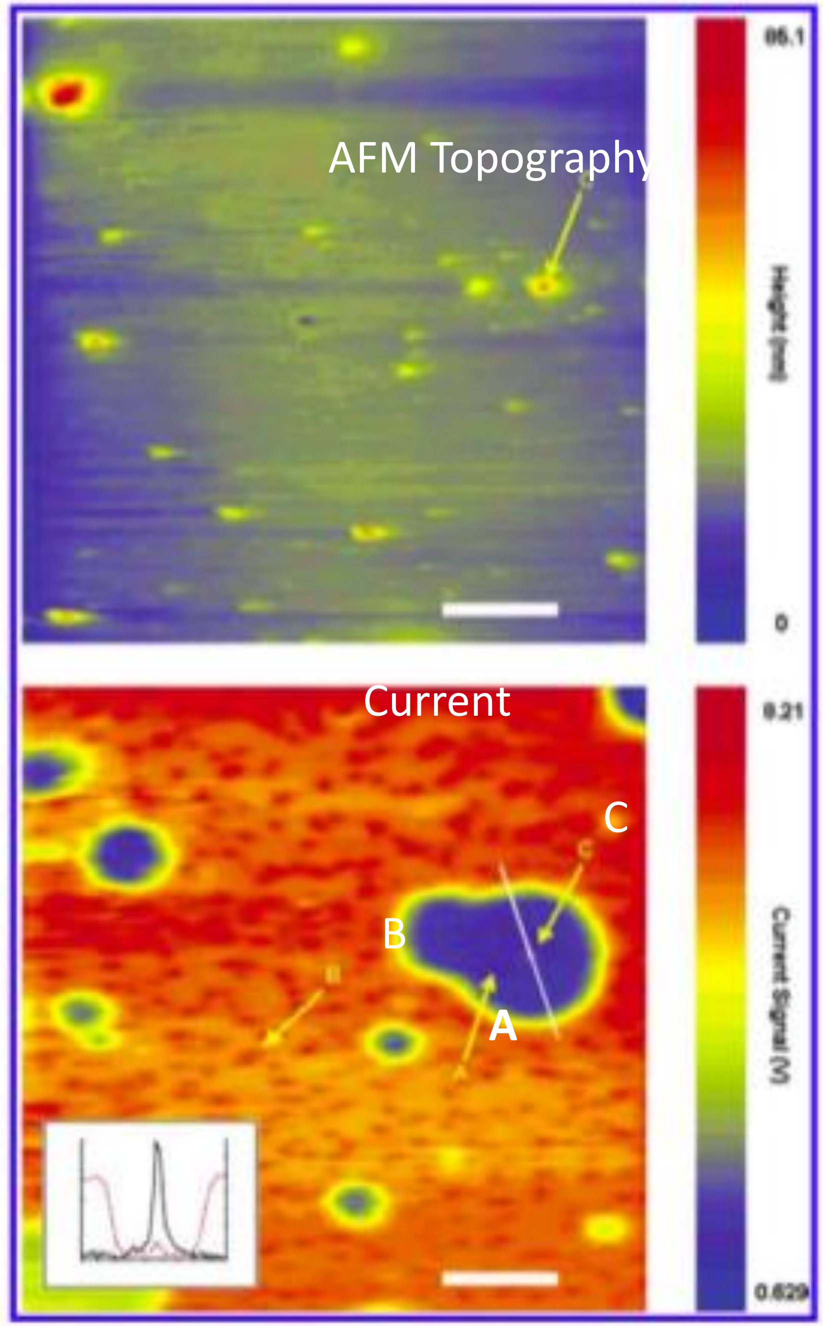
Silicon Probes
For Comparison

Exclusively Available For Nanonics Customers Only

NANONICS IMAGING

Correlated AFM Topography & Current Images of an ITO/ PEDOT PSS/MEH-PPV-PBCM/Ca/Ag Solar Cell Device





The feature marked C corresponds to a small bright feature in the center of the large dark region (A) of the current image is also observed in the AFM image

The inset in the bottom image shows the height (black, solid) and current (red, dotted) traces taken along the white line. The scale bar is 5 μm in length.

NANO LETTERS 2004 Vol. 4, No. 2 219-223

Near-field scanning photocurrent microscopy (NSPM) measurements

Photovoltaic devices based on p-xylene processed poly(9,9′-dioctylfluorene-co-bis-N,N′-(4,butylphenyl)-bis-N,N′-phenyl-1,4-phenylene-diamine) [PFB] and poly(9,9′-dioctylfluorene-co-benzo-thiadiazole) [F8BT] blend films

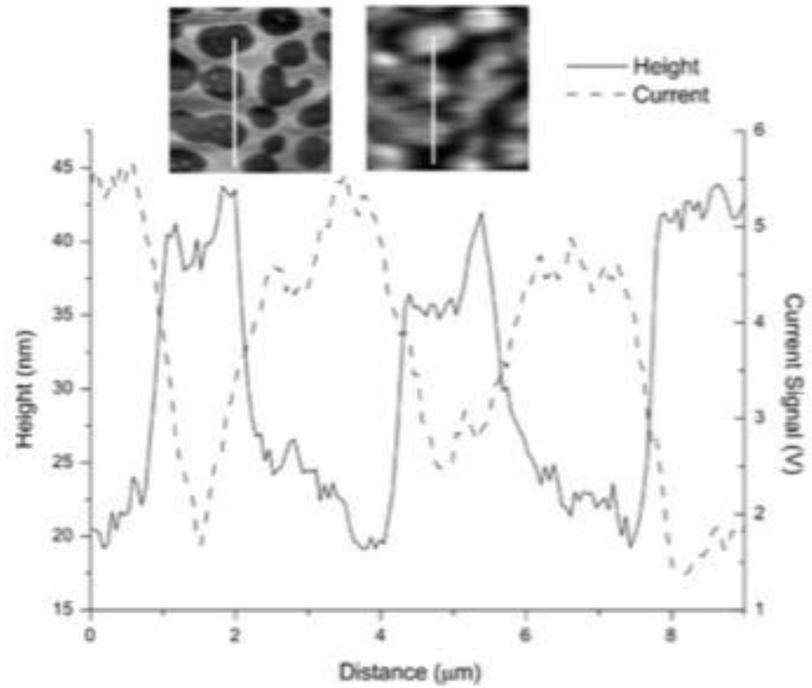
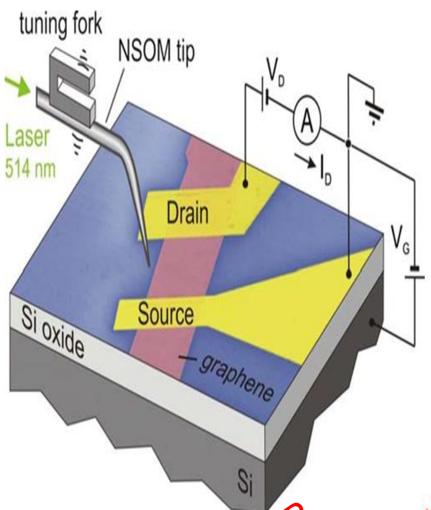


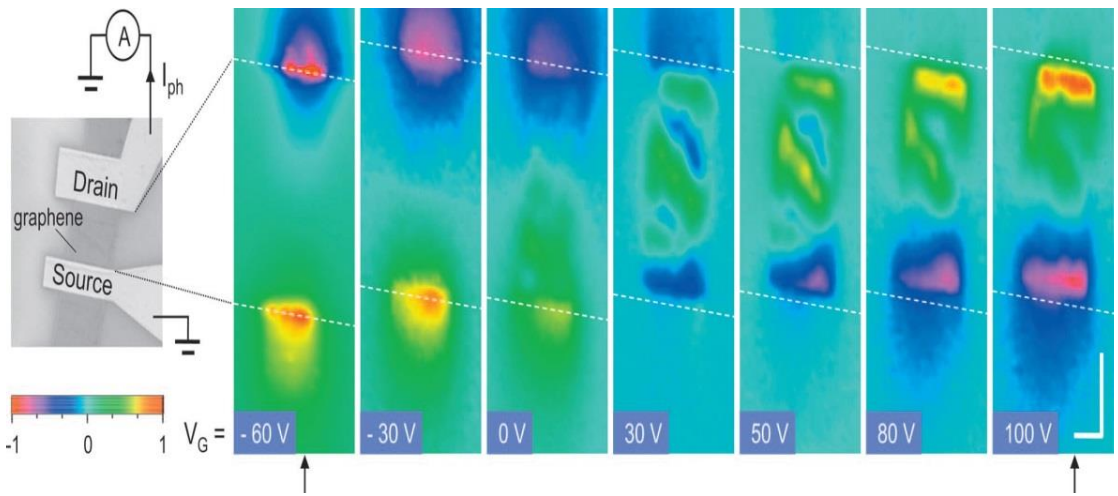
Figure 4. Cross-sectional traces of the AFM image and current map of Figure 3.

NANO LETTERS 2004 Vol. 4, No. 12 2503-2507

Current generation occurs primarily from within the micron-sized phase-segregated domains, with the PFB-rich phase contributing significantly more current than the surrounding F8BT-rich regions.

IBM Produced Photocurrent Images of A Graphene Transistor As A Function Of Voltage With Without Background Using Nanometric Confinement of Illumination in X Y and Z With NSOM





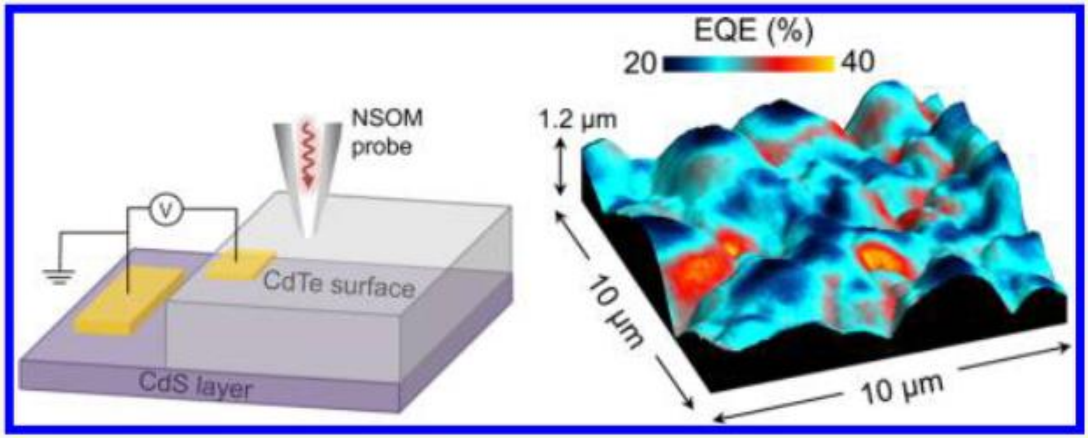
UNDERSTANDING FOR THE FIRST TIME THE ROLE OF CONTACTS IN GRAPHENE TRANSISTORS CITED 313 TIMES SINCE 2009

PHYSICAL REVIEW B 79, 245430 (2009)

Super-resolution Near-Field Photocurrent Measurements

The Full System Includes:

>NanoPhotoconductivity System Correlated With One or Two Probes With Full Controller and Imaging Processing Software
>Laser As Chosen For The Specific Application with Fiber Coupler
>Appropriate Femtoamp Current Amplifier
>Stand or Interface To Any Upright or Inverted Microscope



Paper: Leite, M. S. *et al.* Nanoscale Imaging of Photocurrent and Efficiency in CdTe Solar Cells. *ACS Nano* **8,** 11883–11890 (2014).

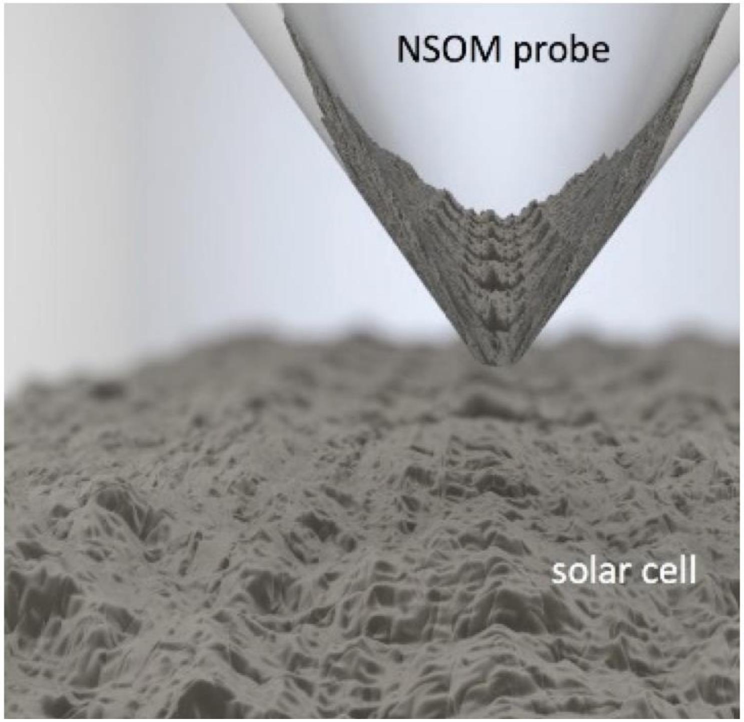
NanoIllumination

Near-field Illumination Without Background

- Near-field Illumination

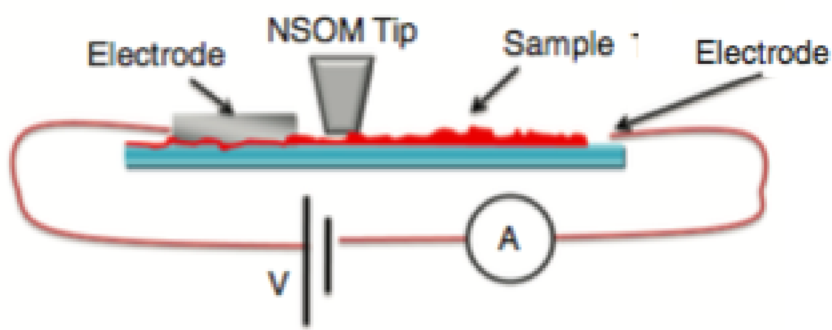
With

- Photocurrent Detection



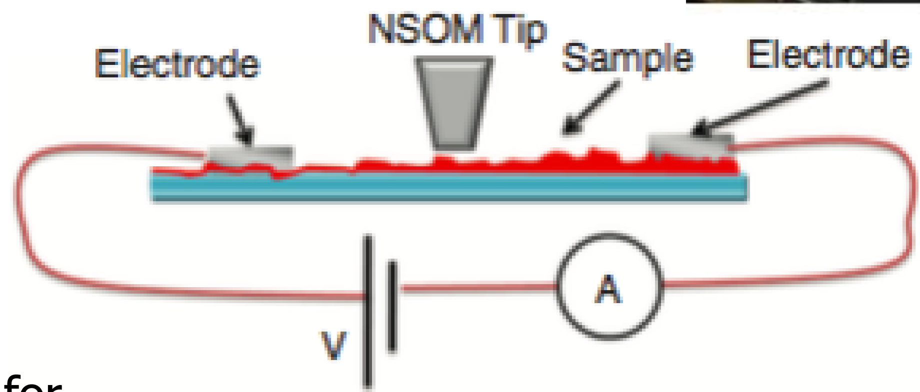
Solar Cells

Single Probe And Multiprobe Configurations For Photoconductivity

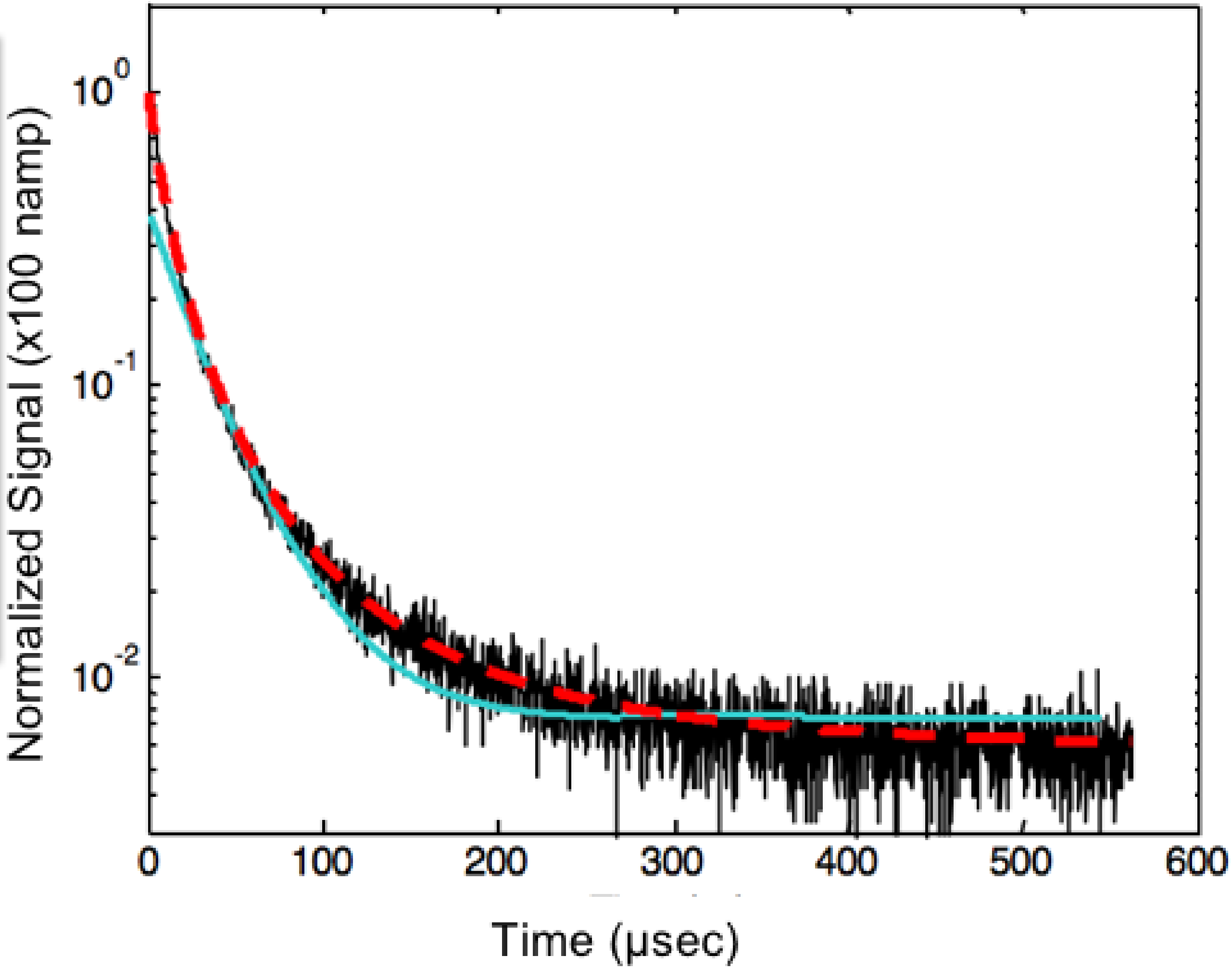


All Single Probe Systems Allow for Such Electrical Connections

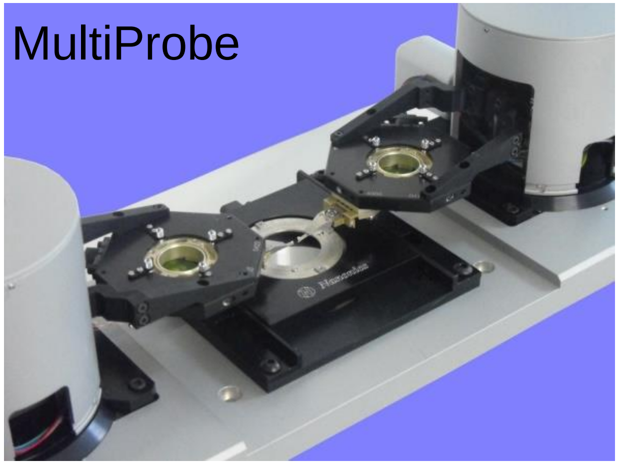
Multiprobe Systems Allow for Electrical Connections at will

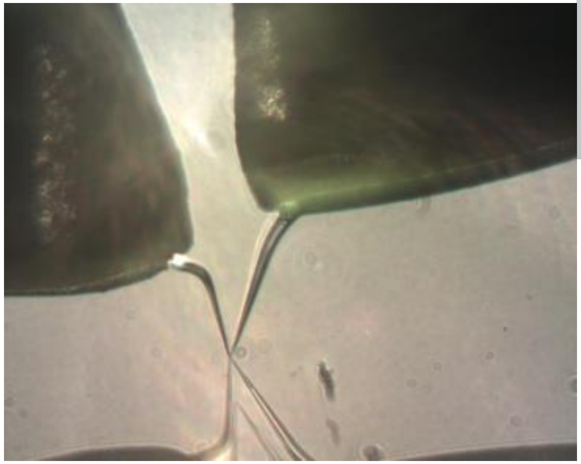


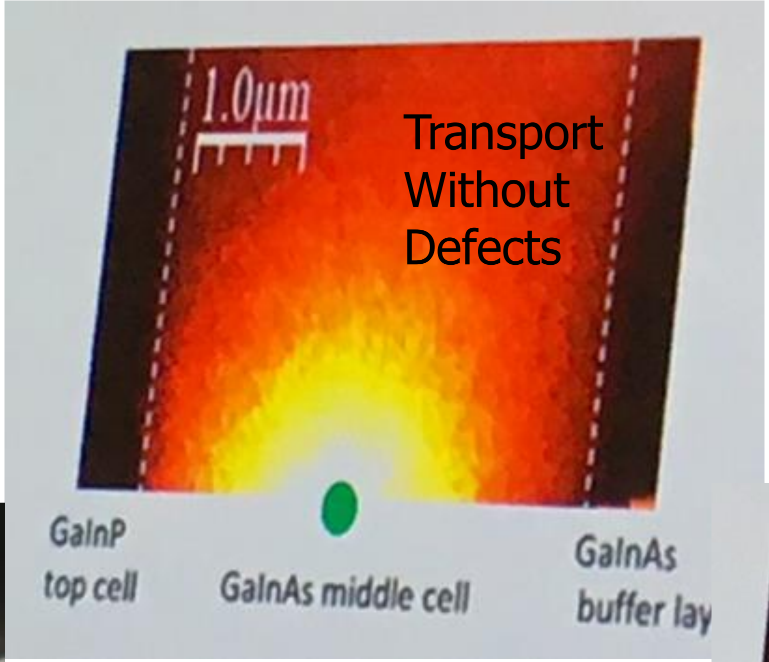
Allowing Time Resolved PhotoCurrent Measurement

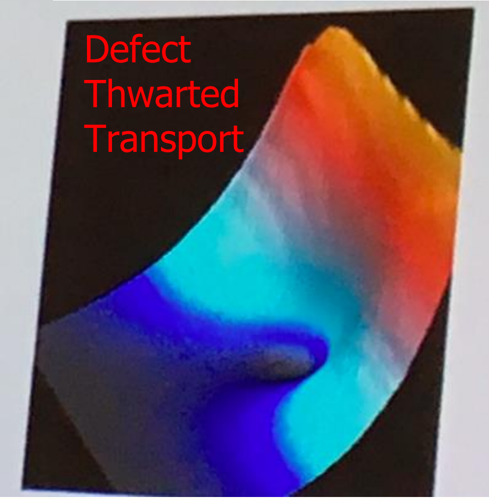


Multiprobe Experiments With Two Nanometrically Confined Excitation Sources Also Allow Charge Transport In Solar Cells





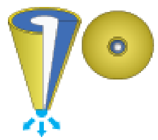




What Investigators From IBM Say In Their Published Work

- NSOM overcomes the far-field resolution limit by bringing a light source of subwavelength size into close proximity to the sample surface
- The resolution of the image is limited by the size of the probe aperture and not by the wavelength of the light
- By analyzing the spatial variation in the PC in the vicinity of the metal contacts, we show that charge-transfer doping occurs underneath the contact metals and adjacent regions in the graphene channel, giving rise to asymmetric conduction characteristics for electrons and holes
- In a complementary experiment, we also demonstrate charge transfer and photocurrent generation at single-layer graphene SLG and multilayer graphene MLG interfaces
- A topographic image is acquired simultaneously with the PC image, allowing correlation of structural and PC properties at the same positions on the graphene transistor

A NanoToolKit^{TM} of Exclusive Functional Probes



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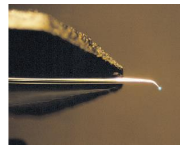

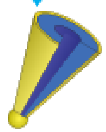

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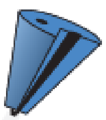

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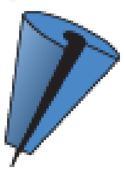

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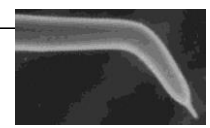

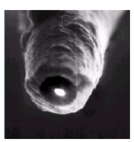

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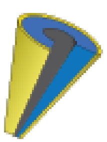

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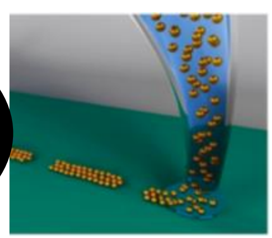

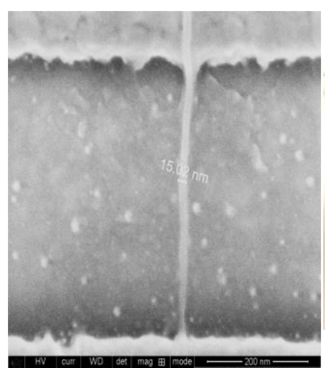

All probes patented & nano-fabricated By Nanonics

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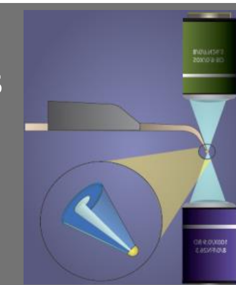
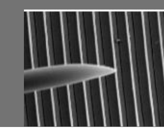
- **Probe Tips Exposed To The Optical Axis**



•All Probes Allow On-line Raman



Nanonics Probes are MultiProbe Friendly

Silicon Probes For Comparison

Exclusively Available For Nanonics Customers Only

NANONICS IMAGING

Therefore Nanonics Is Proven In The Literature To Image With Excellent XY Morphological Fidelity Even Compared To FESEM

Contents lists available at ScienceDirect

Materials Letters

journal homepage: www.elsevier.com/locate/matlet

ELSEVIER

materials letters

Atomic force microscopy (AFM) and 3D confocal microscopy as alternative techniques for the morphological characterization of anodic TiO_2 nanoporous layers

Diego P. Oyarzún [a,*], Omar E. Linarez Pérez [b], Manuel López Teijelo [b], César Zúñiga [a], Eduardo Jeraldo [a], Daniela A. Geraldo [a,c], Ramiro Arratia-Perez [a,c]

[a] Centro de Nanociencias Aplicadas (CENAP), Facultad de Ciencias Exactas, Universidad Andrés Bello, Chile, Avenida República 275, Santiag
[b] Instituto de Investigaciones en Fisicoquímica de Córdoba (INFIQC), Facultad de Ciencias Químicas, Universidad Nacional de Córdoba, Hay
Medina Allende, 5000 Córdoba, Argentina
[c] Núcleo Milenio de Ingeniería Molecular para Catálisis y Biosensores, ICM, Chile

CrossMark

The Tuning Fork Uniquely Provides A High Quality Factor, Q, For Ultra Sensitivity In AFM And In AFM Morphology. This Is Not Available With Any Beam Bounce Feedback AFM (see green highlighted customer description). Also True Non-contact Is Achieved With The Nanonics Tuning Fork Systems. Thus, Nanonics Provides The Only AFM Systems That Allow For Switching Between AFM And STM Feedback With The Same Probe. Proving Non-contact AFM Operation

4. Conclusions

The characterization of the surface morphology by FESEM and TEM was compared with the results obtained by both AFM and 3D confocal microscopy. Characterization of porous oxide layers by AFM shows that the microscope with tuning fork configuration (intermittent mode) presents advantages over the beam bounce configuration (contact mode) namely high sensitivity in amplitude and phase, as well as high mechanical quality factor. This, in turn, allows the acquisition of real images of high resolution of the organized nanostructures. Additionally, the average radius values obtained from the AFM experiments are very similar to those obtained from FESEM images, which reflects that the morphological information obtained by atomic force microscopy for TiO_2 nanotubes is reliable and representative of the properties of the system. In brief, the intermittent AFM mode using tuning fork configuration is a powerful tool for characterizing highly ordered porous nanostructures as it provides conclusive information about the morphology of this one-dimensional nanostructures. On the

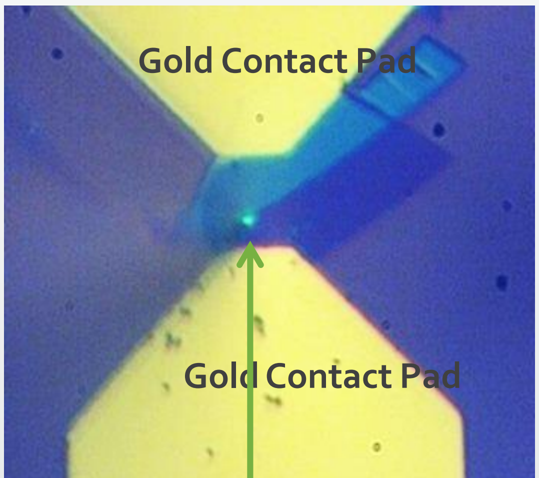
Readily Integrated With Available Or Future Acquisition of Raman MicroSpectroscopy Systems

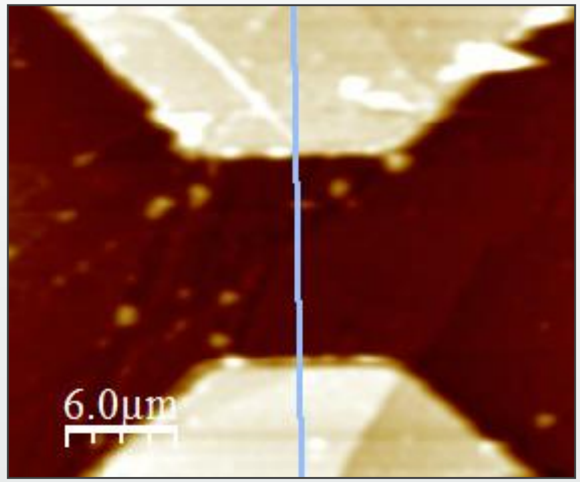
The MV1500

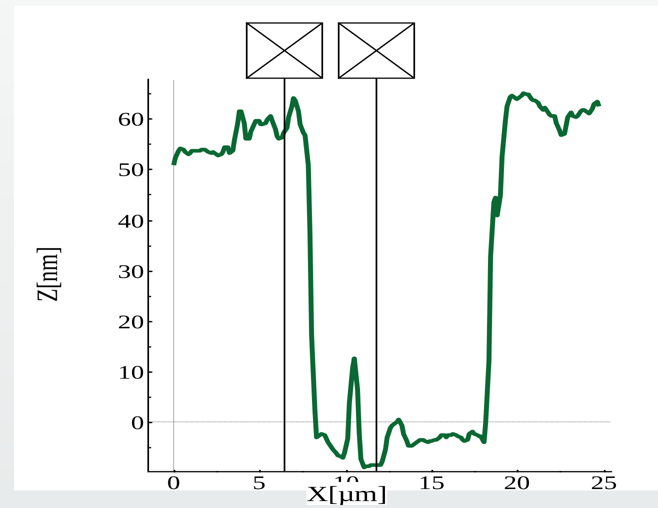
The MV2000

Near-field Scanning Optical Photoconductivity Correlated With Raman

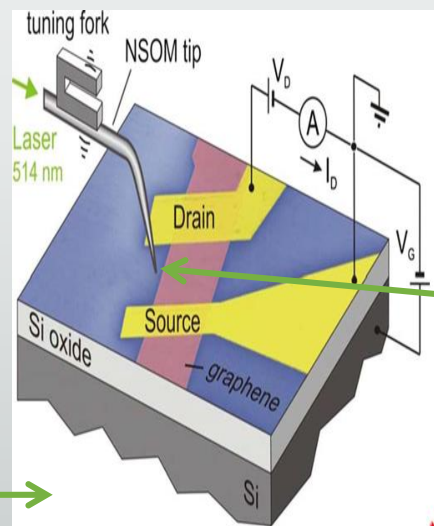
Optical Image of Graphene With Different Doping Content Areas Showing Altered Optical Contrast Due To Index of Refraction Change

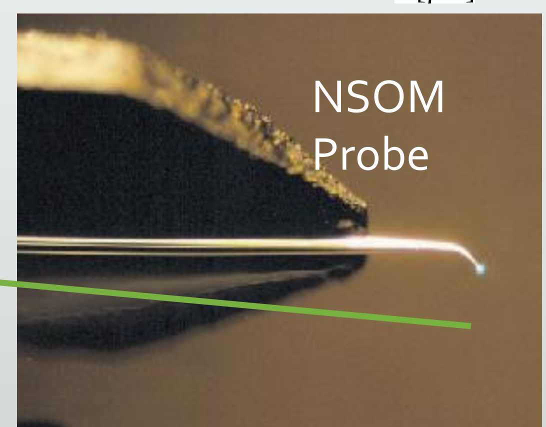






Reflection Optical image above clearly shows the green spot of a 532nm laser on the sample without the probe shaft obscuring any of the light. A diagrammatic representation is seen to the right.

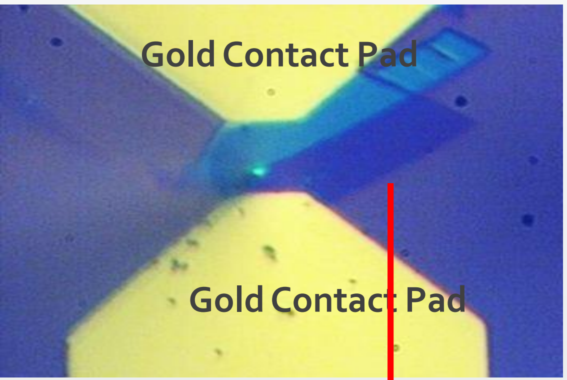


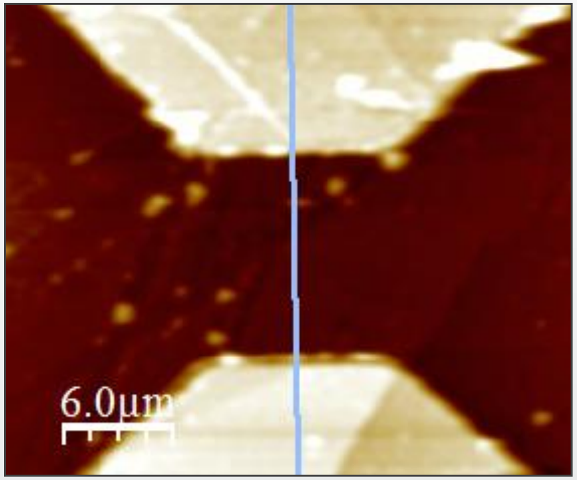


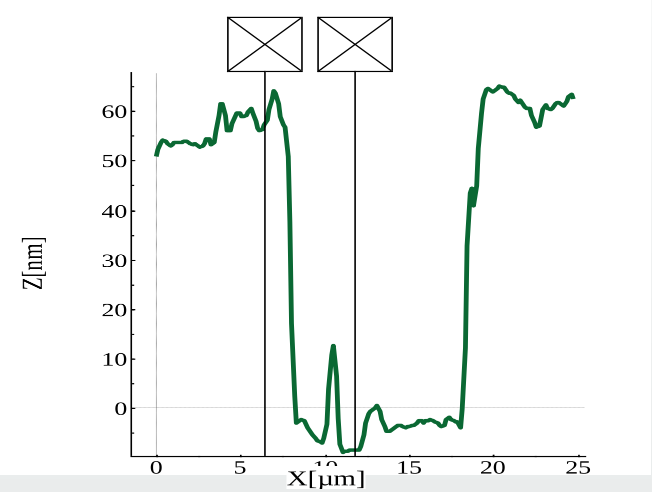
Raman Correlation Following Slide

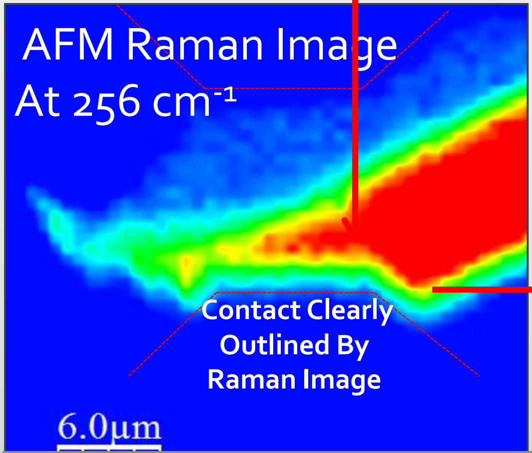
Near-field Scanning Optical Photoconductivity Correlated With Raman

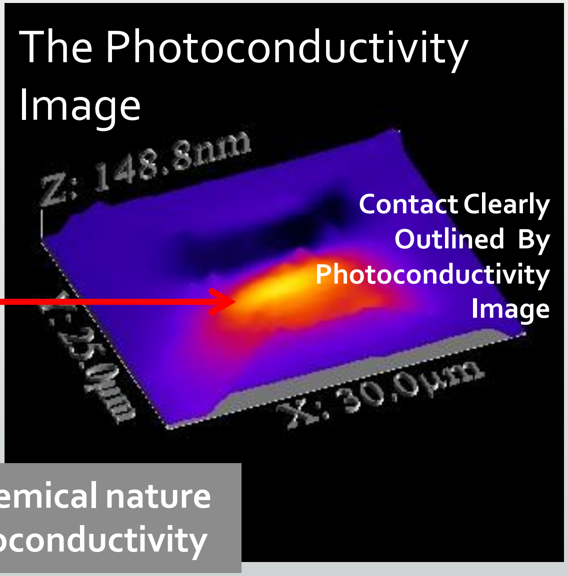
Optical Image of Graphene With Different Doping Content Areas Showing Altered Contrast Due To Index of Refraction Change

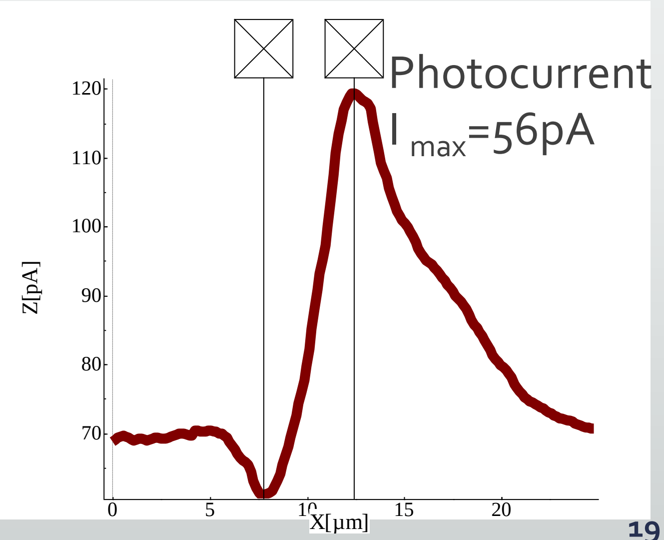












Raman clearly characterizes the chemical nature of material that results in the photoconductivity

Unlimited Possibilities