

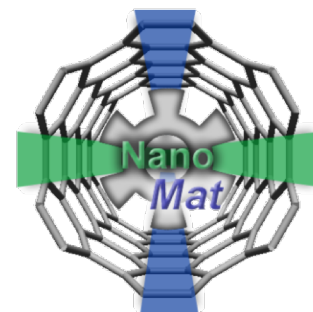
Microscopía Raman Confocal “Introducción”

Dr. Ricardo Faccio

Centro NanoMat

Facultad de Química
Universidad de la República

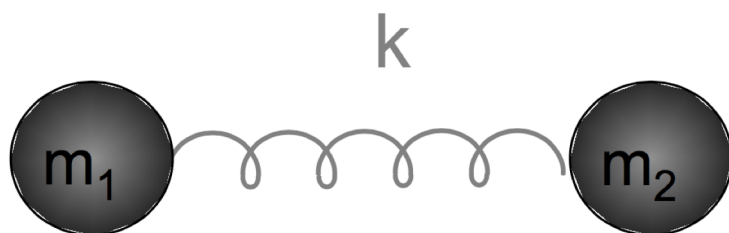
rfaccio@fq.edu.uy



Punteo

- ❑ Modos Vibracionales
- ❑ Reglas de Selección: IR vs Raman
- ❑ Microscopia Óptica y Confocal
- ❑ Microscopia Raman Confocal
- ❑ Aplicaciones de MicroRaman

1. Modos Vibracionales



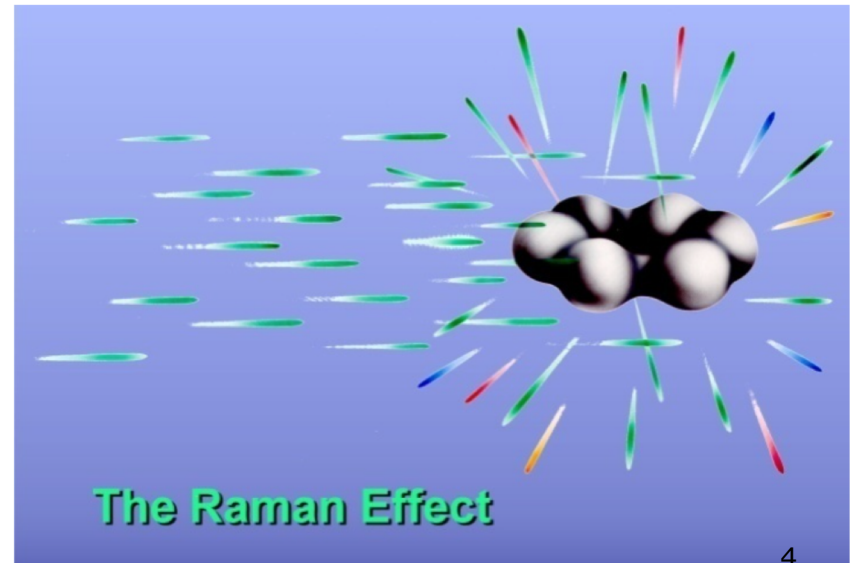
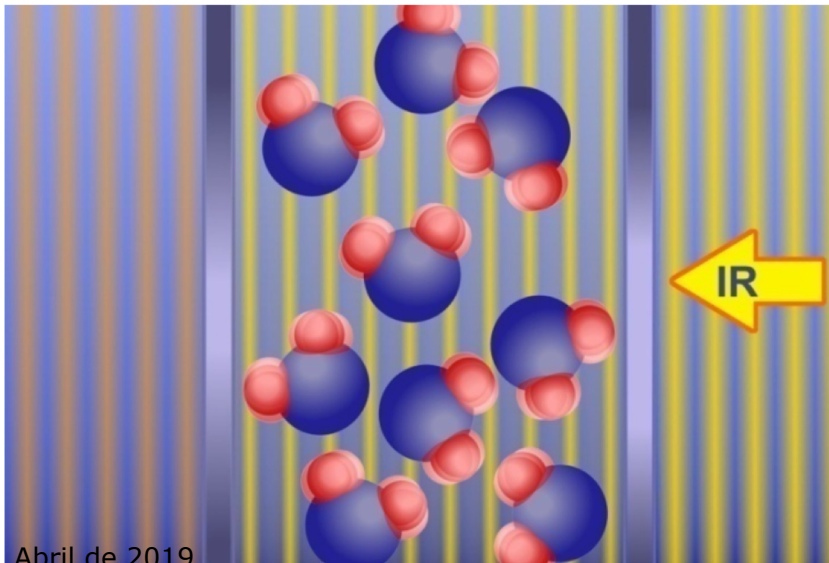
$$V = \frac{1}{2} kx^2$$

$$\nu = \frac{1}{2\pi} \sqrt{\frac{k}{\mu}}; \quad \frac{1}{\mu} = \frac{1}{m_1} + \frac{1}{m_2}$$

Bond	Bond Energy [kcal (kJ)]	Stretching Frequency (cm ⁻¹)
<i>Frequency dependence on bond energies</i>		
C—C	83 (350)	1200
C=C	146 (611)	1660
C≡C	200 (840)	2200
		<i>stronger bond</i> ↓ <i>$\bar{\nu}$ increases</i>
Bond	Bond Energy [kcal (kJ)]	Stretching Frequency (cm ⁻¹)
<i>Frequency dependence on atomic masses</i>		
C—H	100 (420)	3000
C—D	100 (420)	2100
C—C	83 (350)	1200
		<i>heavier atoms</i> ↓ <i>$\bar{\nu}$ decreases</i>

2. Reglas de Selección

- IR: Absorción de fotón por dipolo (μ) del modo normal de vibración.
- Raman: Dispersión inelástica mediada por momento dipolar inducido (polarizabilidad α) generado por la OEM.

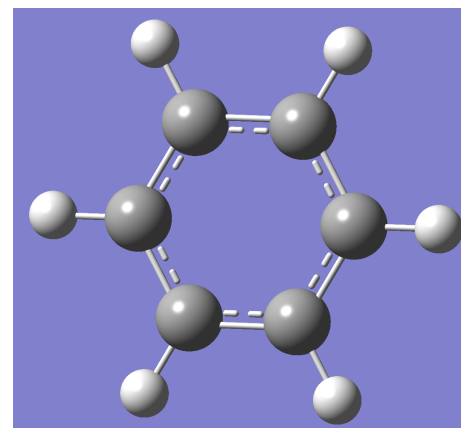


1. Modos Vibracionales

□ Número de modos depende de los grados de libertad

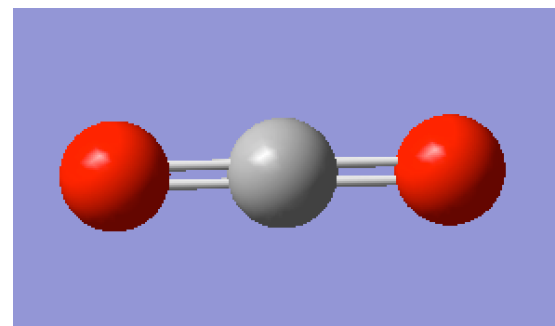
■ Moléculas no Lineales

- $N^{\circ} \text{ modos} = 3N - 6$
- Ejemplo: Benceno
 - 30 modos

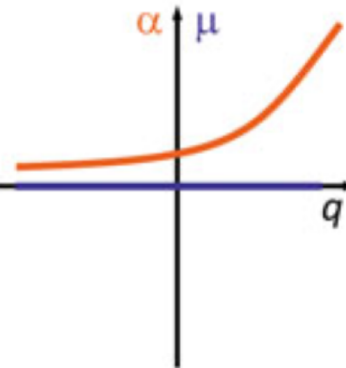
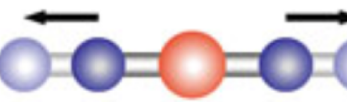
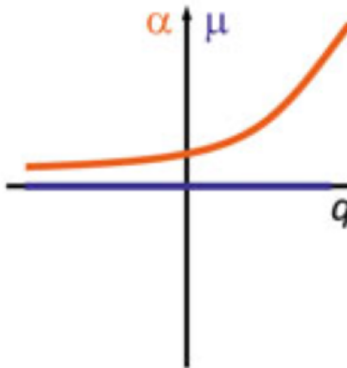
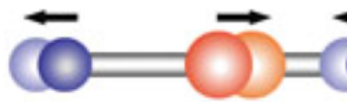
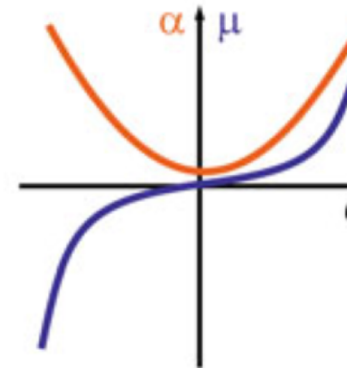
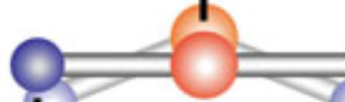
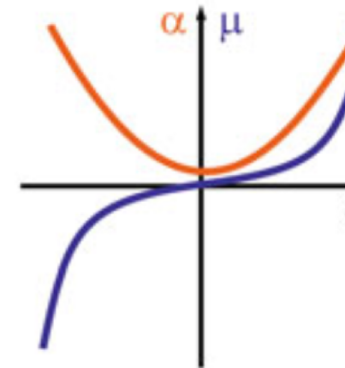


■ Moléculas Lineales

- $N^{\circ} \text{ modos} = 3N - 5$
- Ejemplo: CO_2
 - 4 modos



2. Reglas de Selección: IR vs Raman

 A  $\left(\frac{\partial \alpha}{\partial q}\right)_{q_0} \neq 0$ $\left(\frac{\partial \mu}{\partial q}\right)_{q_0} = 0$ Raman active IR inactive	 B  $\left(\frac{\partial \alpha}{\partial q}\right)_{q_0} \neq 0$ $\left(\frac{\partial \mu}{\partial q}\right)_{q_0} = 0$ Raman active IR inactive	 C  $\left(\frac{\partial \alpha}{\partial q}\right)_{q_0} = 0$ $\left(\frac{\partial \mu}{\partial q}\right)_{q_0} \neq 0$ Raman inactive IR active	 D  $\left(\frac{\partial \alpha}{\partial q}\right)_{q_0} = 0$ $\left(\frac{\partial \mu}{\partial q}\right)_{q_0} \neq 0$ Raman inactive IR active
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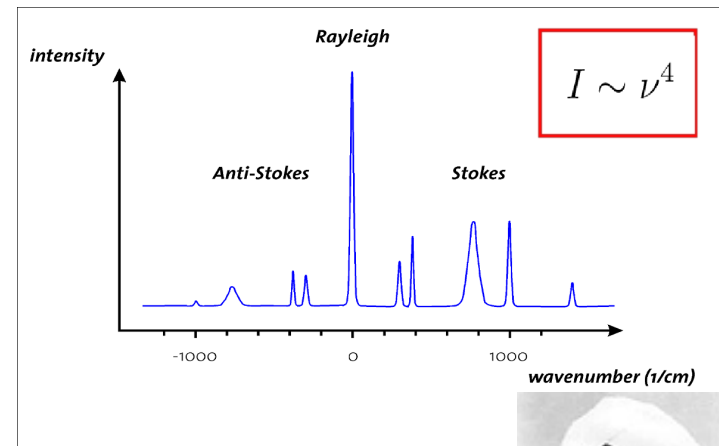
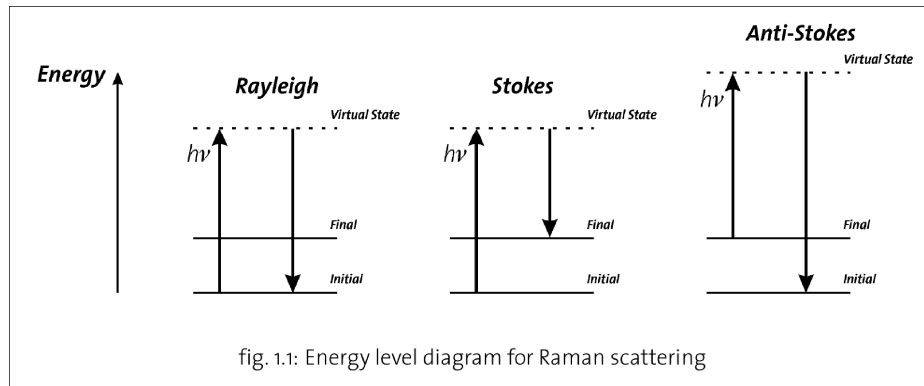
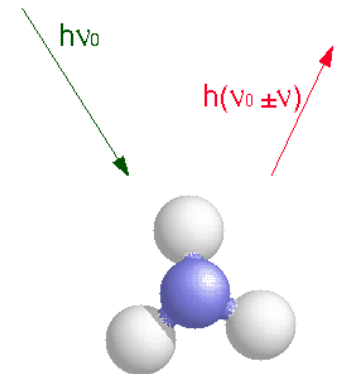
The Raman Effect



2. El efecto Raman

The Raman Effect

- non-resonant excitation (Stokes) or annihilation (Anti-Stokes) of a vibrational quantum
- energy shift between the exciting and scattered photon is characteristic for the molecules involved in the scattering process

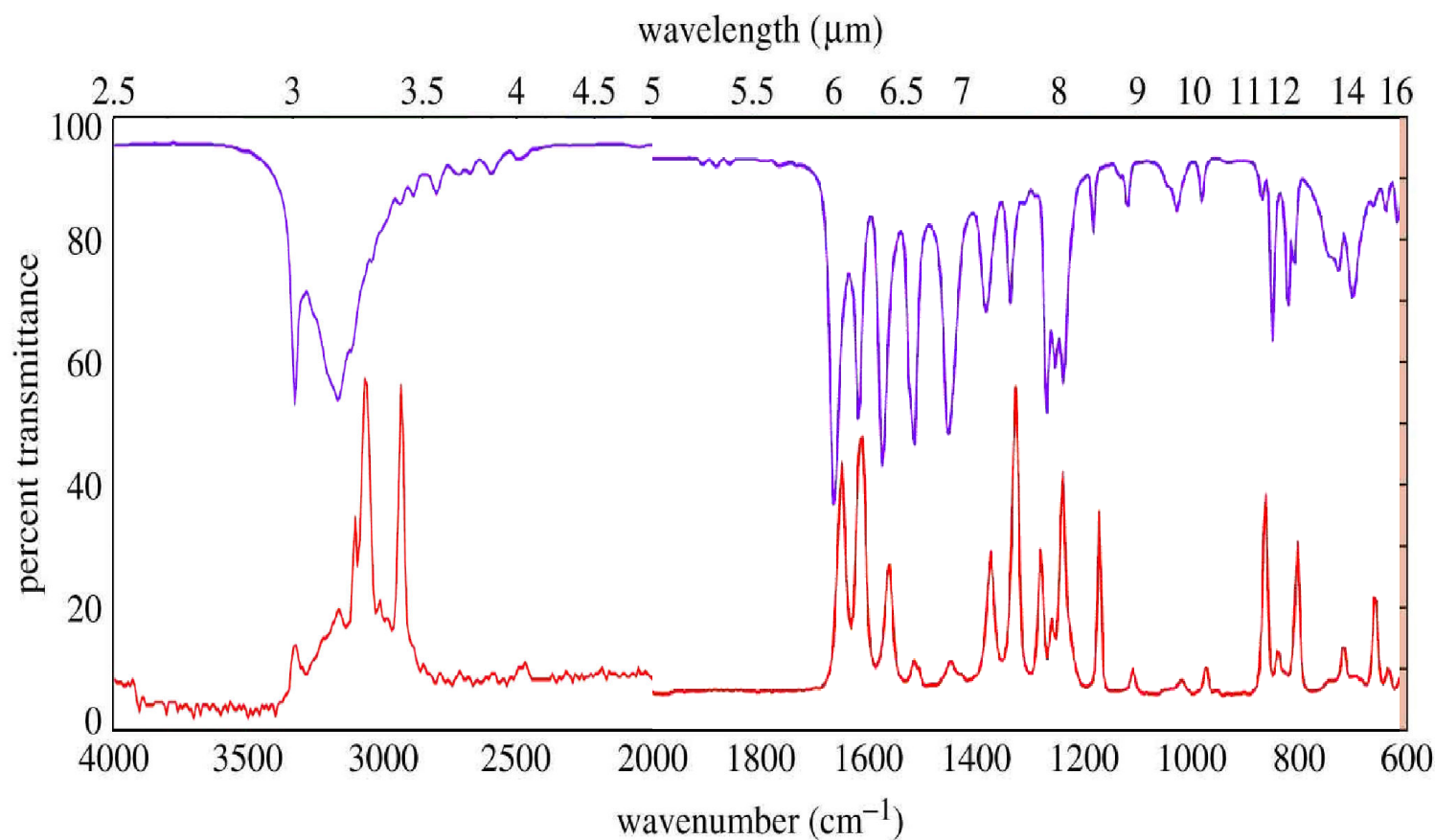


- theoretical prediction 1923 by A. Smekal
- experimentally discovered 1928 by Sir Chandrasekhara Raman, Nobel Prize 1930

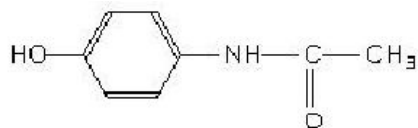
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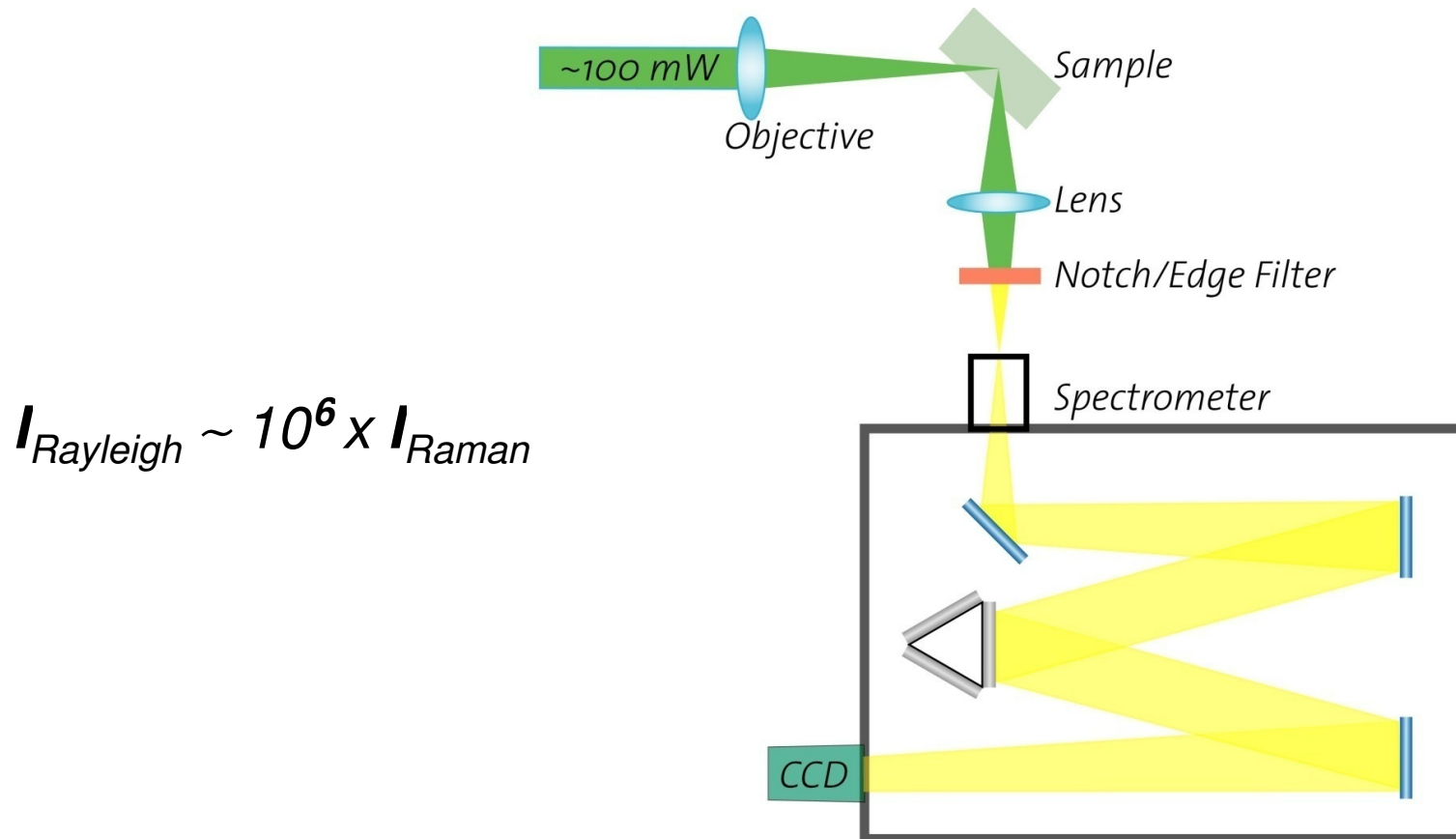
2. Infrarrojo vs. Raman



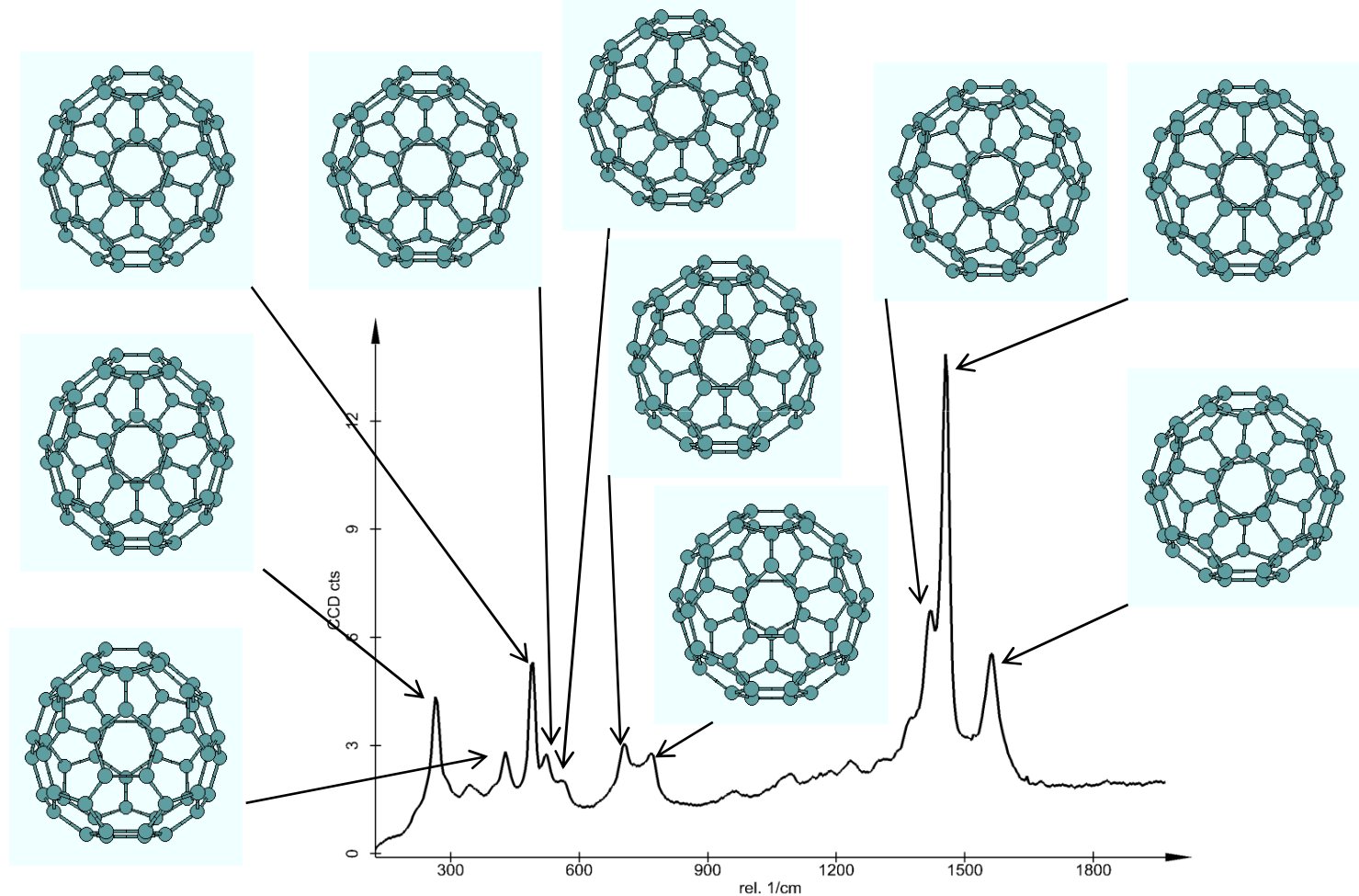
Paracetamol



2. Esquema Típico de Experimento



2. Espectroscopia Raman



2. Identificación de Bandas

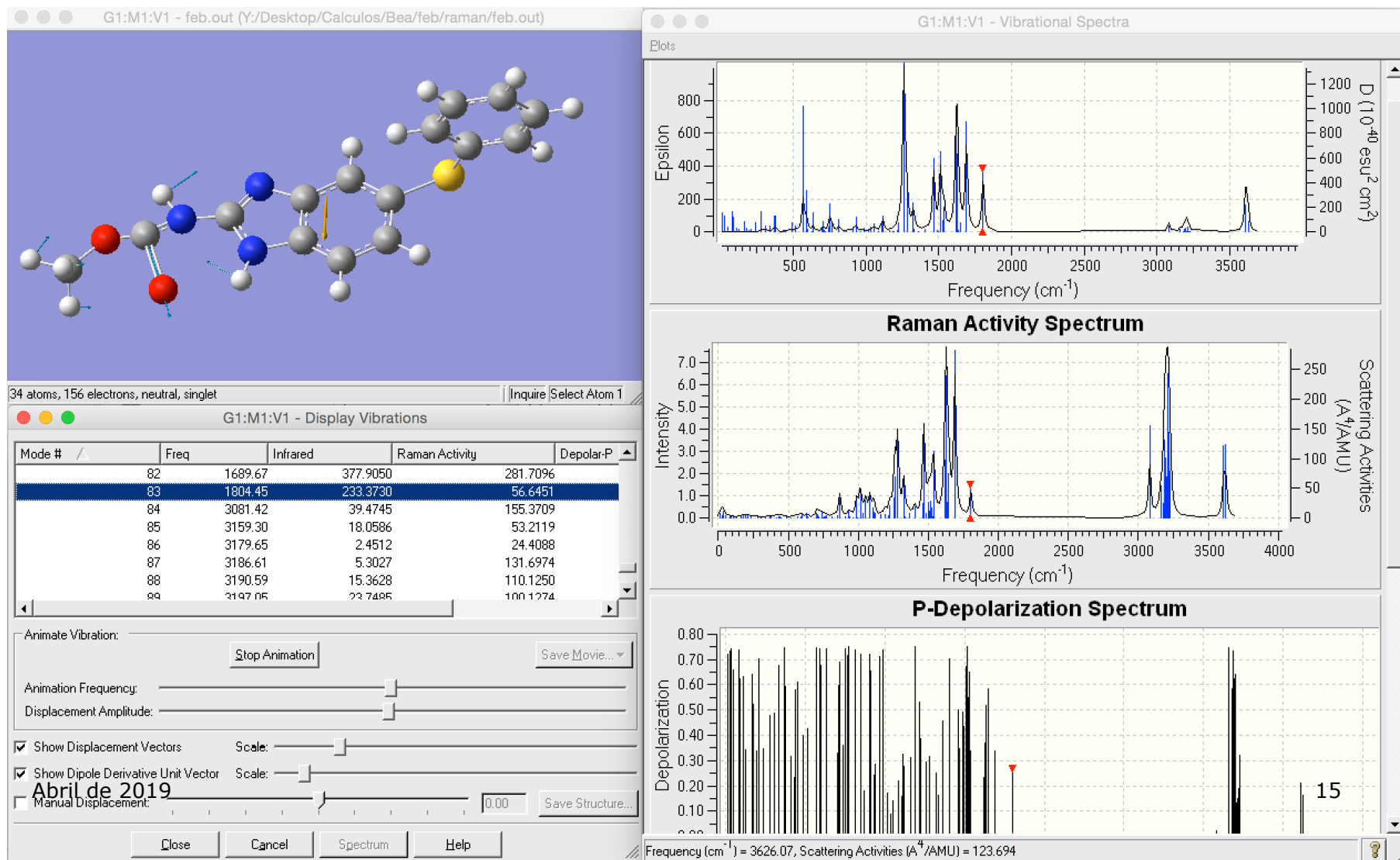
Functional Group/ Vibration	Region	Raman	InfraRed
Lattice vibrations in crystals, LA modes	10 - 200 cm^{-1}	strong	strong
$\delta(\text{CC})$ aliphatic chains	250 - 400 cm^{-1}	strong	weak
$\nu(\text{Se-Se})$	290 -330 cm^{-1}	strong	weak
$\nu(\text{S-S})$	430 -550 cm^{-1}	strong	weak
$\nu(\text{Si-O-Si})$	450 -550 cm^{-1}	strong	weak
$\nu(\text{Xmetal-O})$	150-450 cm^{-1}	strong	med-weak
$\nu(\text{C-I})$	480 - 660 cm^{-1}	strong	strong
$\nu(\text{C-Br})$	500 - 700 cm^{-1}	strong	strong
$\nu(\text{C-Cl})$	550 - 800 cm^{-1}	strong	strong
$\nu(\text{C-S})$ aliphatic	630 - 790 cm^{-1}	strong	medium
$\nu(\text{C-S})$ aromatic	1080 - 1100 cm^{-1}	strong	medium
$\nu(\text{O-O})$	845 -900 cm^{-1}	strong	weak
$\nu(\text{C-O-C})$	800 -970 cm^{-1}	medium	weak
$\nu(\text{C-O-C})$ asym	1060 - 1150 cm^{-1}	weak	strong

	$\nu(\text{CC})$ alicyclic, aliphatic chain vibrations	600 - 1300 cm^{-1}	medium	Medium
	$\nu(\text{C}=\text{S})$	1000 - 1250 cm^{-1}	strong	weak
	$\nu(\text{CC})$ aromatic ring chain vibrations	*1580, 1600 cm^{-1}	strong	medium
		*1450, 1500 cm^{-1}	medium	medium
		*1000 cm^{-1}	strong/medium	weak
	$\delta(\text{CH}_3)$	1380 cm^{-1}	medium	strong
	$\delta(\text{CH}_2)$ $\delta(\text{CH}_3)$ asym	1400 - 1470 cm^{-1}	medium	medium
	$\delta(\text{CH}_2)$ $\delta(\text{CH}_3)$ asym	1400 - 1470 cm^{-1}	medium	medium
	$\nu(\text{C}-(\text{NO}_2))$	1340 - 1380 cm^{-1}	strong	medium
	$\nu(\text{C}-(\text{NO}_2))$ asym	1530 - 1590 cm^{-1}	medium	strong
	$\nu(\text{N}=\text{N})$ aromatic	1410 - 1440 cm^{-1}	medium	-
	$\nu(\text{N}=\text{N})$ aliphatic	1550 - 1580 cm^{-1}	medium	-
	$\delta(\text{H}_2\text{O})$	~1640 cm^{-1}	weak broad	strong
	$\nu(\text{C}=\text{N})$	1610 - 1680 cm^{-1}	strong	medium
	$\nu(\text{C}=\text{C})$	1500 - 1900 cm^{-1}	strong	weak
	$\nu(\text{C}=\text{O})$	1680 - 1820 cm^{-1}	medium	strong
	$\nu(\text{C}\equiv\text{C})$	2100 - 2250 cm^{-1}	strong	weak
	$\nu(\text{C}\equiv\text{N})$	2220 - 2255 cm^{-1}	medium	strong
	$\nu(-\text{S}-\text{H})$	2550 - 2600 cm^{-1}	strong	weak
	$\nu(\text{C}-\text{H})$	2800 - 3000 cm^{-1}	strong	strong
	$\nu(=\text{C}-\text{H})$	3000 - 3100 cm^{-1}	strong	medium
	$\nu(\equiv\text{C}-\text{H})$	3300 cm^{-1}	weak	strong
Abril de 2019	$\nu(\text{N}-\text{H})$	3300 - 3500 cm^{-1}	medium	medium
	$\nu(\text{O}-\text{H})$	3100 - 3650 cm^{-1}	weak	strong

2. Métodos Teóricos

- Cálculos *ab initio* o *Primeros Principios*
- *DFT*
 - *Gaussian*

2. Simulación de IR y Raman

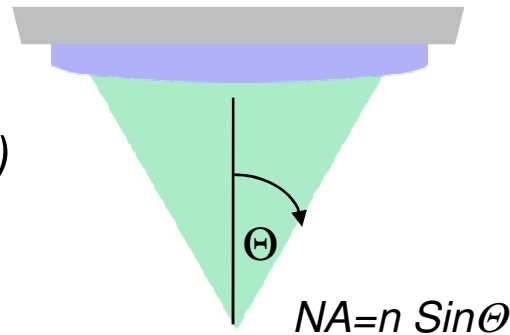


3 Microscopia Óptica Clásica

What is the resolution limit of a classical optical microscope?

Ernst Abbé (1840-1905): diffraction theory

$$\Delta x \geq 0,61 \times (\lambda / NA)$$

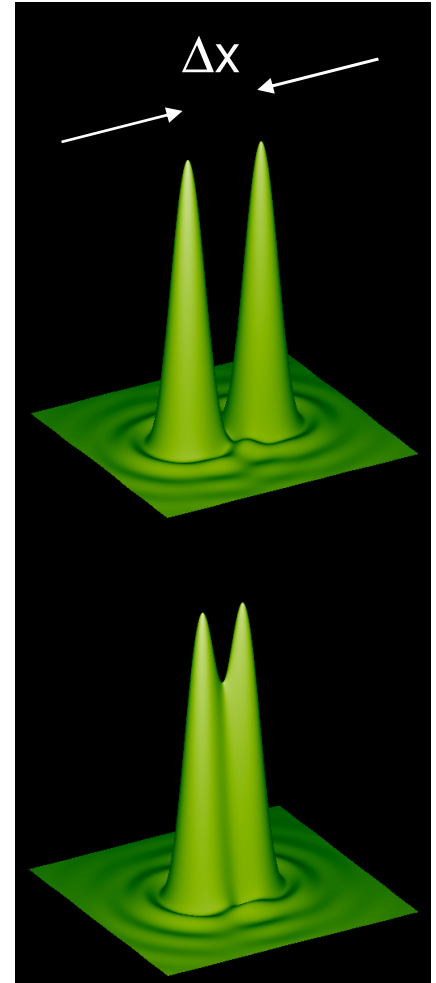


air: NA ≤ 0,95 (340nm @ 532nm exc.)

water: NA ≤ 1,2 (270nm @ 532nm exc.)

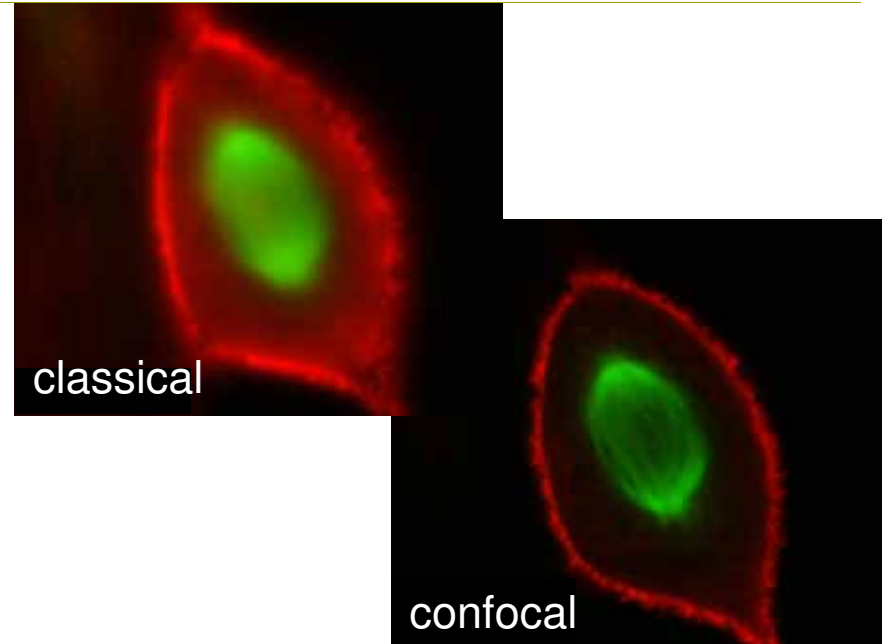
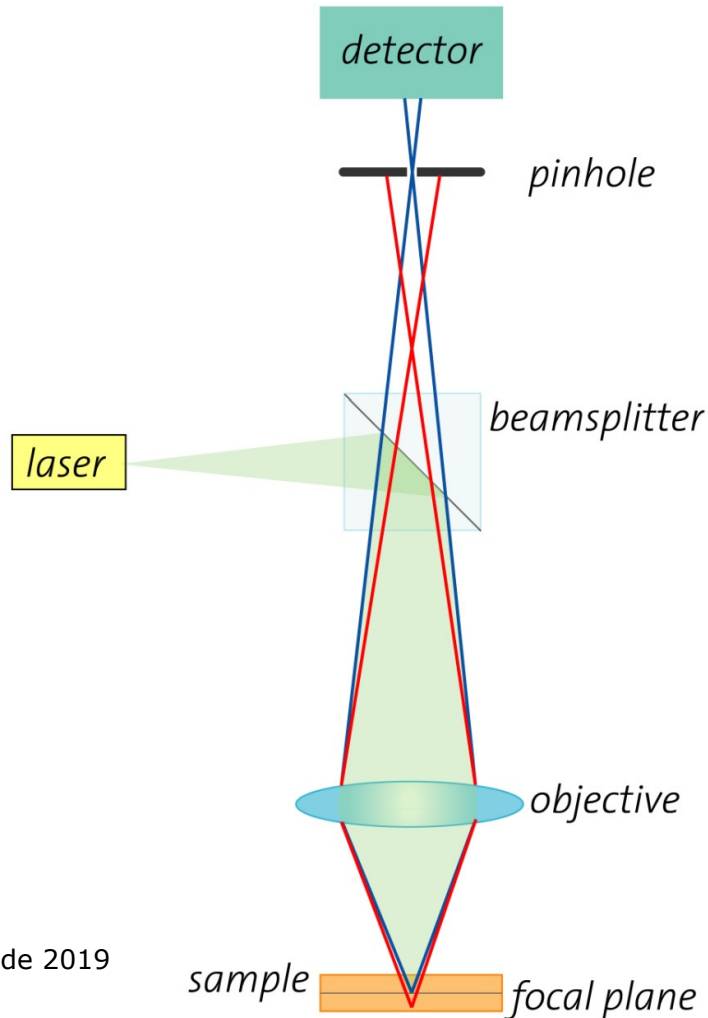
oil: NA ≤ 1,4 (230nm @ 532nm exc.)

resolution limit $\approx \lambda / 2$



3. Microscopia Confocal

confocal microscopy



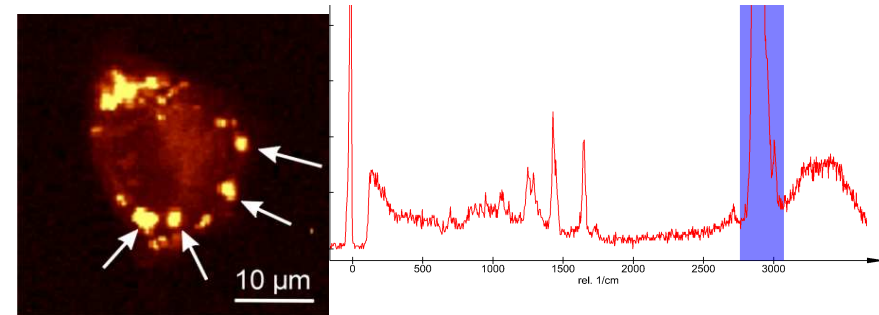
- much smaller background
- 3-D information
- slightly higher resolution possible

spatial, but NO chemical information

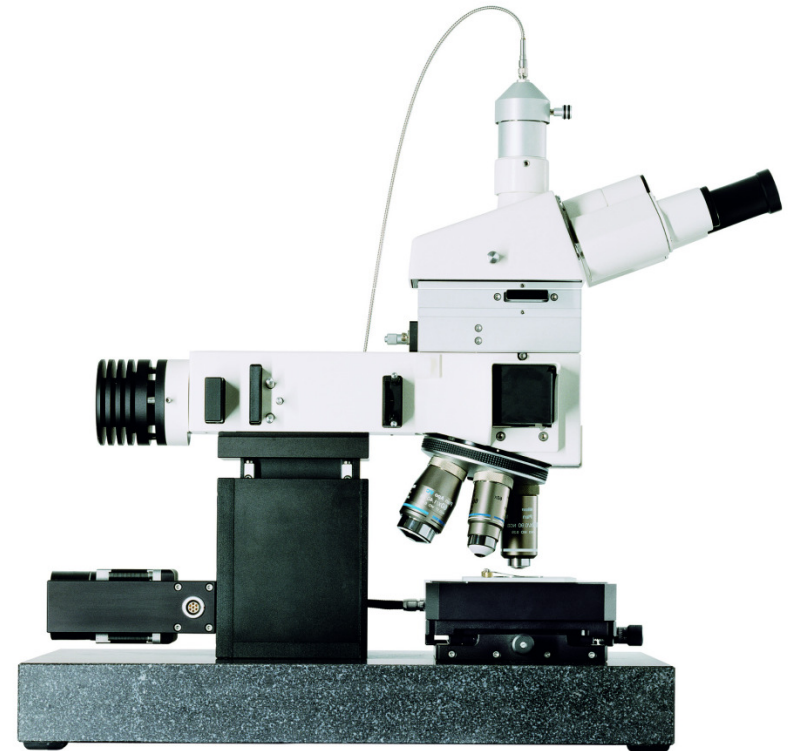
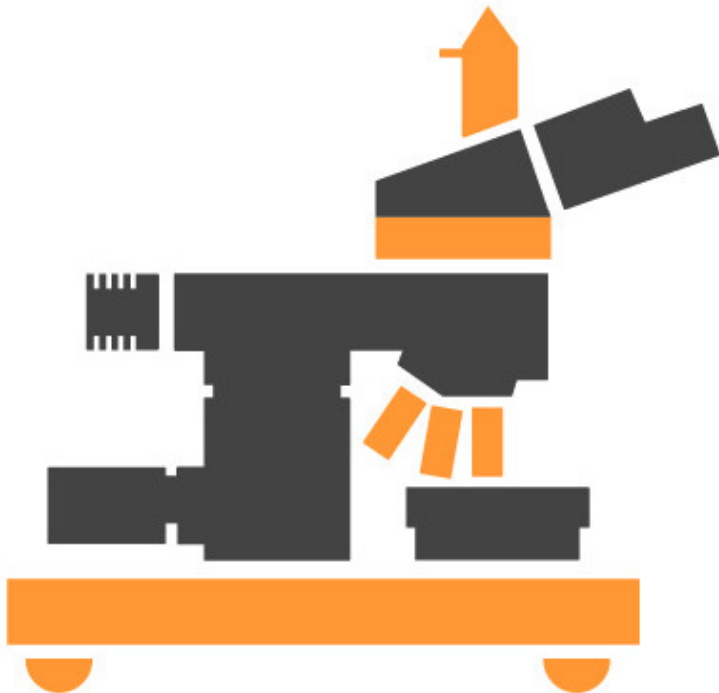
3. Microscopio Confocal + Espectroscopia Raman

3-D Imaging with chemical sensitivity

- take a complete Raman spectrum at every image pixel
- extract the relevant information (peak intensity, width, position etc.)
- display this information as image

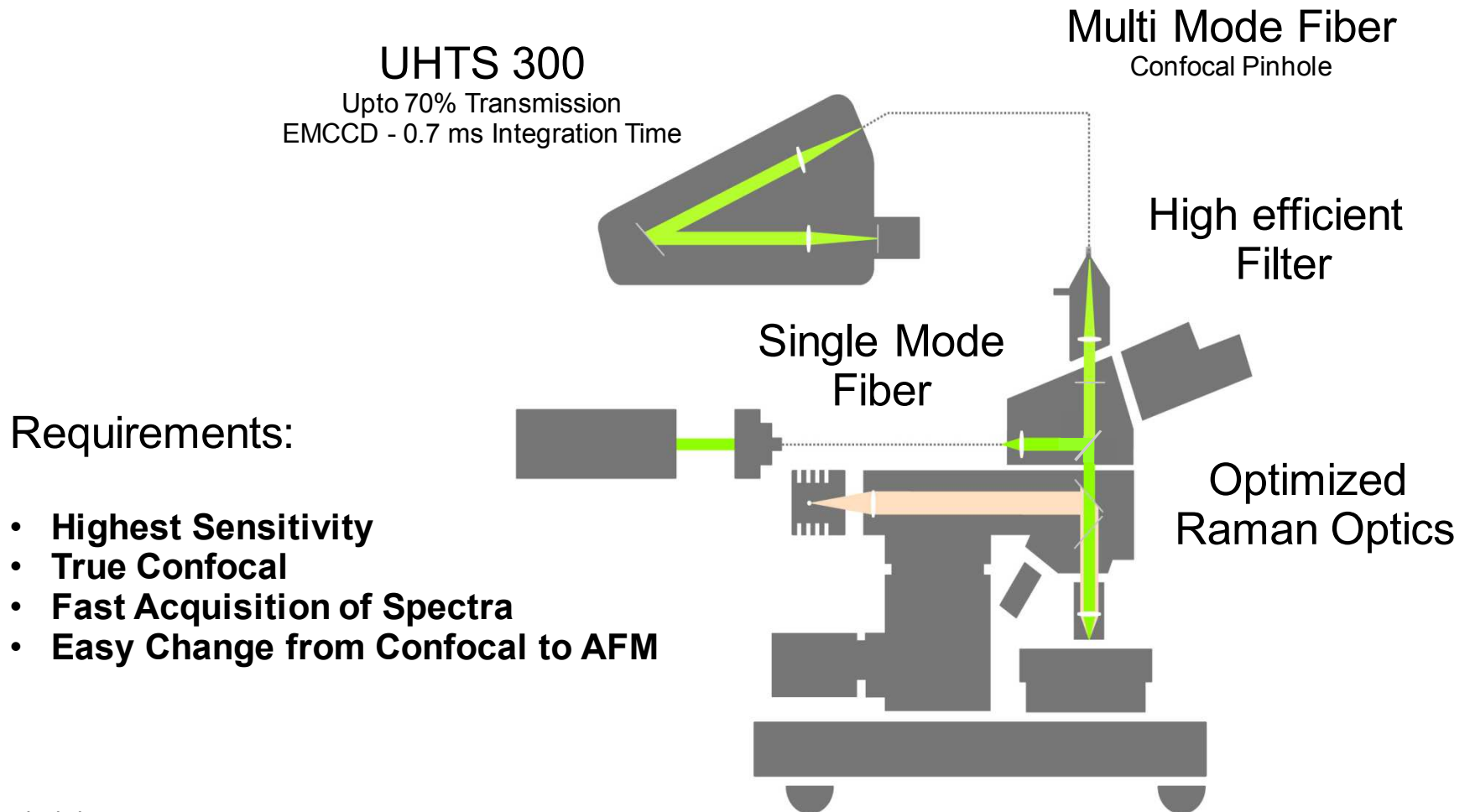


3. Microscopio Confocal + Espectrómetro Raman



Imaging with chemical sensitivity

3. Esquema



3. Características de la Técnica

- ❑ No Destructivo
- ❑ Identificación Química Directa
- ❑ Identificación de Propiedades de Materiales
- ❑ Fácil o nula preparación de muestra
- ❑ Sólidos cristalinos, sólidos amorfos y Líquidos
- ❑ Detección 3-dimensional
- ❑ Variación de Temperatura (Linkam)
- ❑ Combinación de detección química con AFM (EFM & MFM)

3. WITec Alpha 300 RA

WITec Confocal Raman Microscope System Alpha300R de alta sensibilidad para longitudes de onda de excitación de 532 nm y 785 nm.

- ❑ Imagen Espectral Raman: adquisición de espectros Raman completos en cada pixel (mapping)
- ❑ Adquisición de espectros Raman en áreas seleccionadas (micro-Raman)
- ❑ Imágenes 3D Raman confocal.
- ❑ Microscopía confocal de Reflexión
- ❑ Resolución Óptica: Límite de difracción, típico 300 nm @ 532 nm de longitud de onda de excitación (objetivo NA 1.4)
- ❑ Tamaño de la muestra: máx. 120 mm x e y dirección, 25 mm de altura
- ❑ **Dos espectrómetros y detectors CCD optimizados, uno para IR cercano y otro para rango Visible.**

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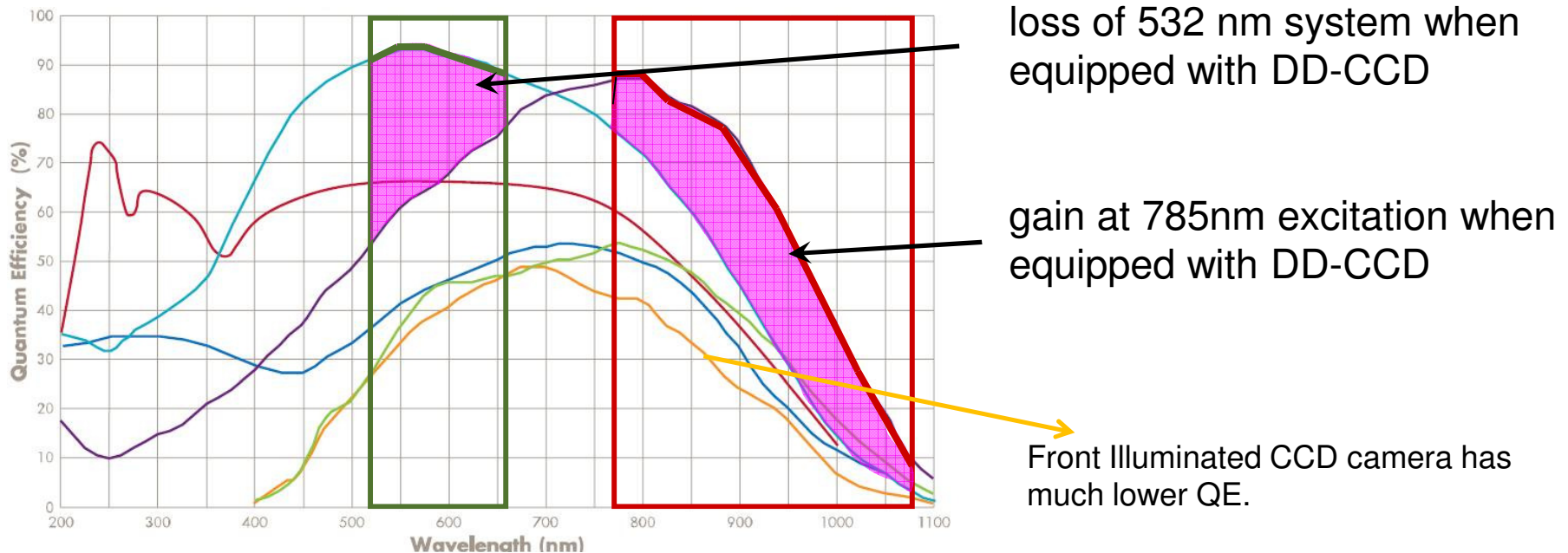
- ❑ Criostato para micro-confocal rango T= -196 C a 600 C (Linkam)

3. Plataforma Piezoeléctrica

- ❑ Plataforma piezoeléctrica para el barrido de muestras.
- ❑ Rango continuo de barrido de hasta 200µm en ejes X e Y y 20 µm en eje Z.
- ❑ Dispositivo de barrido lineal con feedback de loop cerrado
- ❑ Resolución de barrido:
 - Precisión de posicionamiento:
 - < 2 nm en eje ejes X e Y
 - < 0.2 nm (2 Å) en eje Z
- ❑ AFM, MFM y EFM
 - FSE_1_2014_1_102008 Fondo Sectorial de Energía - ANII
 - “Nanomateriales para almacenamiento de energía: nueva serie de cátodos₂₃ para baterías de ion-Litio”

3. Doble CCD optimizada para cada región del espectro

dual wavelength system (532nm + 785 nm)



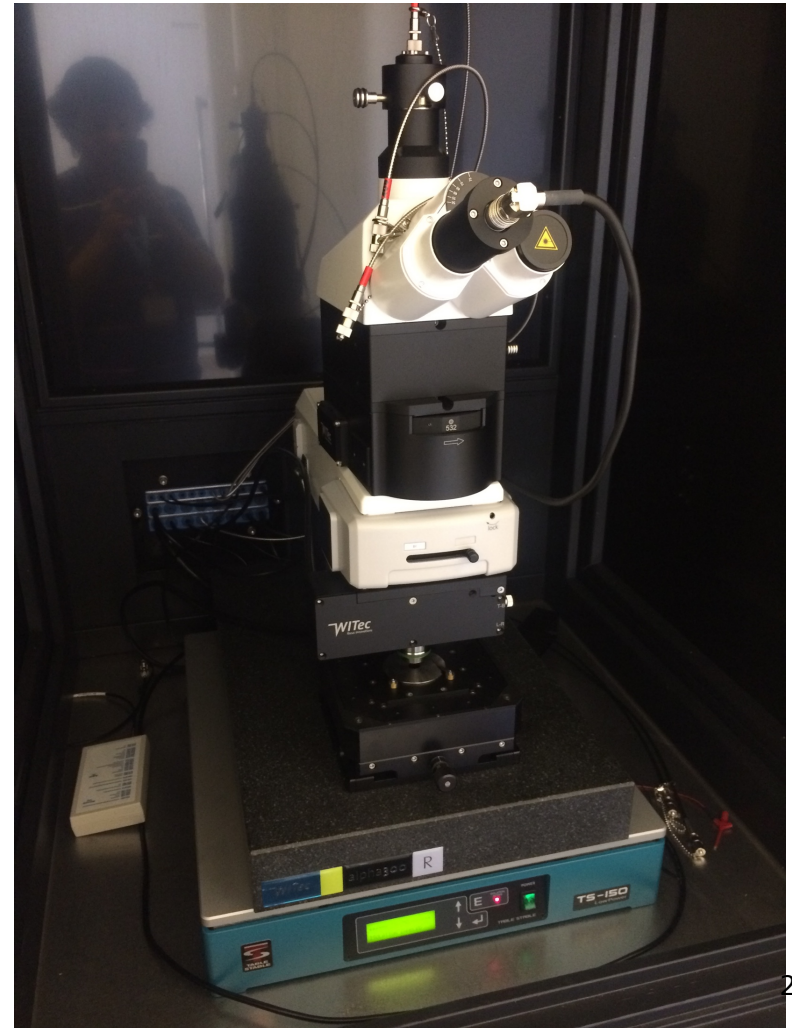
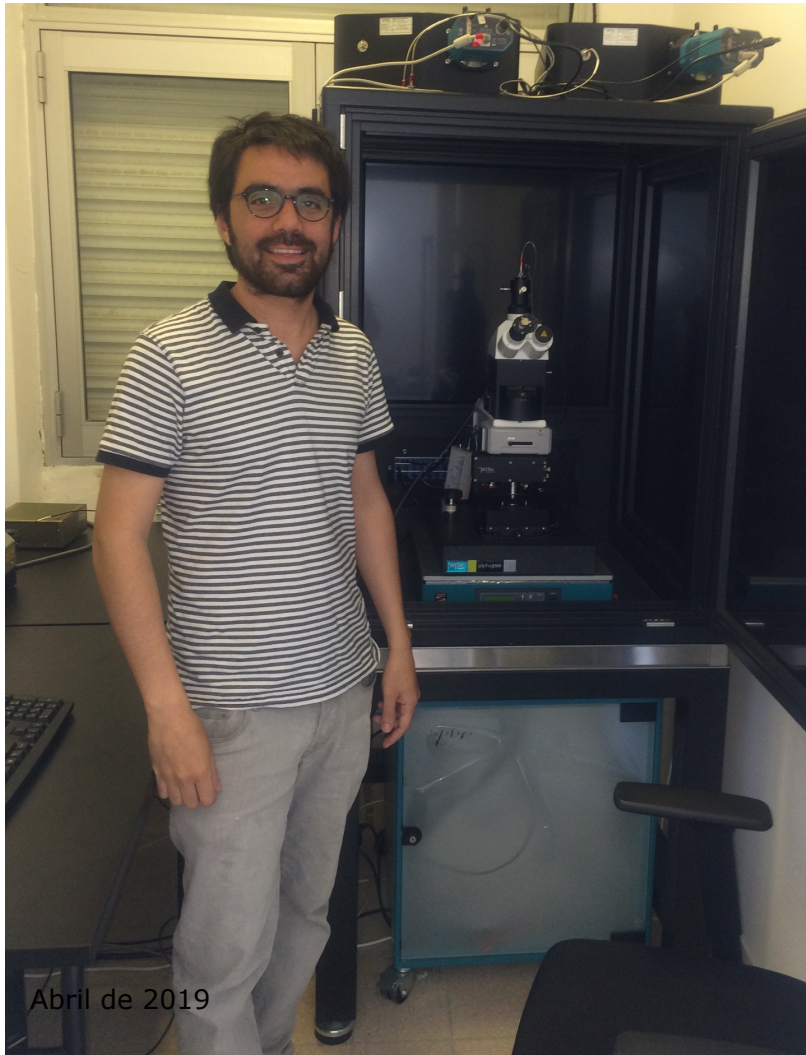
solution for optimized dual wavelength system:

=> 2 spectrometers + 2 cameras

532nm excitation: 500nm blaze, standard BI-CCD

785nm excitation: 750nm blaze, DD-CCD

3. Disposición

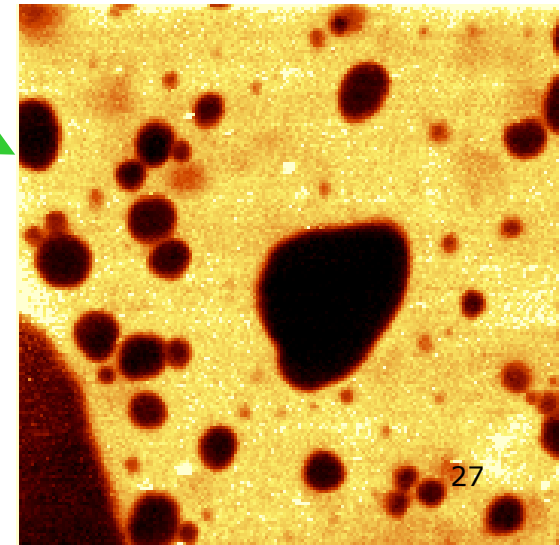
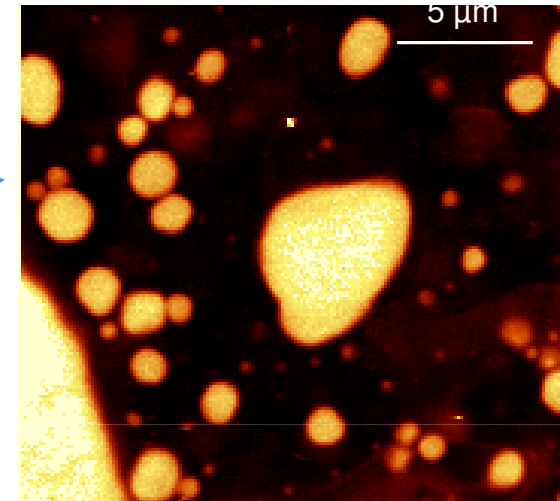
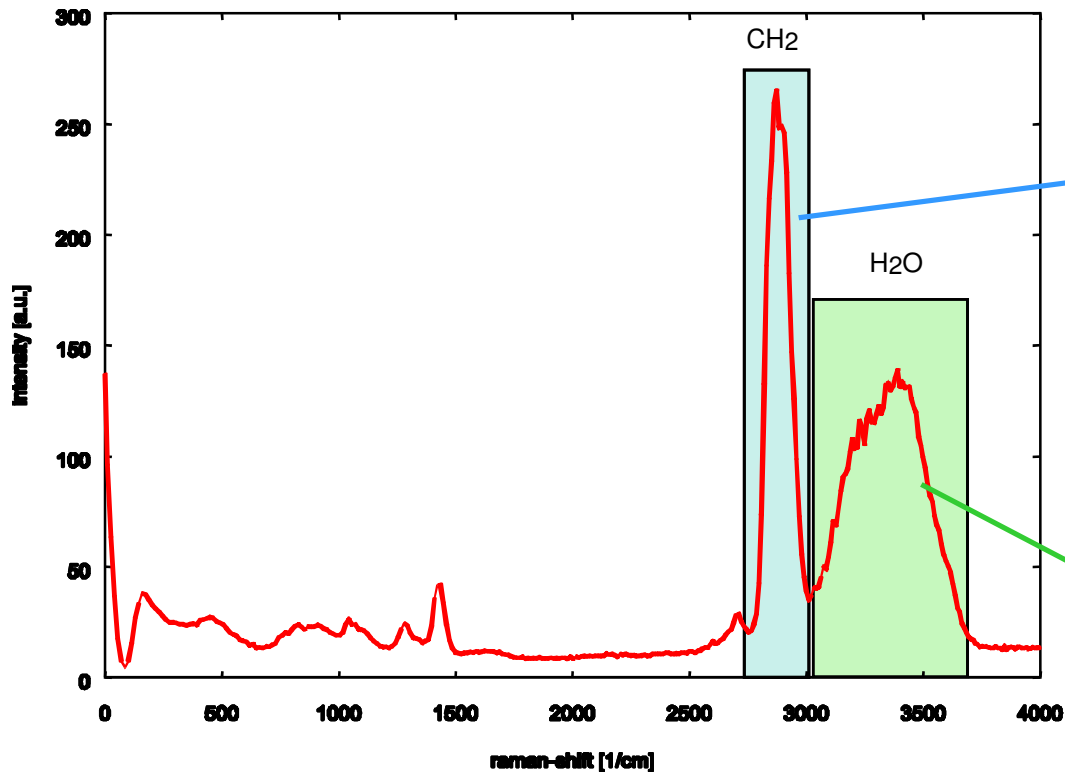


4. Aplicaciones



Microscopia Raman Confocal

Imagen Raman: dispersión agua-aceite



Body lotion, imaging parameters:

2 mW excitation @ 532nm, 100x oil, NA=1,25

20 x 20 μm , 180 x 180 pixels (= 32400 spectra)

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50ms/spectrum

Reconstrucción Imagen Raman 3D

Sample: Oil/Water Emulsion

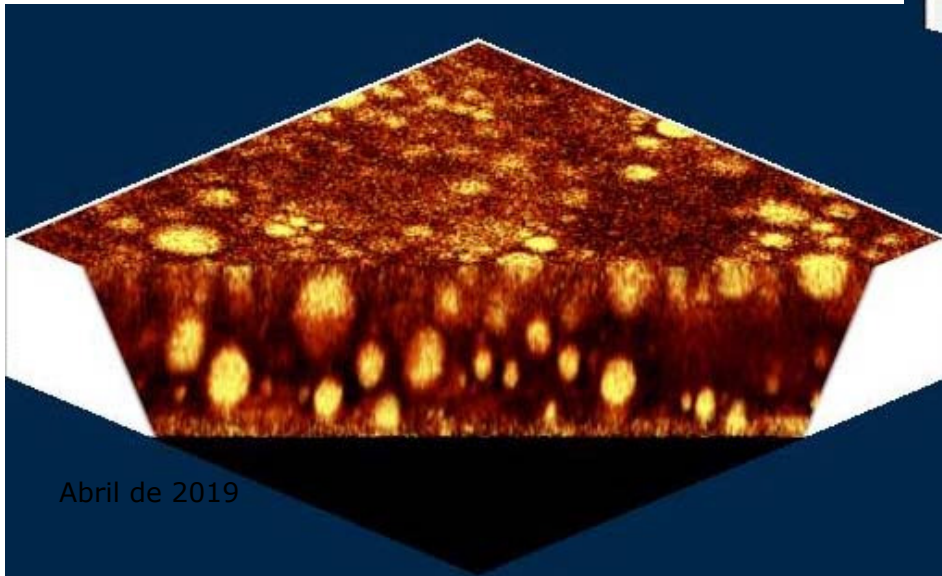
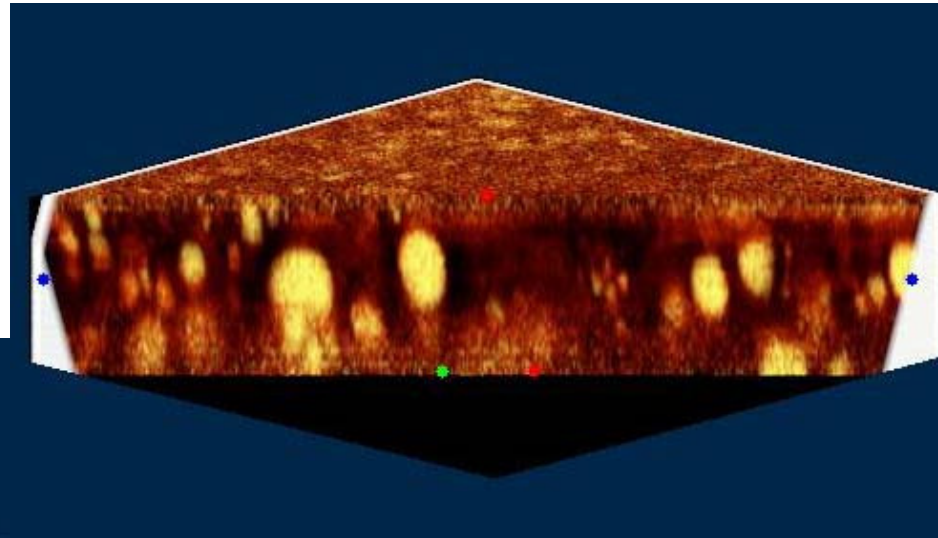
3-D Reconstruction

Evaluated Band: CH-Stretching

Excitation: 532nm

Scan Range XY: 100x100 μm

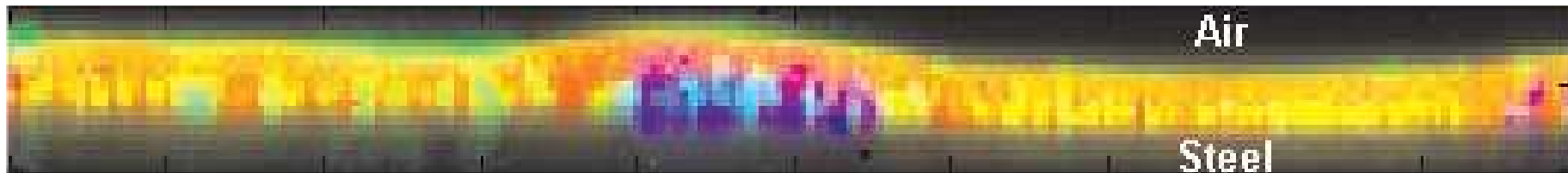
Scan Range Z: 30 μm /32 layers



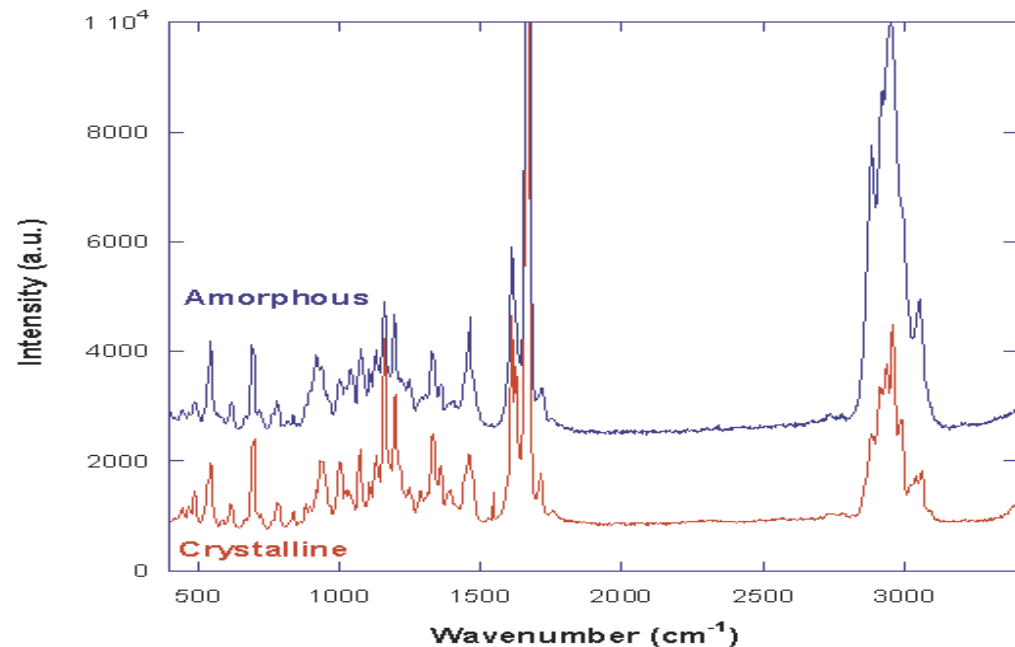
Total number of Spectra: 517 500

Total Acquisition Time: 23 min

Stents para Drug Delivery



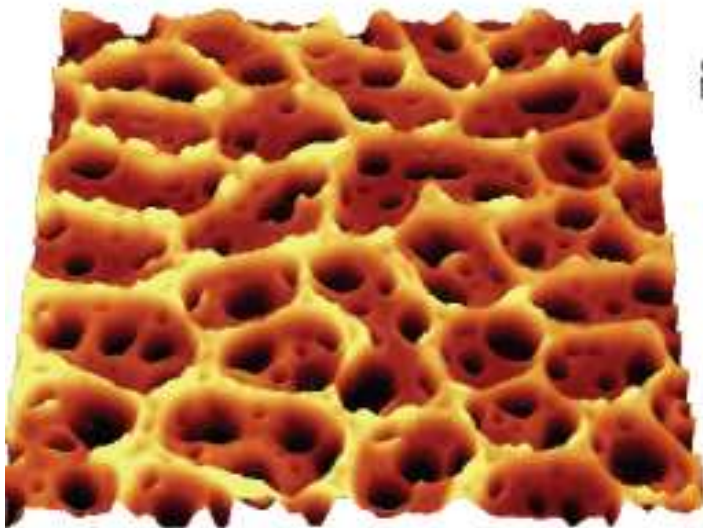
Raman cross-sectional image
of a coating of a drug plus
polymer on a stent.
Polymer (red),
amorphous drug (green),
crystalline drug (blue),
polymer + amorphous drug (yellow).
100x 10 microns scan.



Polímeros

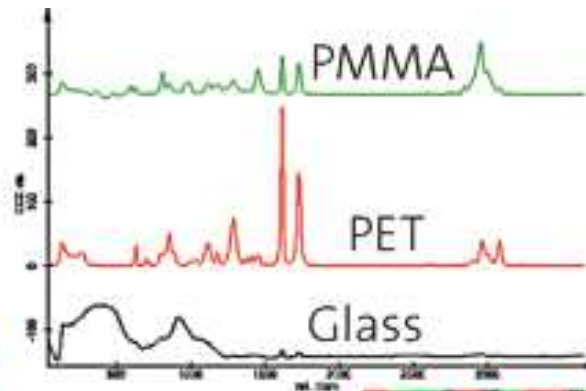
Thin Film of PMMA - PET

AFM image

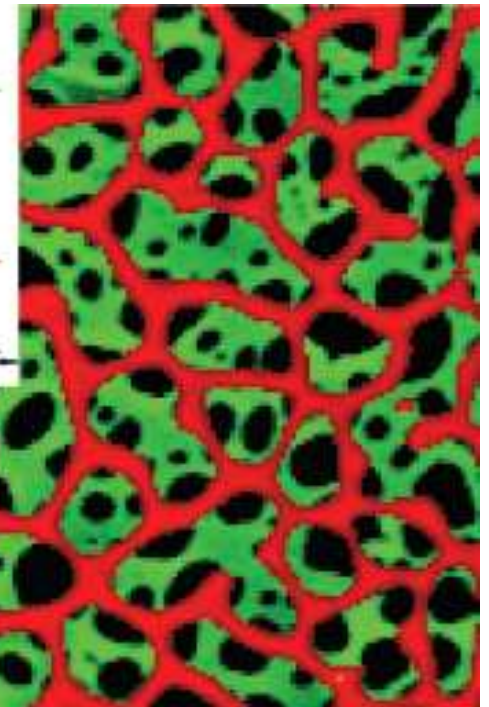


A
20x20x0.2 μm^3 scan area

Raman image



C

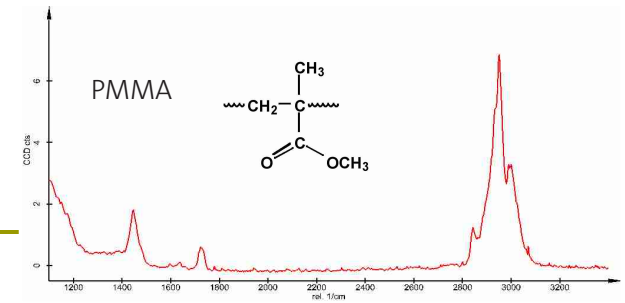
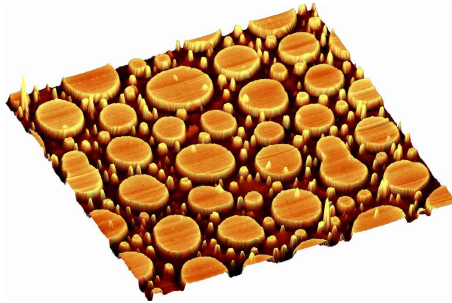


B

20x20 μm^2 scan area, 150x150 pixel
•0,05 s integration time
•total 22500 spectra

Blend PMMA+SBR

Fig. 5: Overview AFM image of a PMMA-SBR blend.



3

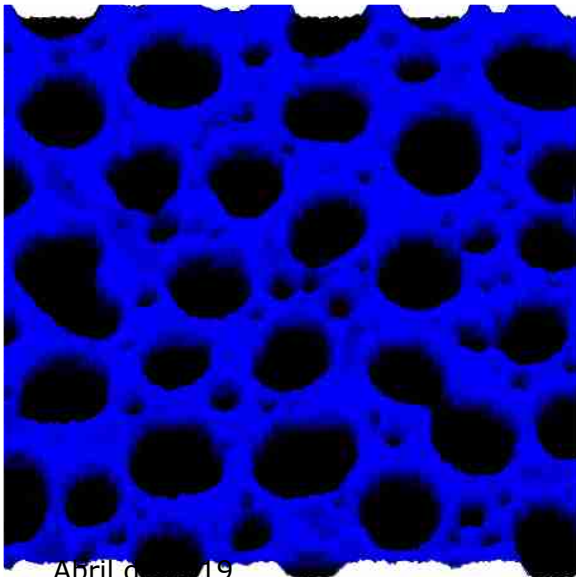
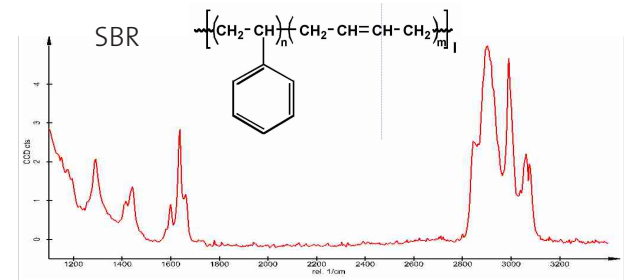


Fig. 9: Color coded Raman image of SBR resulting from the integral intensity of each spectrum.

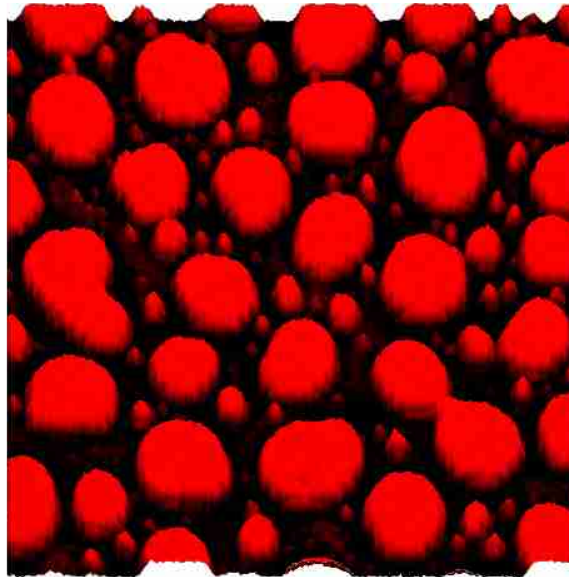


Fig. 10: Color coded Raman image of PMMA resulting from the integral intensity of each spectrum.

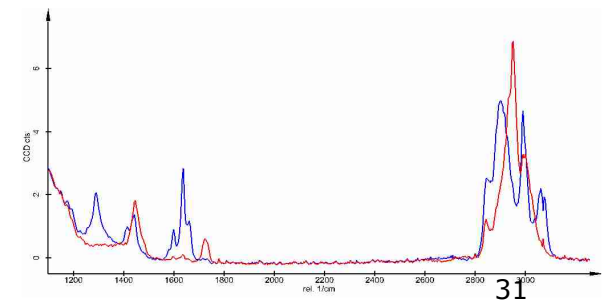


Fig. 11: Corresponding spectra: SBR (blue) and PMMA (red).

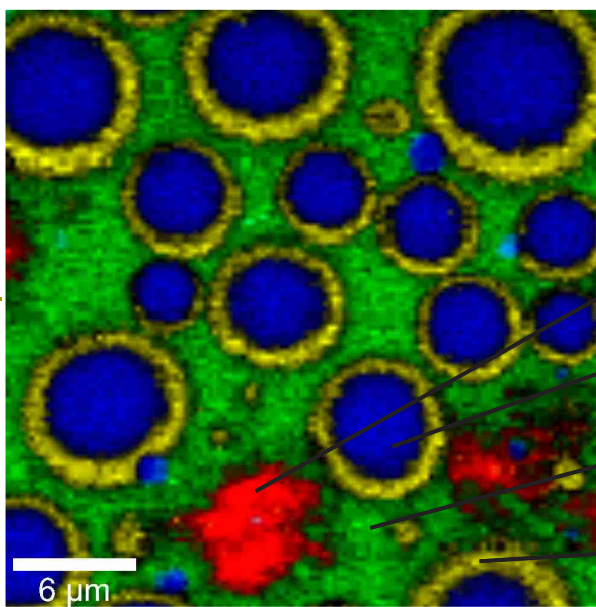


Fig. 2a: Raman Image of an emulsion used in food production. Scan range: 30 μm x 30 μm , 120x120 pixels (=14400 spectra, 532 Nd:Yag Laser for excitation, 100 x oil objective (NA=1.25)). Red + green: fatty matrix, blue: aqueous phase, yellow: emulsifier PGPR

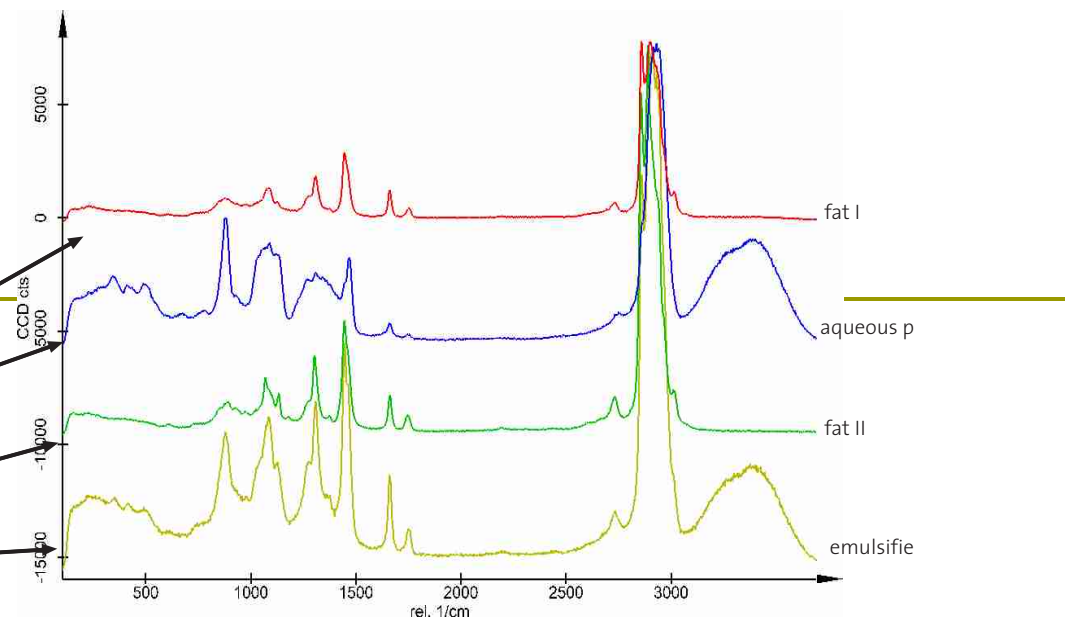
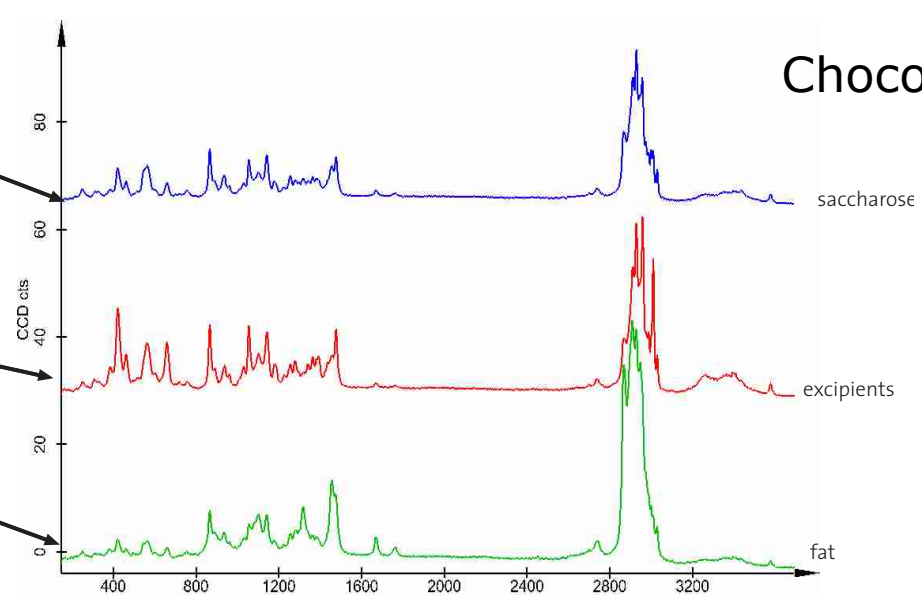
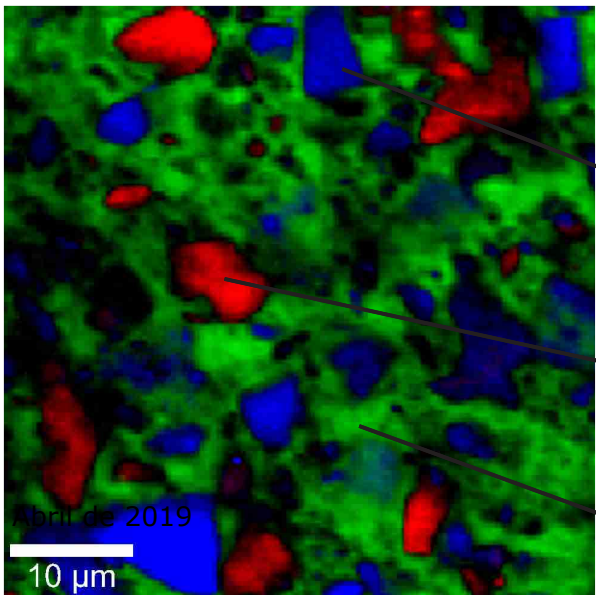


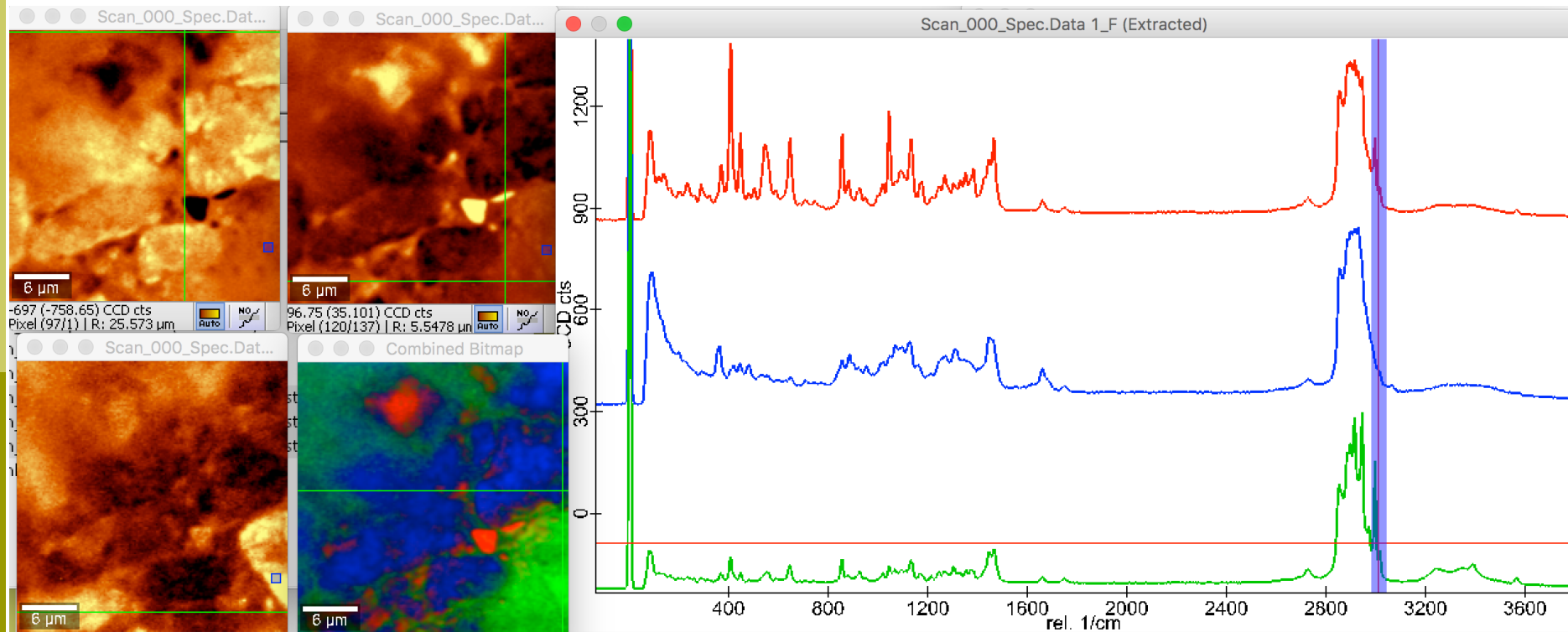
Fig. 2b: Corresponding spectra of the compounds contained within the emulsion.



Chocolate blanco

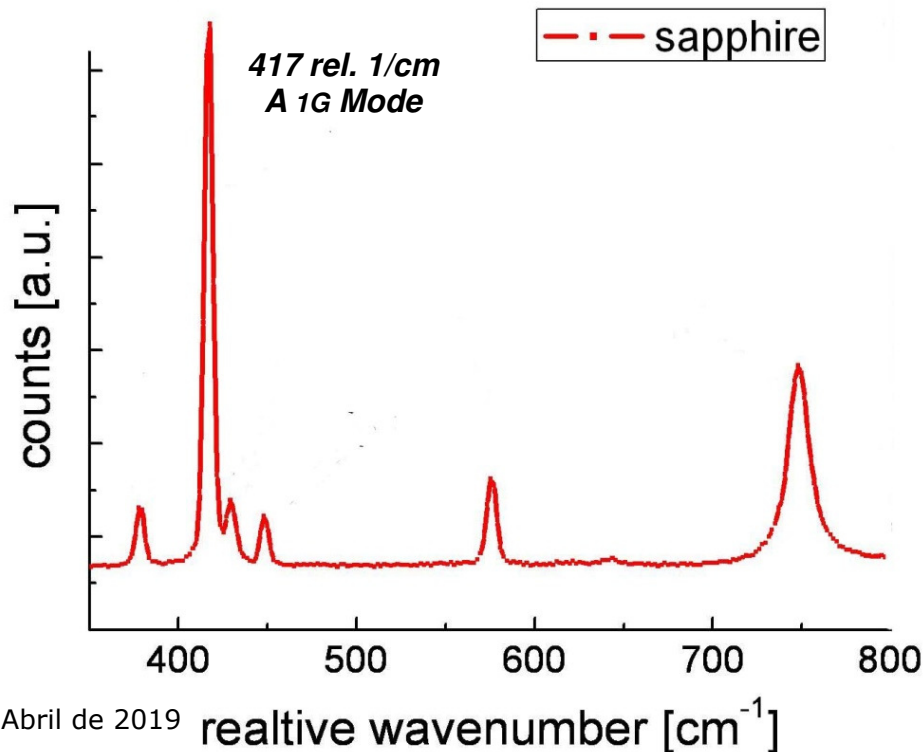
Chocolate Blanco (toblerone)

▣ Sacharose, Maltose and Fats

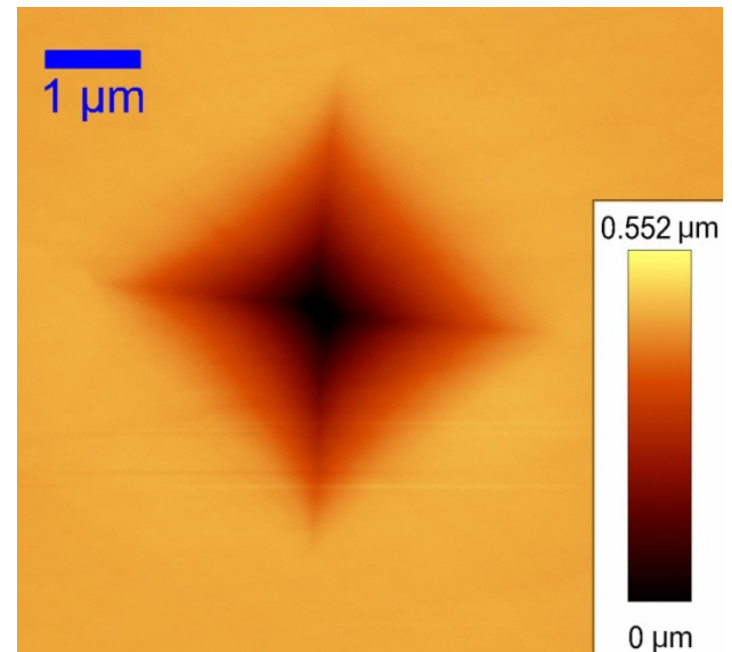


Medidas de Tensiones Residuales

***Sample: Vickers Indent in Single Crystal Sapphire
Internal Stress Measurement based on Peak Shift of Raman Spectrum***



AFM Image of Vickers Indent

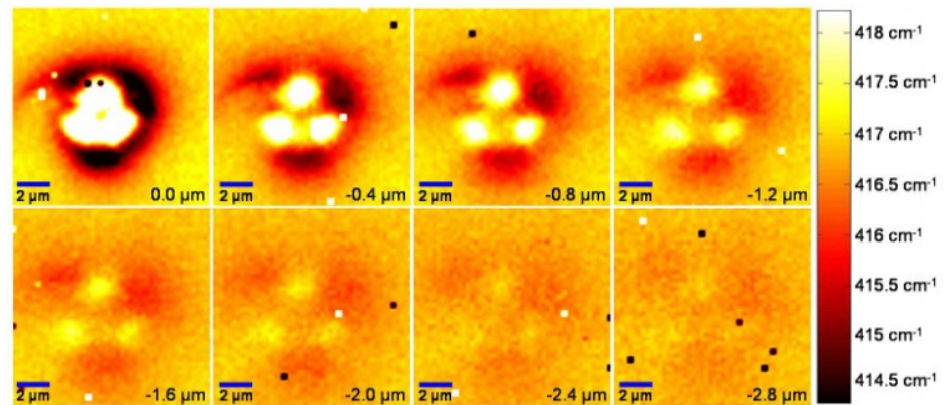


Reconstrucción 3D

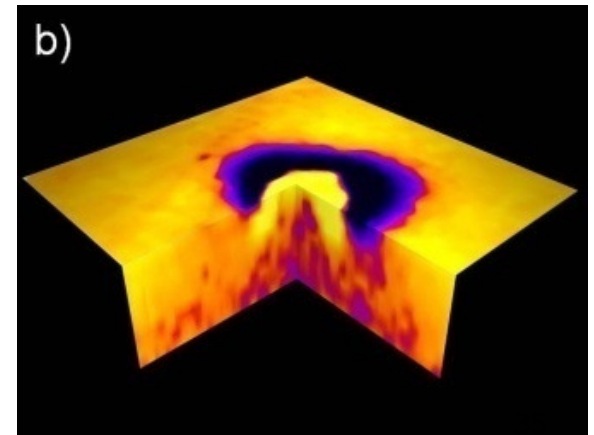
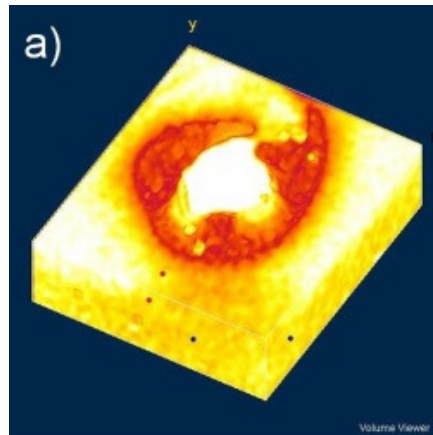
***Sample: Vickers Indent in Single Crystal Sapphire
Visualization of Stress Distribution***



***Layer by Layer
Visualization***



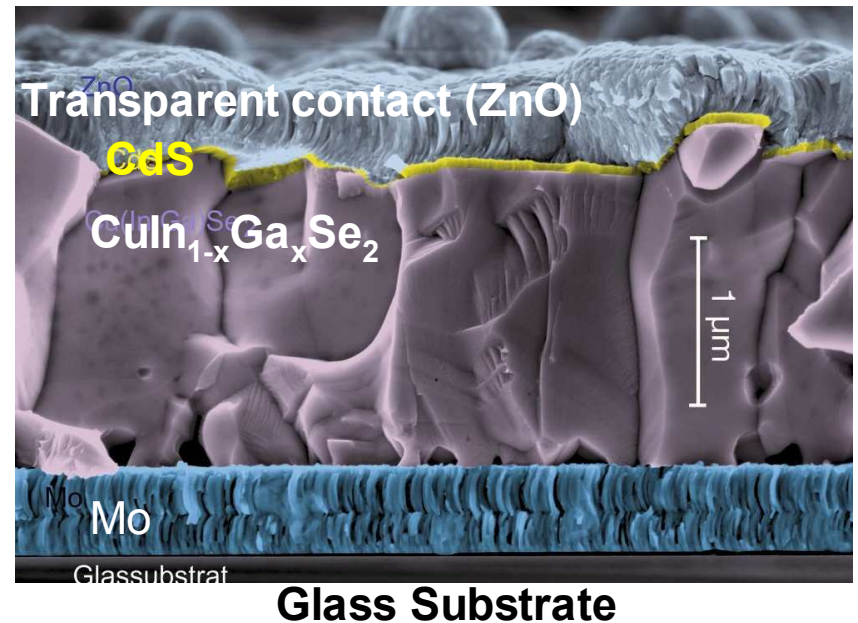
3-D Reconstruction



Aplicación Celdas Solares

Composition of a CIGS ($\text{CuIn}_{1-x}\text{Ga}_x\text{Se}_2$) solar cell

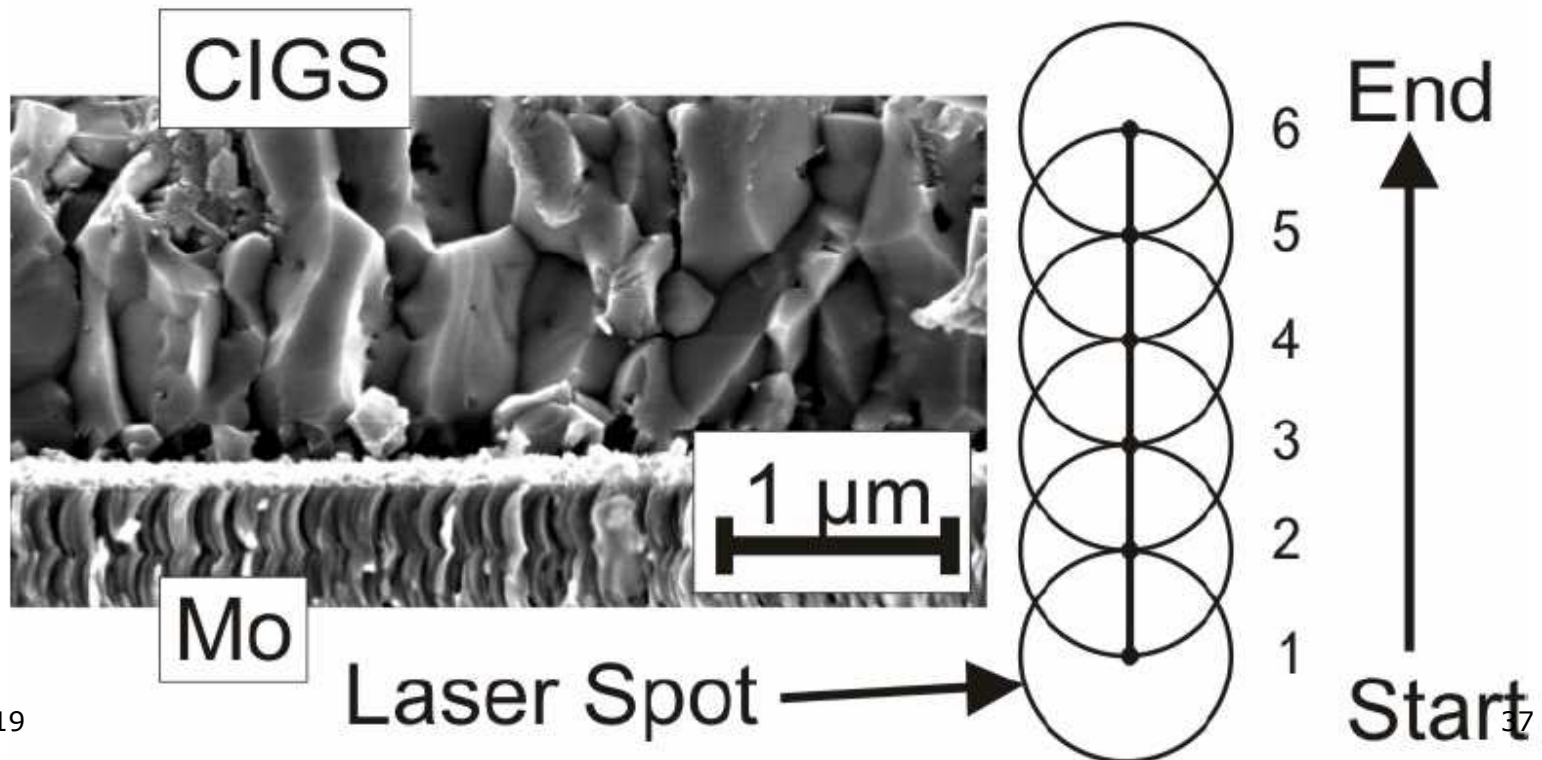
- Multilayer structure
- Ga concentration increases the bandgap energy
 - increase of efficiency of solar cells
- Interface between CIGS and Mo back contact
 - Formation of a MoSe_2 compound
=> ohmic type contact
- Experimental Parameter:
 - Frequency doubled NdYAG laser
- Samples:
 - Cu poor composition of CIGS
 - Ga concentration is varied from $x = 0$ (CIS) $\rightarrow x = 1$ (CGS)



Mapping: Variación de Concentración con posición

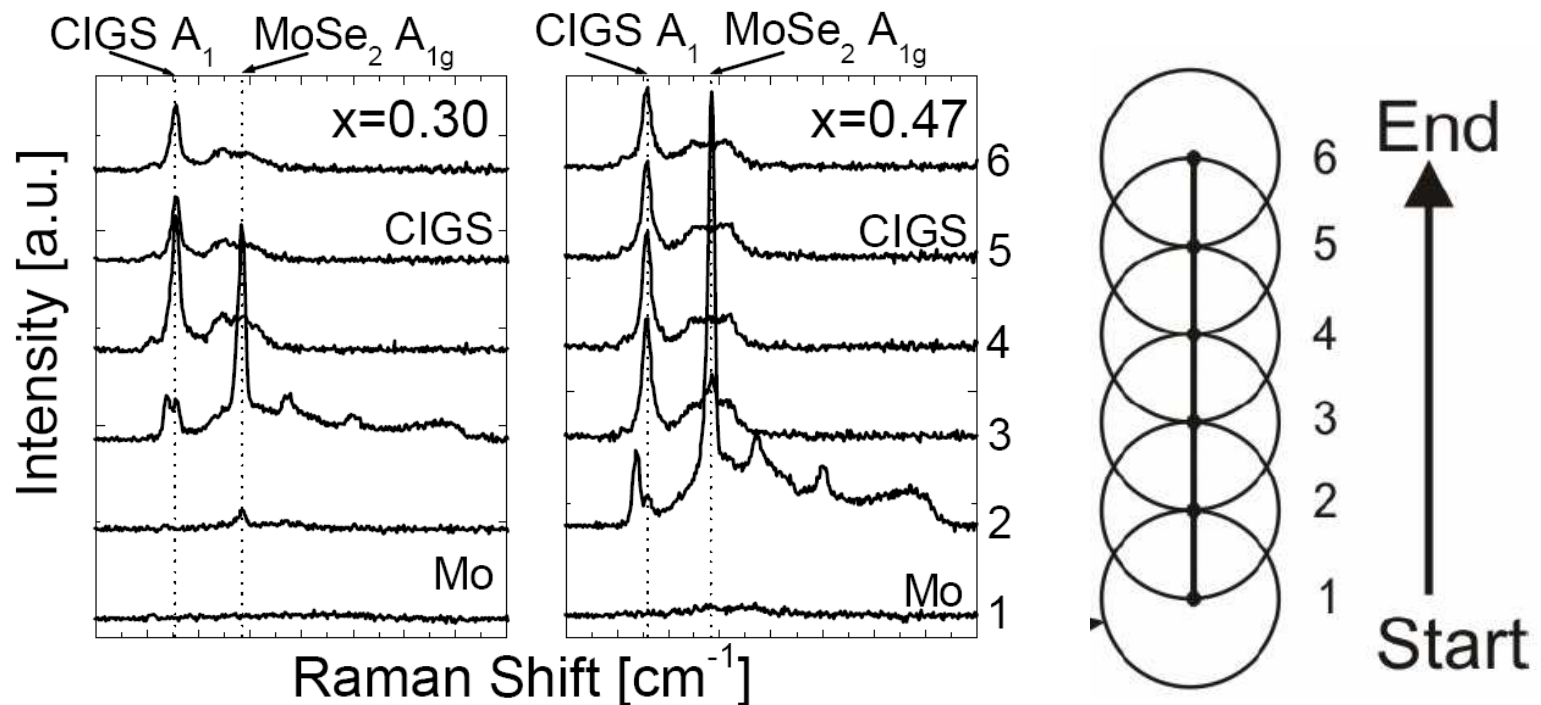
Composition of a CIGS ($\text{CuIn}_{1-x}\text{Ga}_x\text{Se}_2$) solar cell

Raman line scans on cross-sections to identify MoSe_2 interface layers

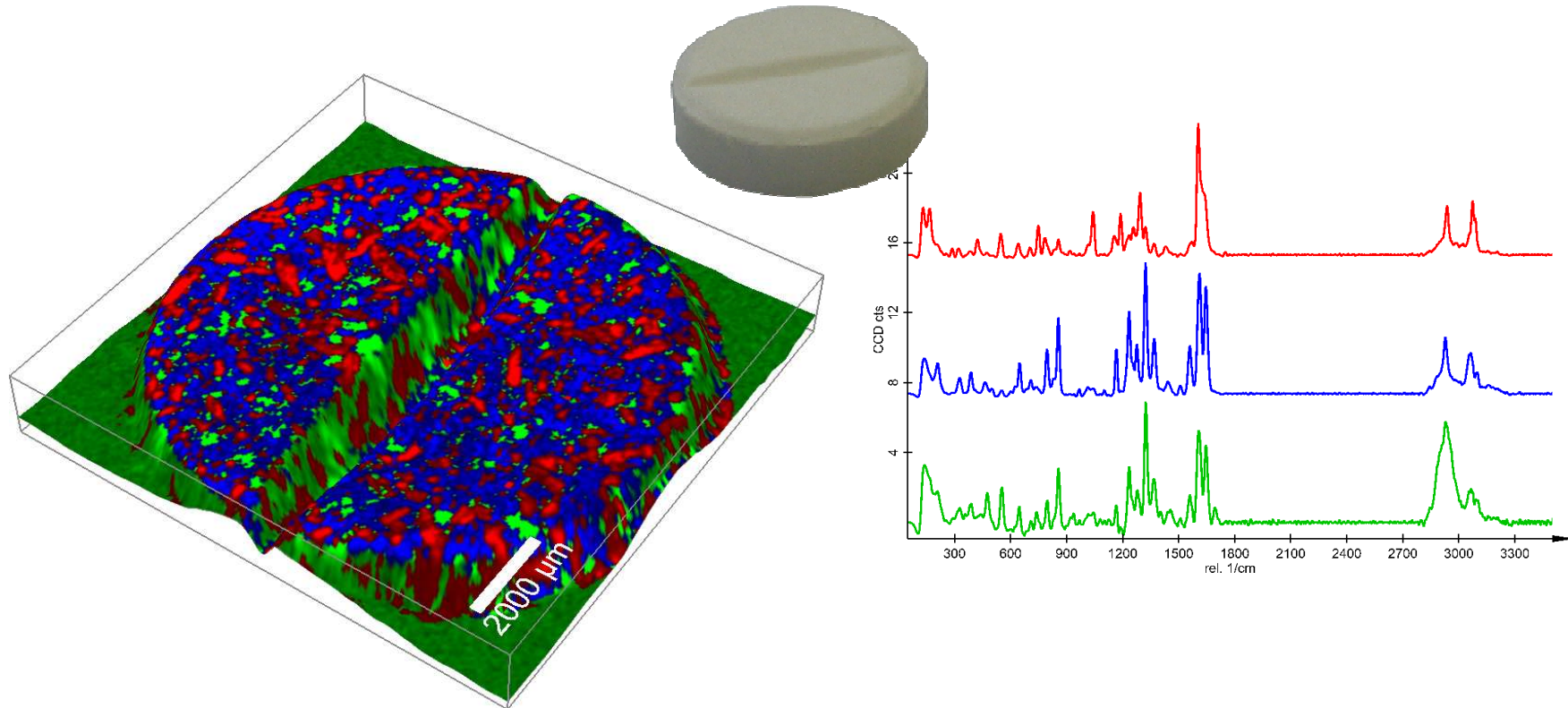


Mapping de Variación de Concentración con posición

Raman line scans on cross-sections to identify MoSe₂ interface layers



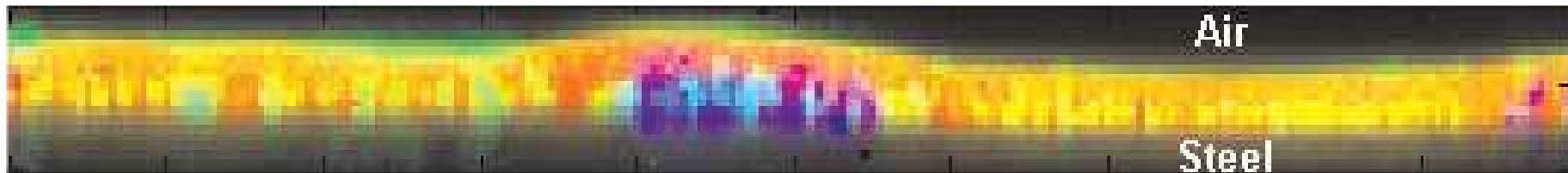
Tabletas: API y Excipientes



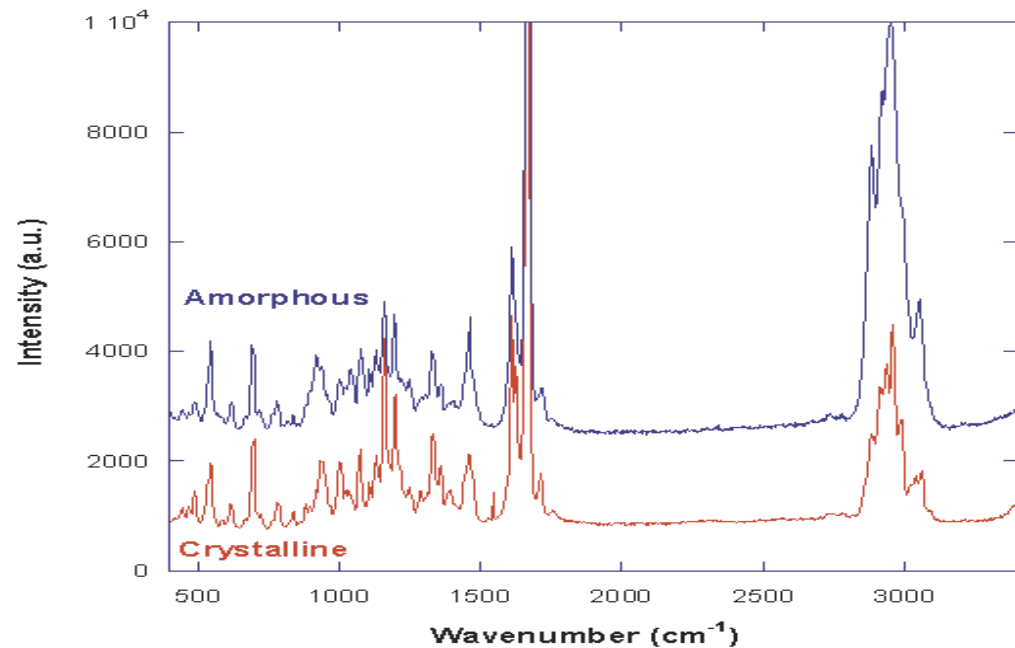
Confocal Raman Image overlaid
on the topography

Corresponding Spectra
Red & Blue : API
Green : Excipient

Stents para Drug Delivery



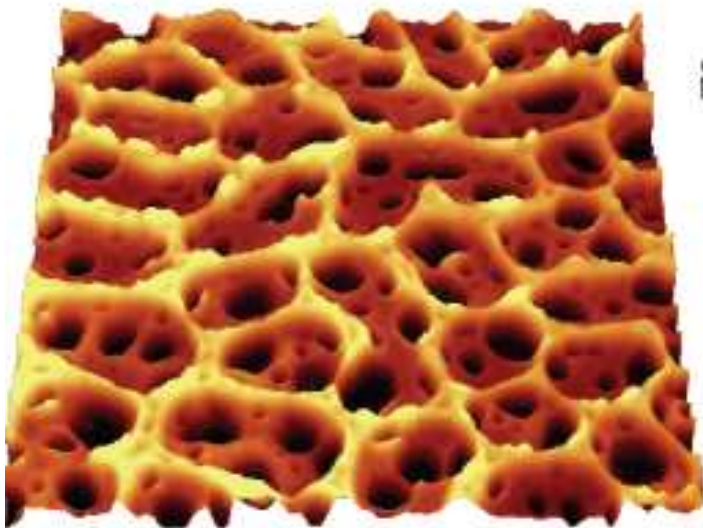
Raman cross-sectional image
of a coating of a drug plus
polymer on a stent.
Polymer (red),
amorphous drug (green),
crystalline drug (blue),
polymer + amorphous drug (yellow).
100x 10 microns scan.



Polímeros

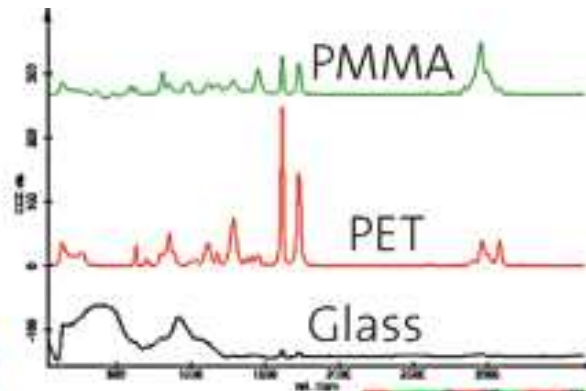
Thin Film of PMMA - PET

AFM image

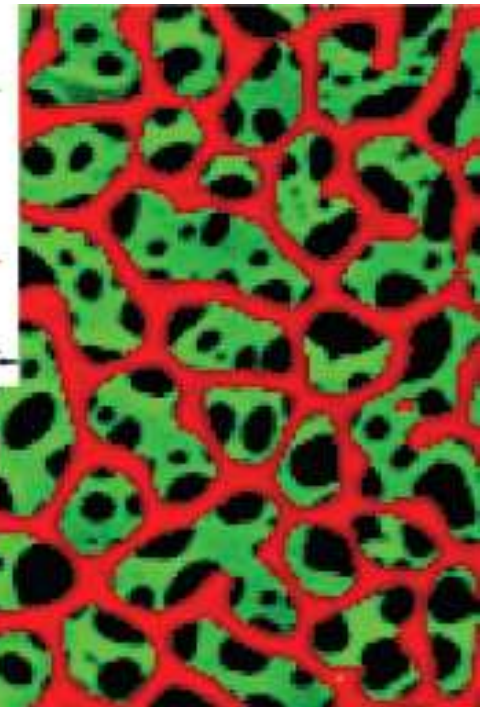


A
20x20x0.2 μm^3 scan area

Raman image



C



B

20x20 μm^2 scan area, 150x150 pixel
•0,05 s integration time
•total 22500 spectra

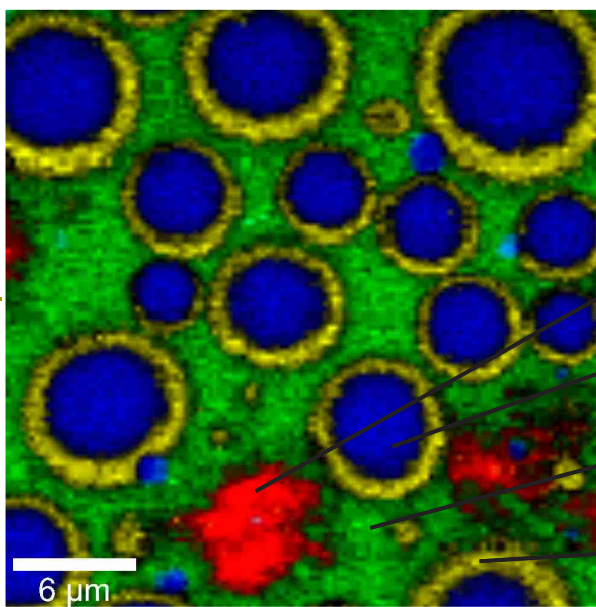


Fig. 2a: Raman Image of an emulsion used in food production. Scan range: 30 μm x 30 μm , 120x120 pixels (=14400 spectra, 532 Nd:Yag Laser for excitation, 100 x oil objective (NA=1.25)). Red + green: fatty matrix, blue: aqueous phase, yellow: emulsifier PGPR

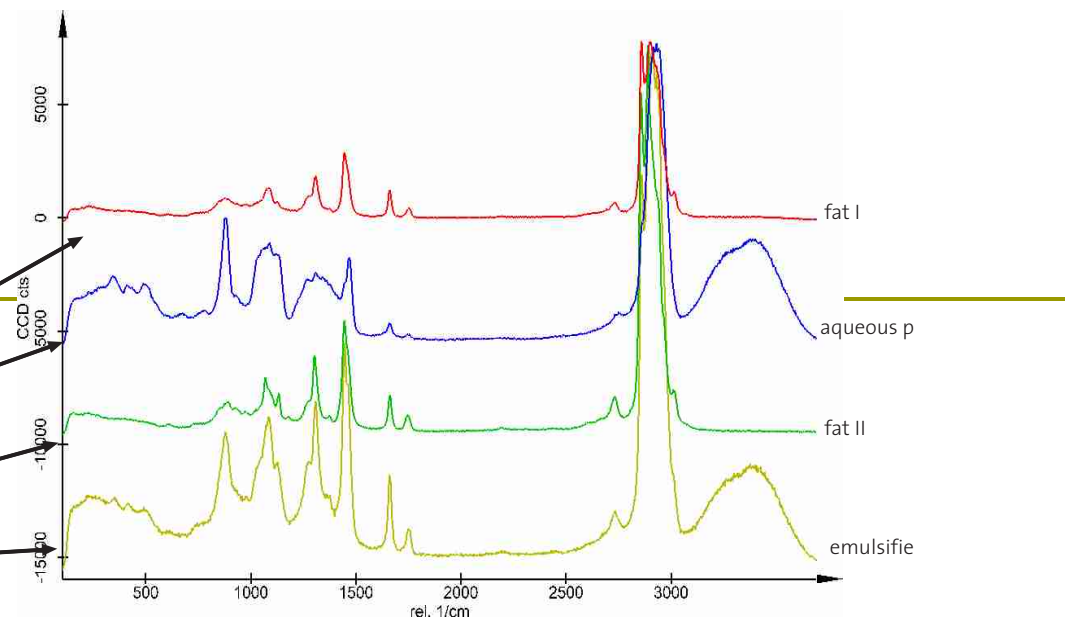
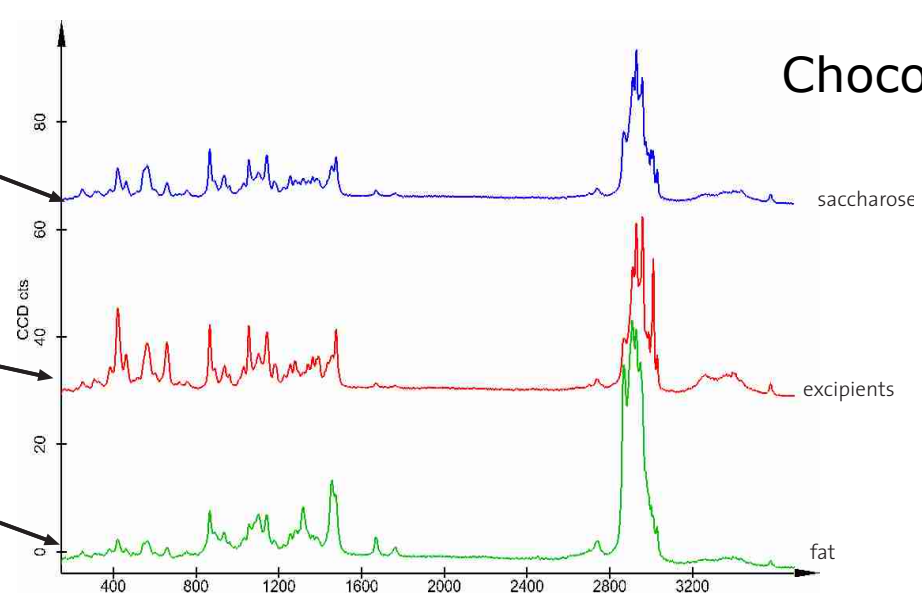
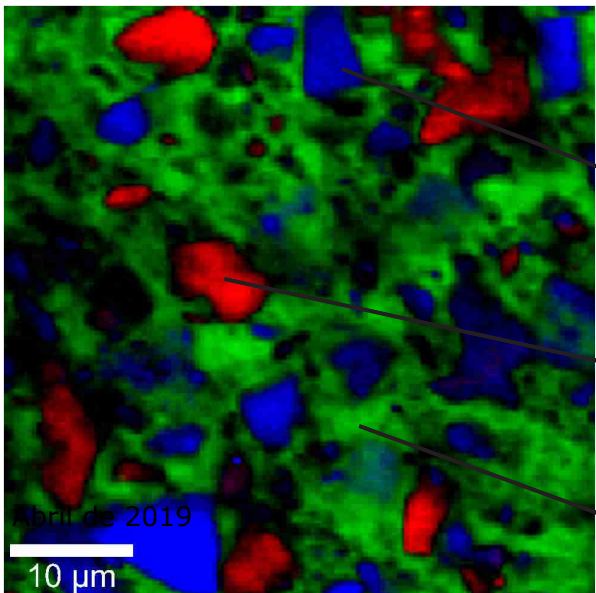


Fig. 2b: Corresponding spectra of the compounds contained within the emulsion.



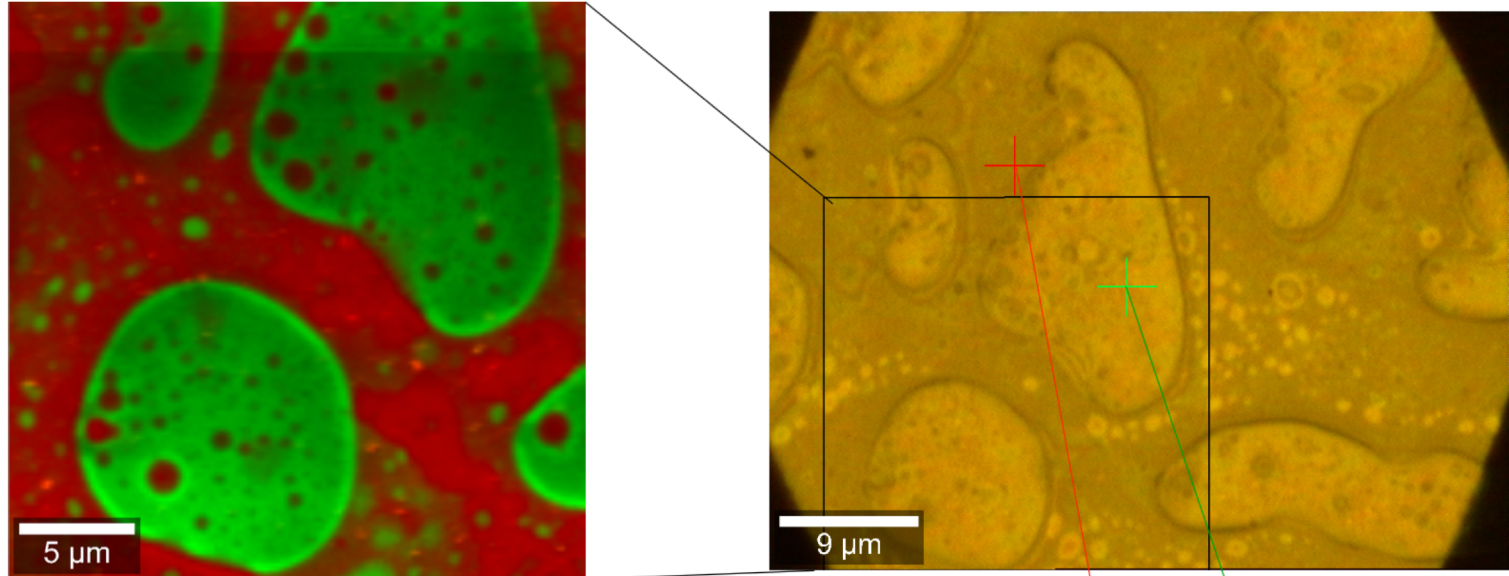
Chocolate blanco

Experiencias



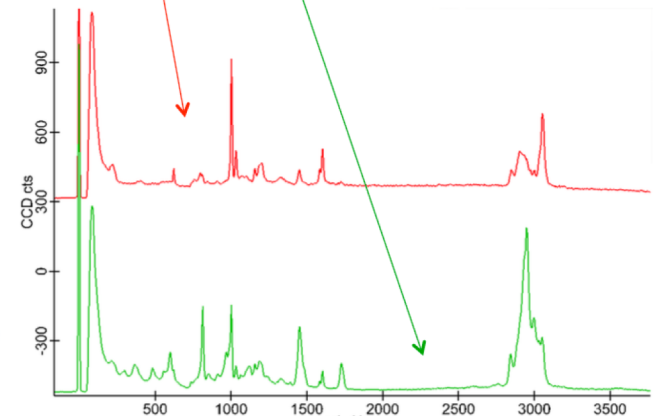
WITec alpha300RA

Ejemplo 1: Blend PMMA+PS



Mezcla de Poliestireno (PS) con polimetilmetacrilato (PMMA). Se identifican dos zonas (roja y verde), se obtiene un espectro raman en ambos lugares. El espectro indica que la zona marcada en verde es PMMA y la roja PS

Observando las diferencias en el mapping correspondiente al recuadro negro, donde se obtiene la imagen combinada de ambos componentes.



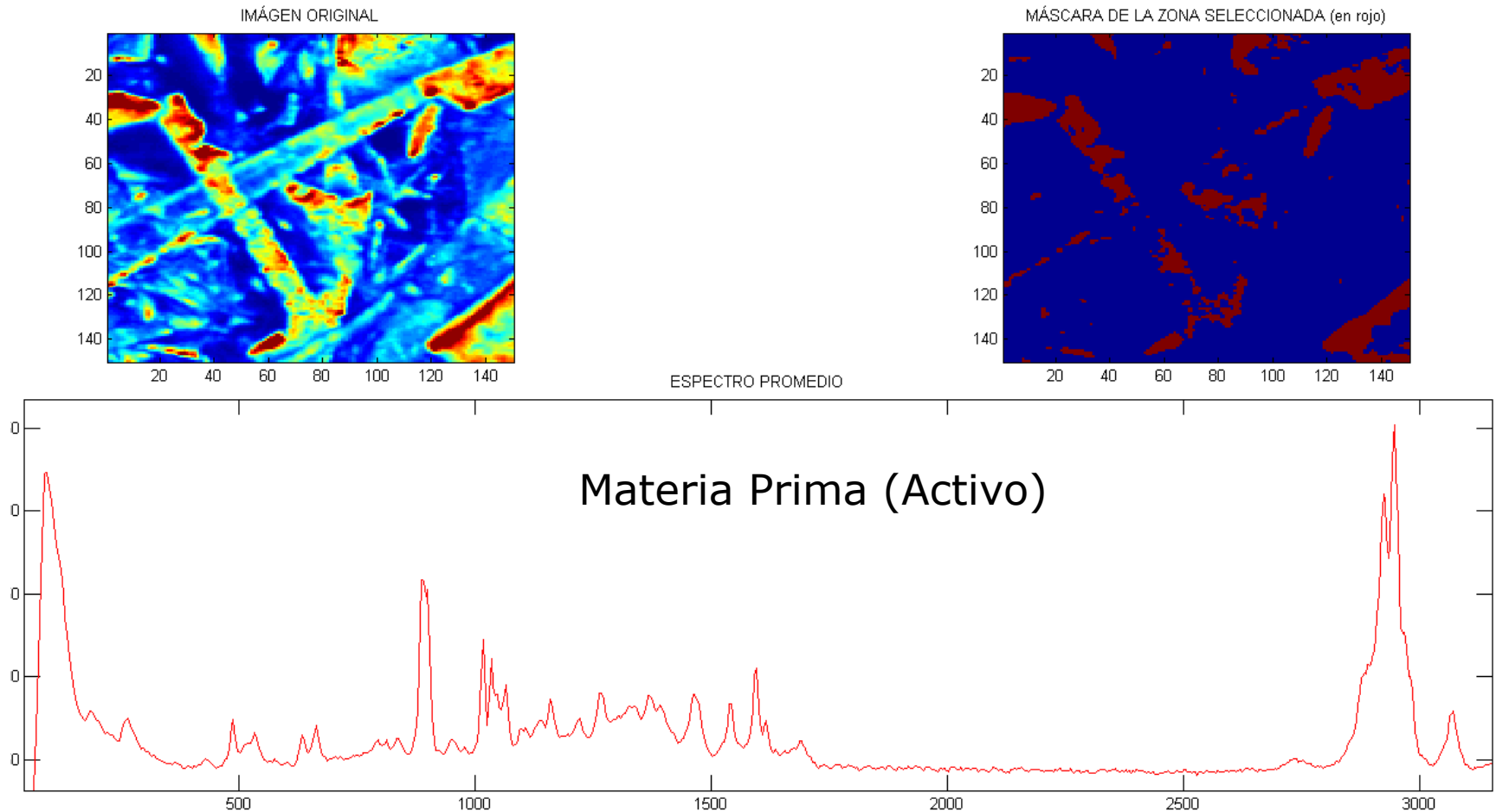
Ejemplo 2: Asesoramiento

- Ejemplo de identificación de componentes:
 - Activo
 - Excipientes

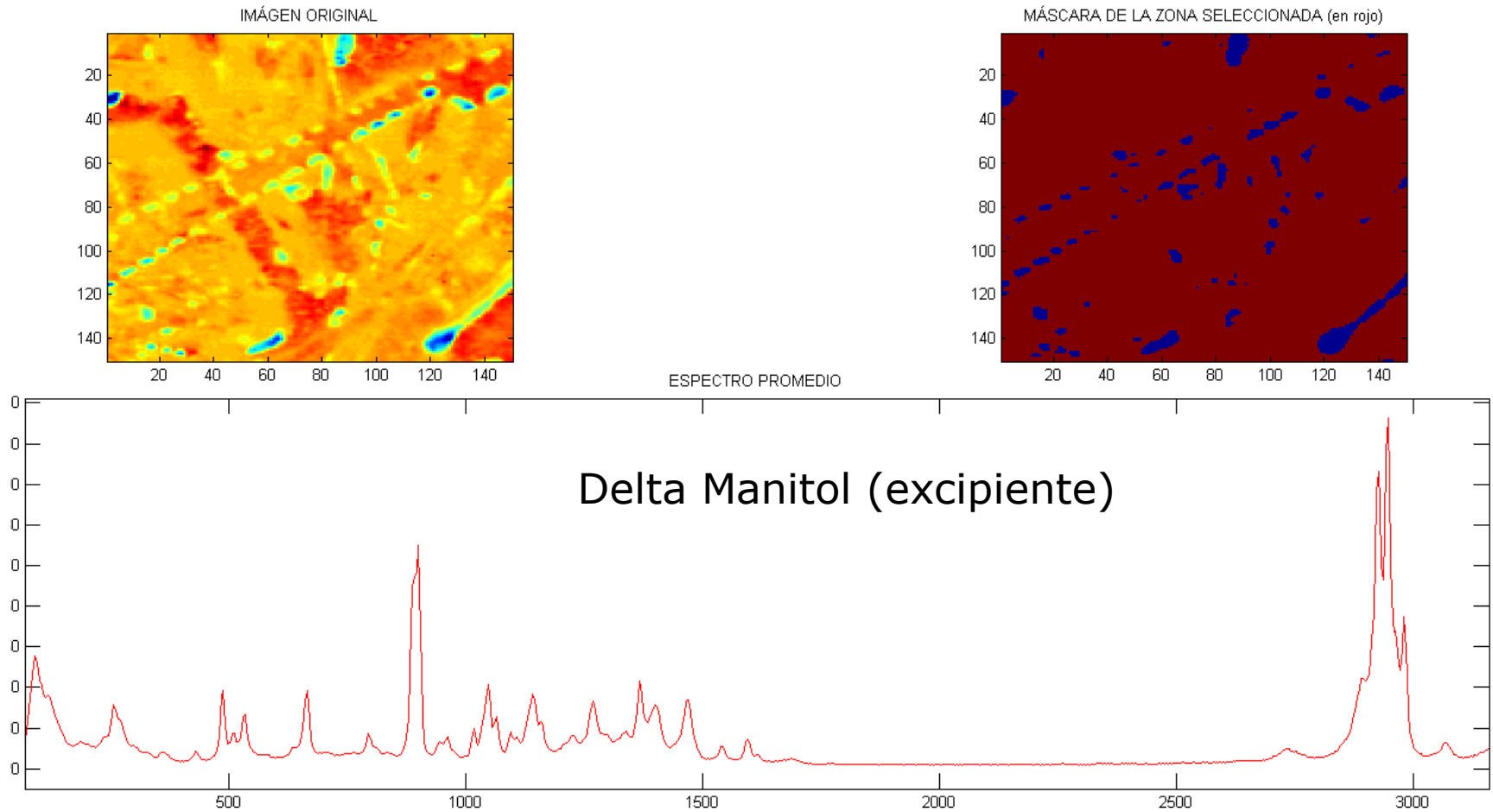
- Primero se realiza Análisis por Componente Principales (PCA)

- Luego se procede a la generación de imágenes con el software Project FOUR

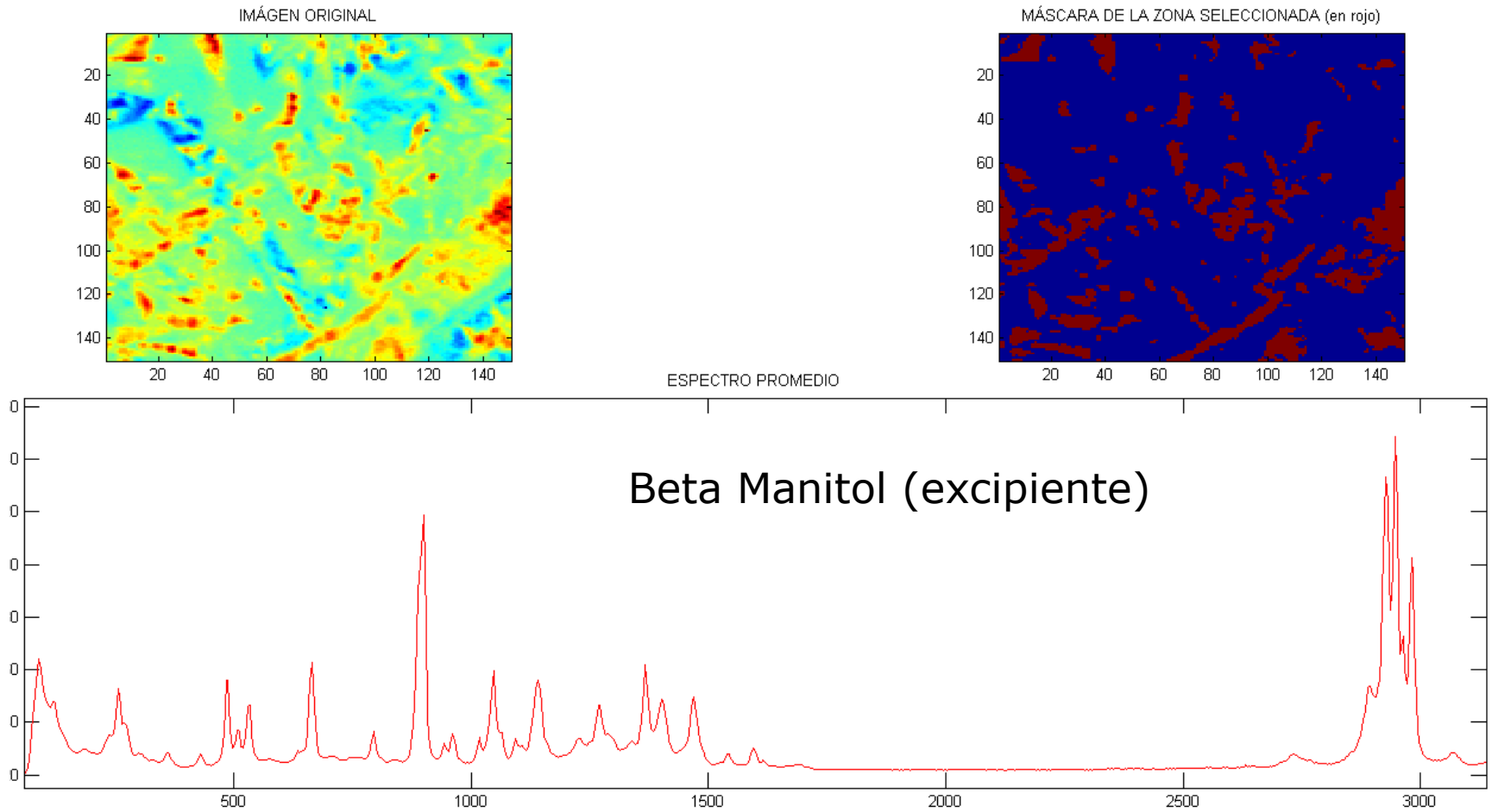
PCA: Componente 1



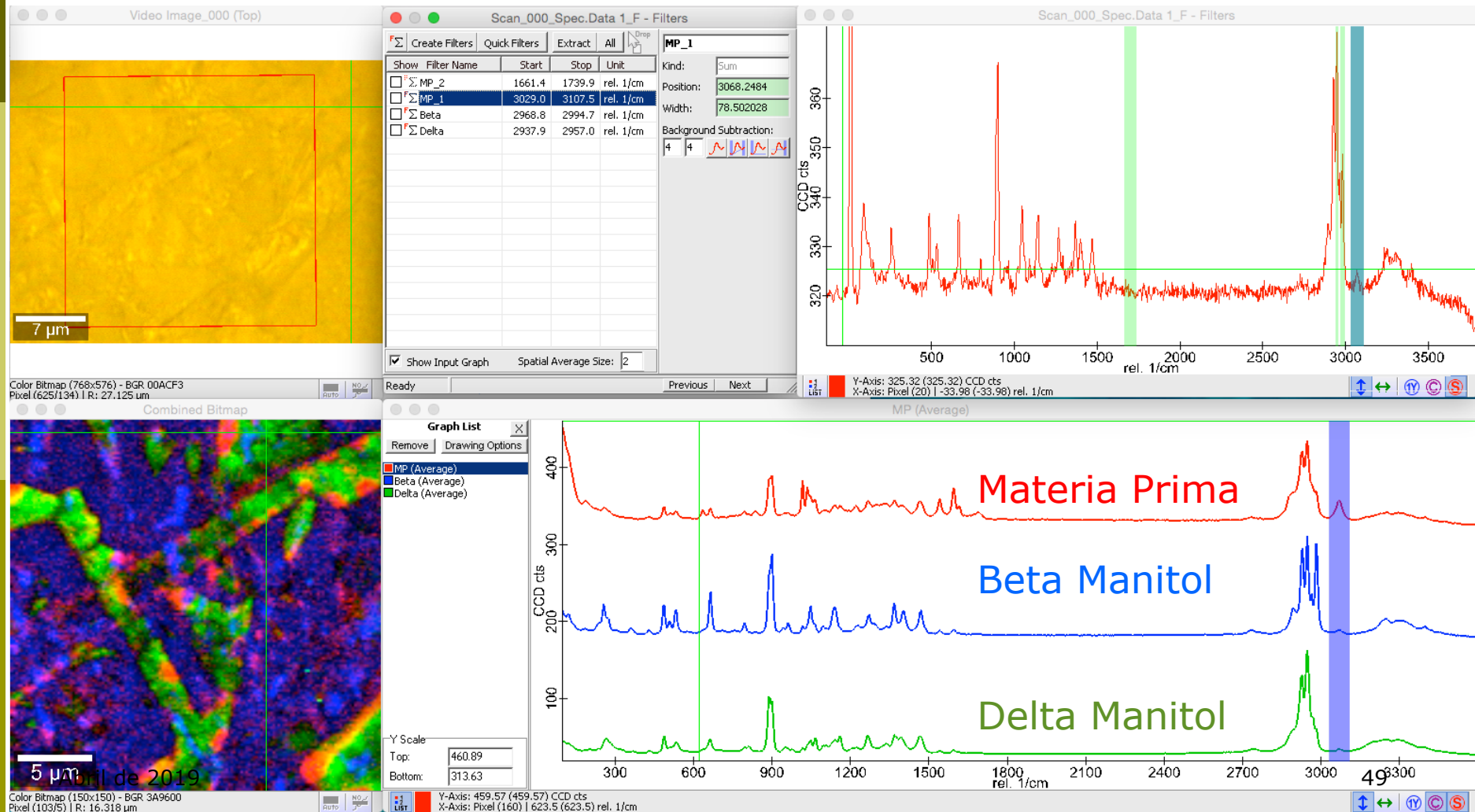
PCA: Componente 2



PCA: Componente 3



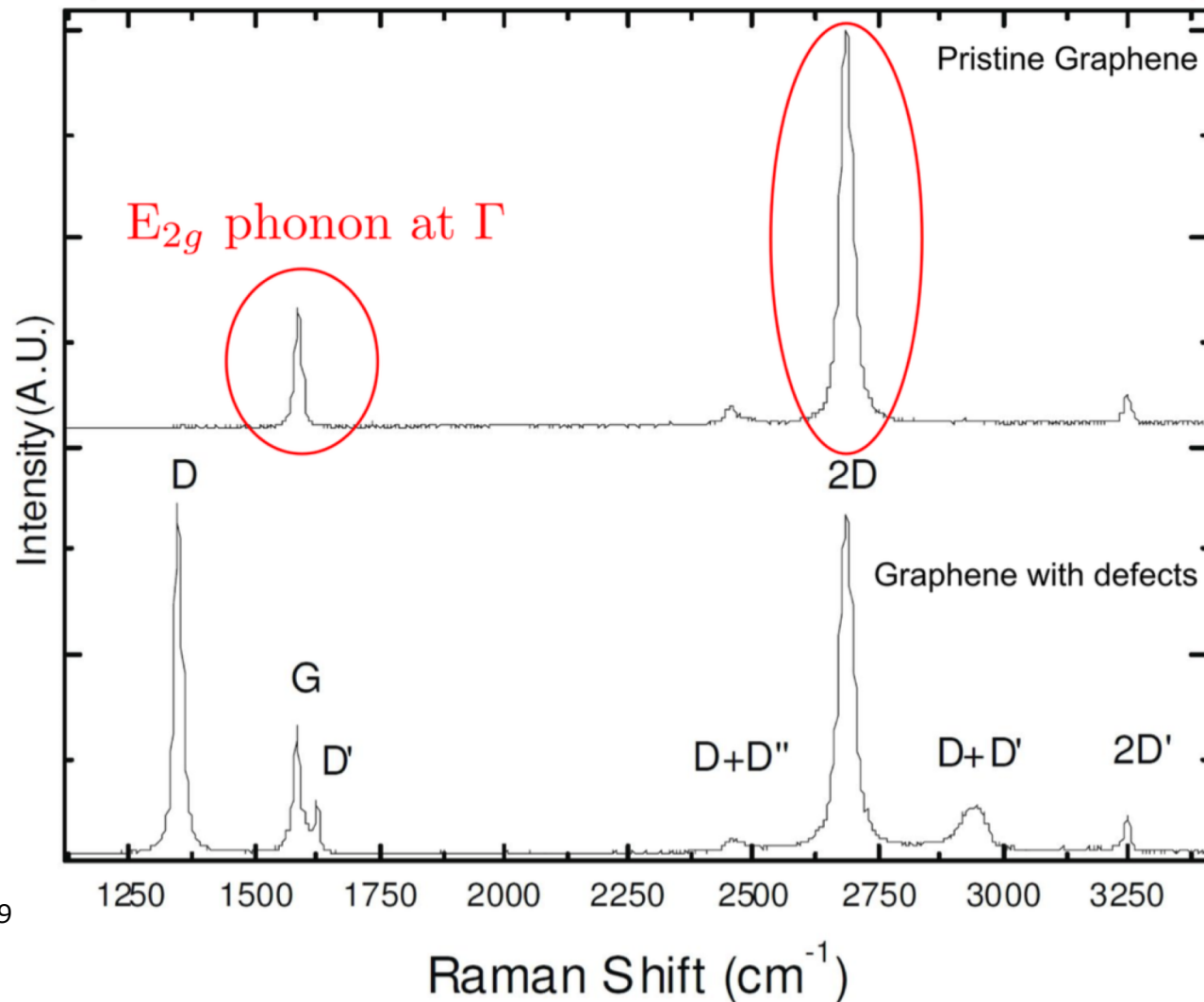
Formulaciones: Mannitol+ API



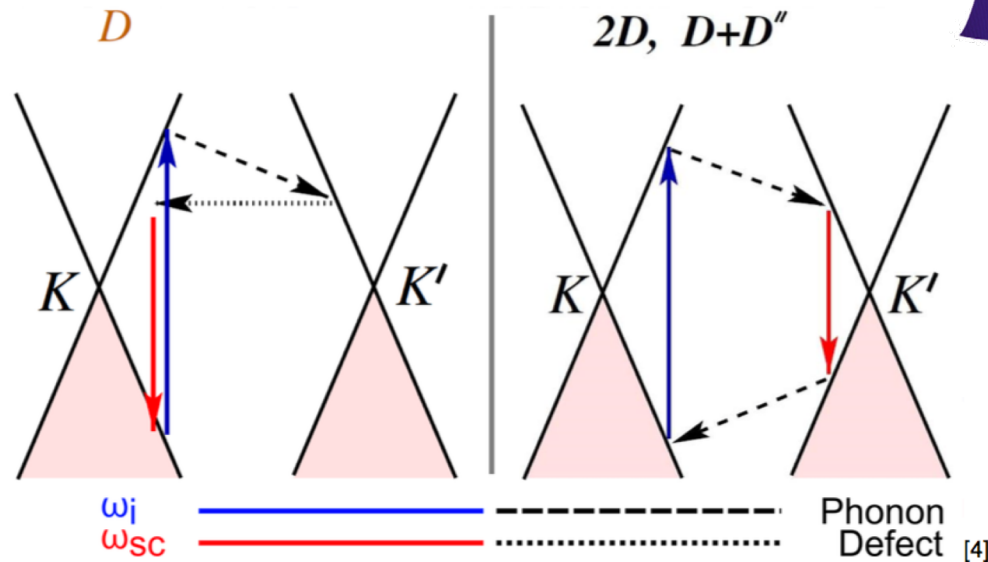
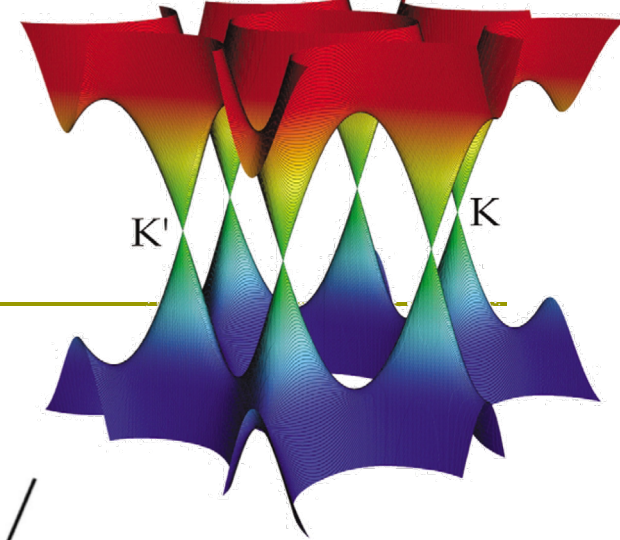
Conclusión:

- ❑ 1 solo activo
- ❑ 2 excipientes:
 - Manitol forma Beta
 - Manitol forma Delta

Ejemplo 3: Grafeno



Ejemplo 3: Grafeno



D

- Intervalley scattering with TO phonon at K-point, $\vec{q}_{ph} \neq 0$
- D peak requires defect scattering to conserve momentum

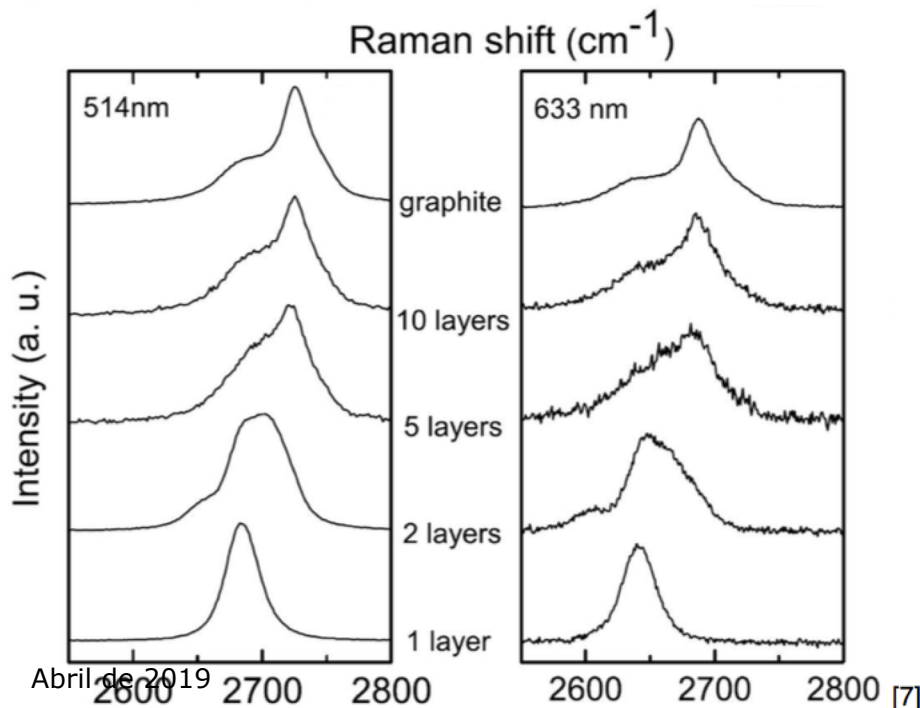
Abril de 2019

2D

- Double-resonant, intervalley scattering^[5] requires no defects
- Strong e⁻-ph coupling: 2D peak is more intense than G

Ejemplo 3: Grafeno

"Position and fwhm of the G and 2D peak(...)confirm presence of single-layer graphene"

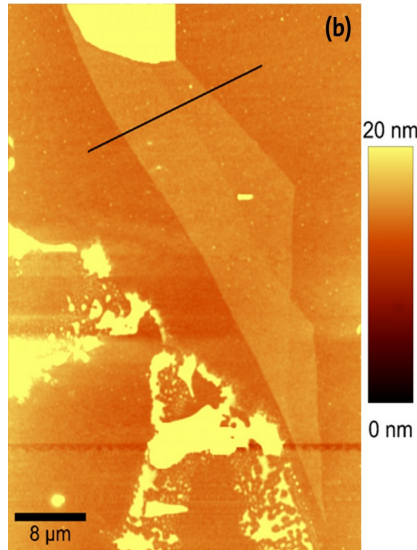


- Position of 2D peak depends on number of layers
- Additional layers increase FWHM of 2D peak (more e^- states for resonant scattering)
- Occurrence of peaks at 1350 cm^{-1} (D) and 1620 cm^{-1} (D') reveal defects of graphene sample

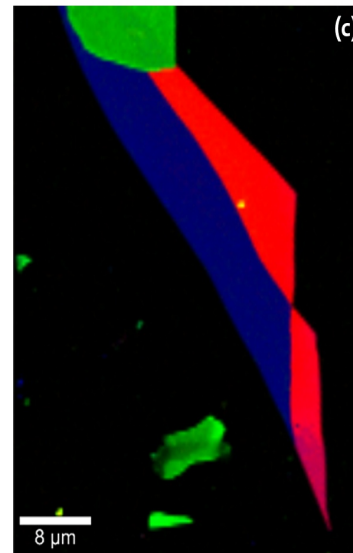
Ejemplo 3: Grafeno y MLG



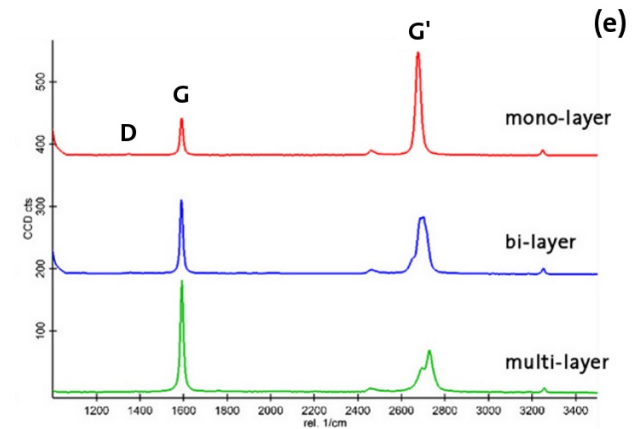
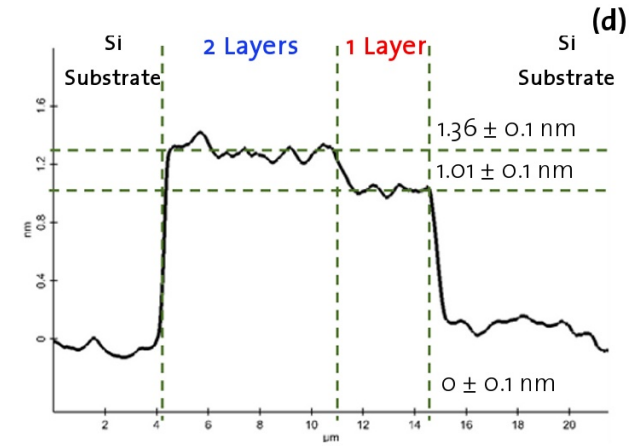
Óptica



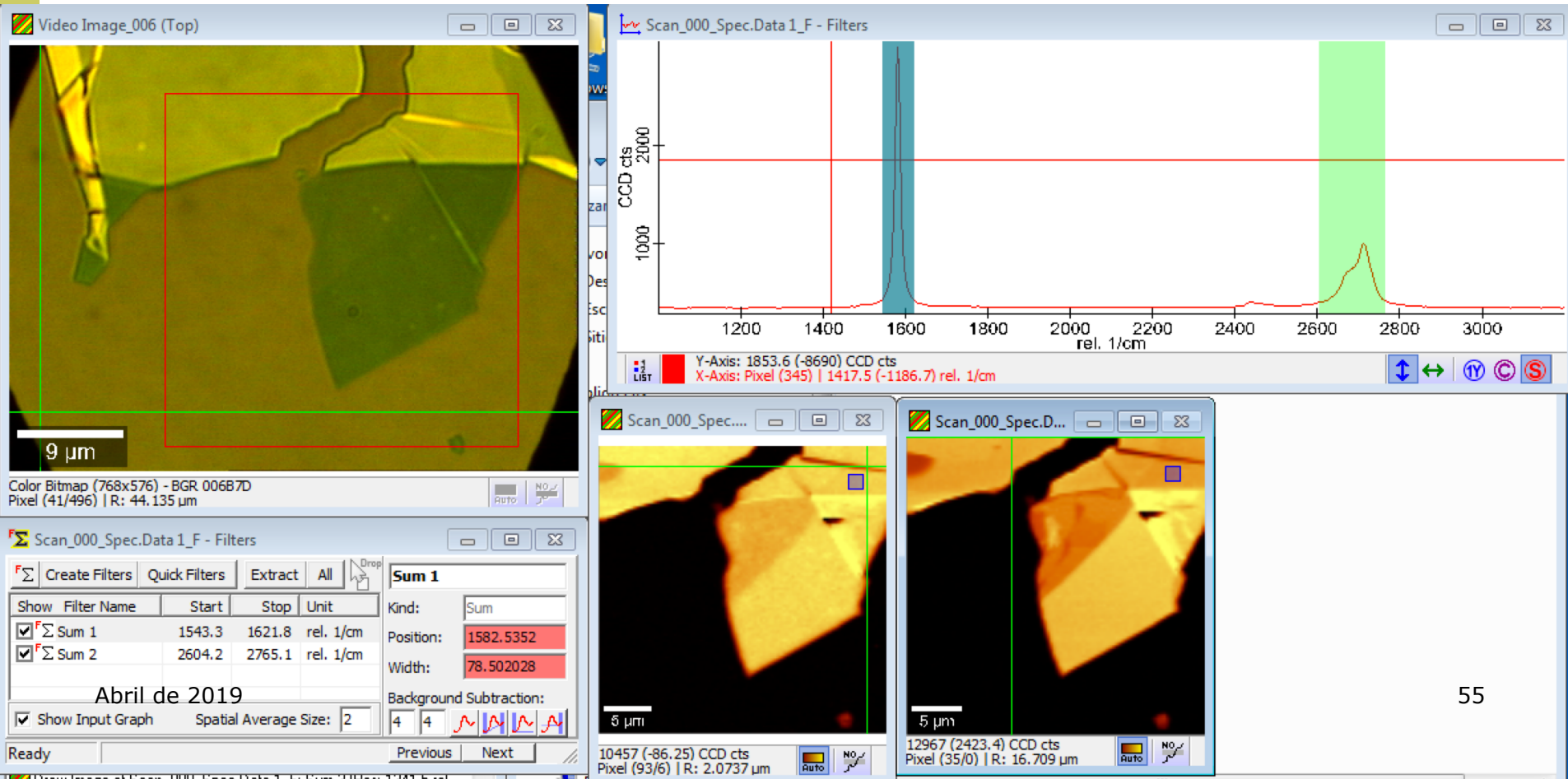
AFM



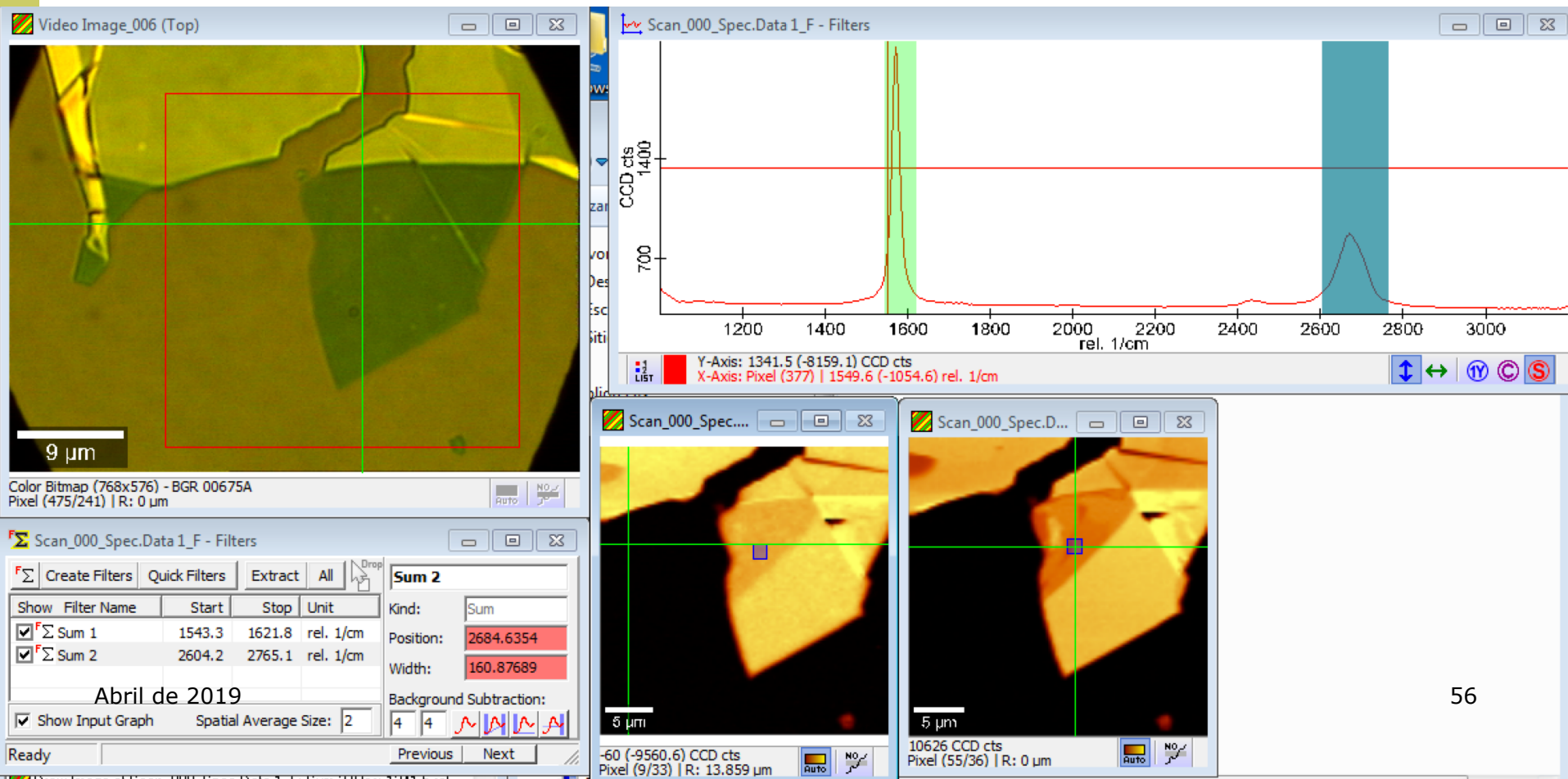
Raman



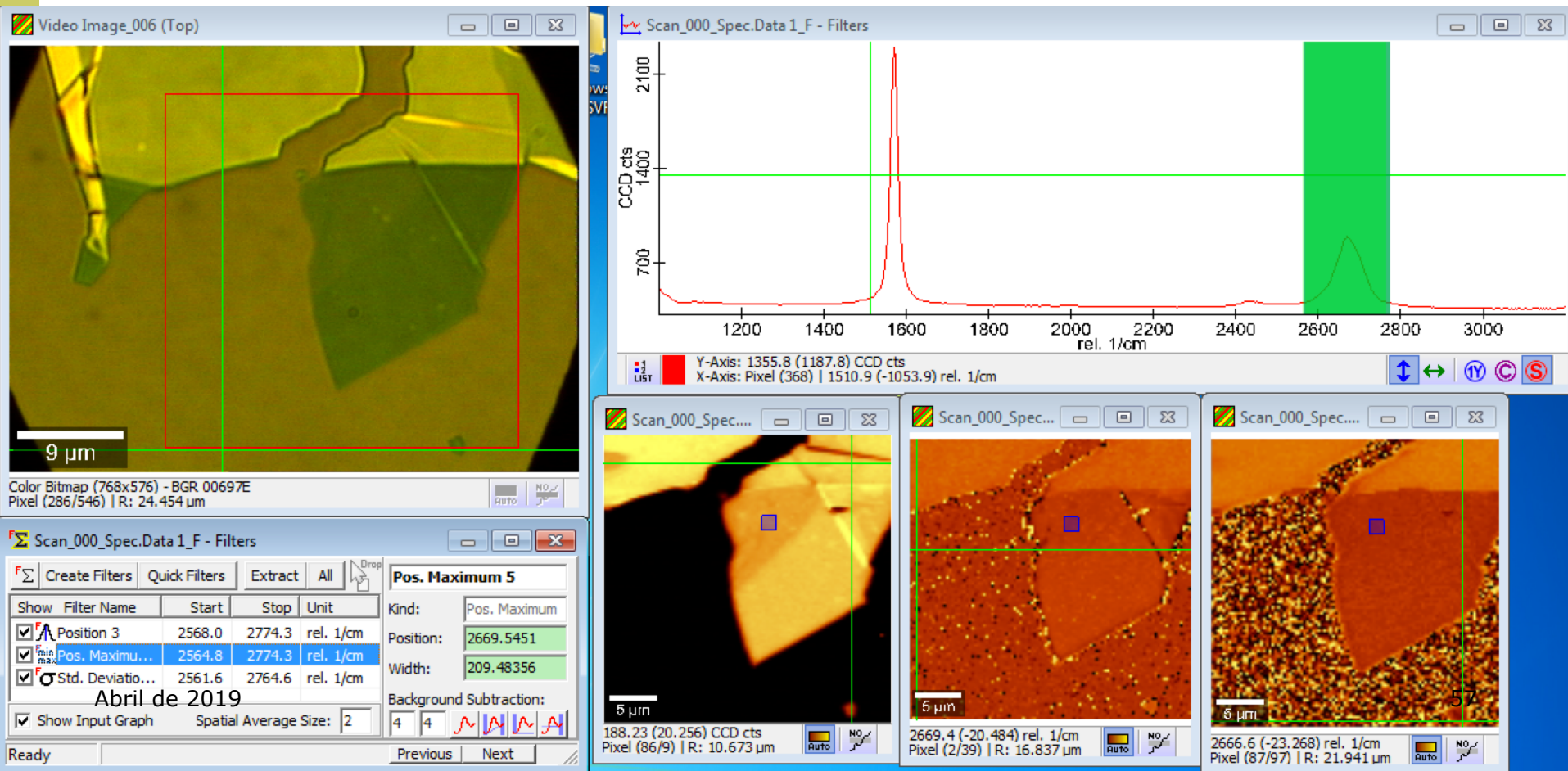
Ejemplo 3: Grafeno



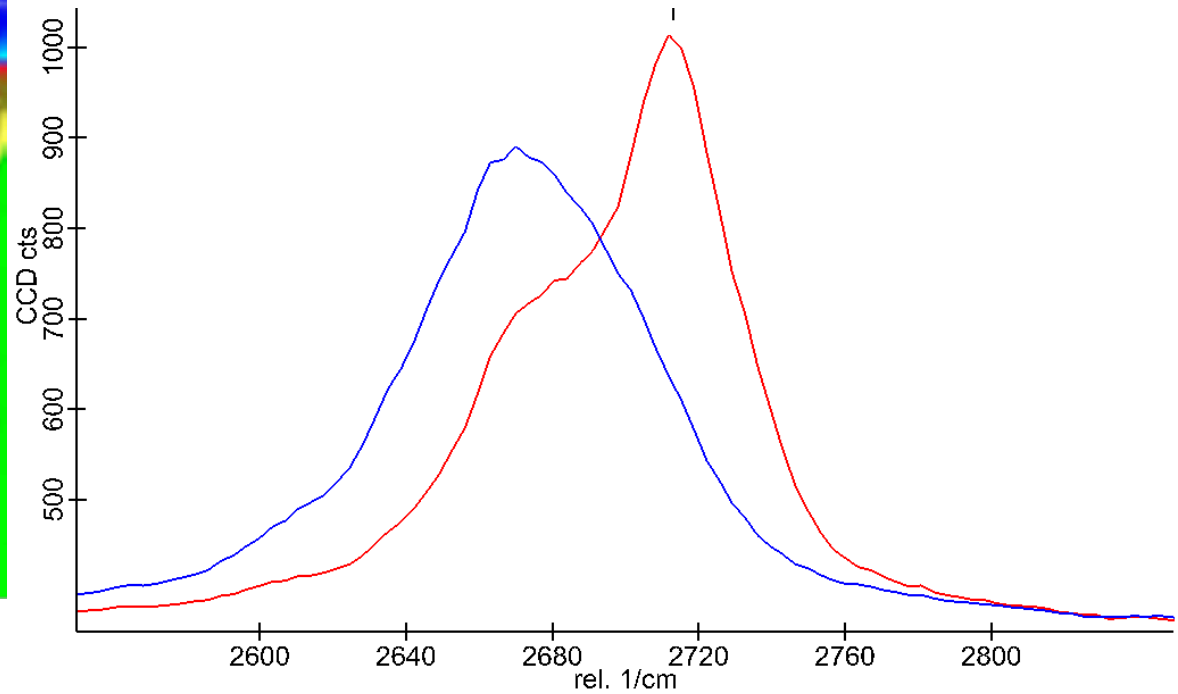
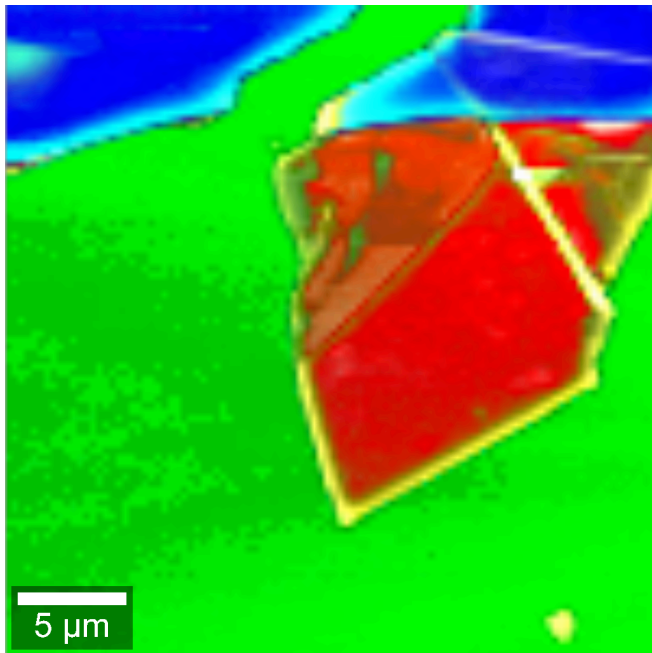
Ejemplo 3: Grafeno



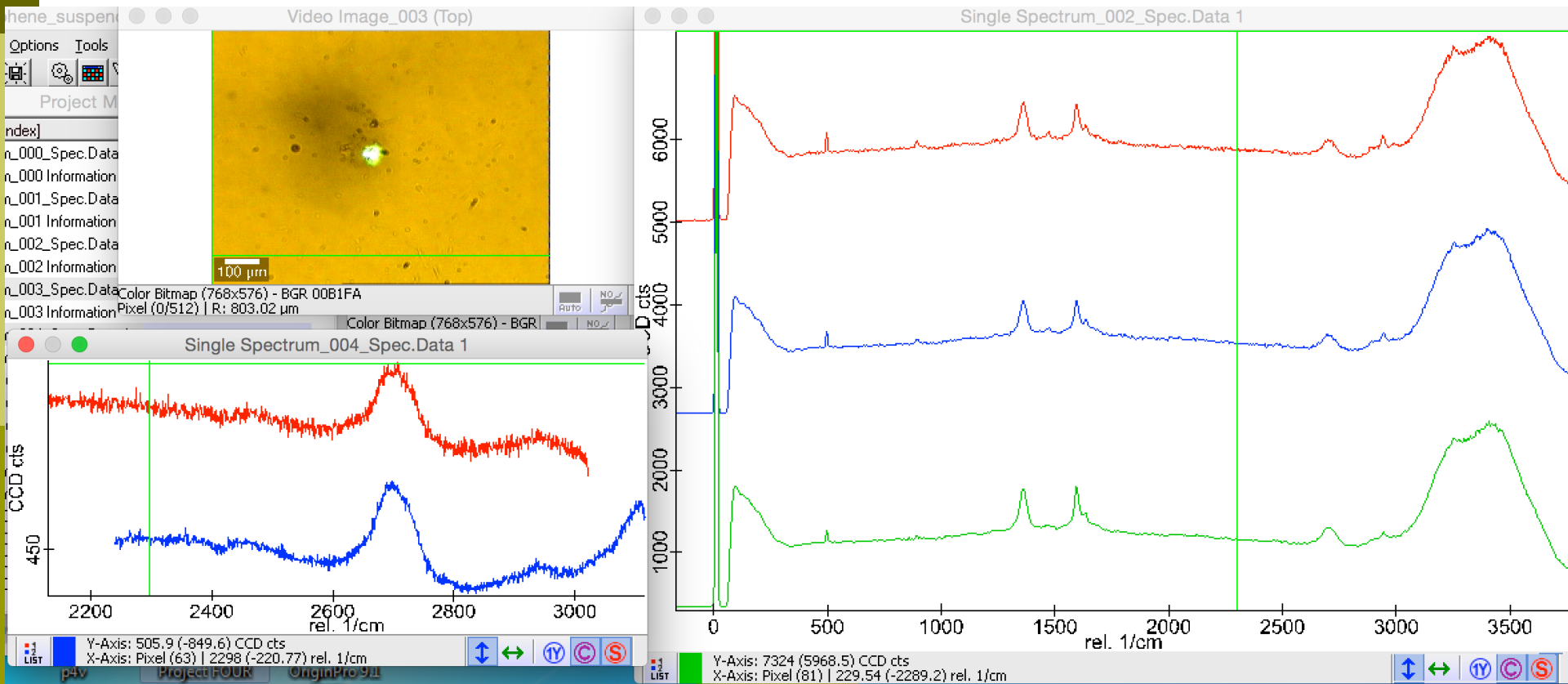
Ejemplo 3: Grafeno



Ejemplo 3: Grafeno



Ejemplo 3: Grafeno en Solución



Ejemplo 3: Cuantificación de Defectos

Phil. Trans. R. Soc. A (2010)

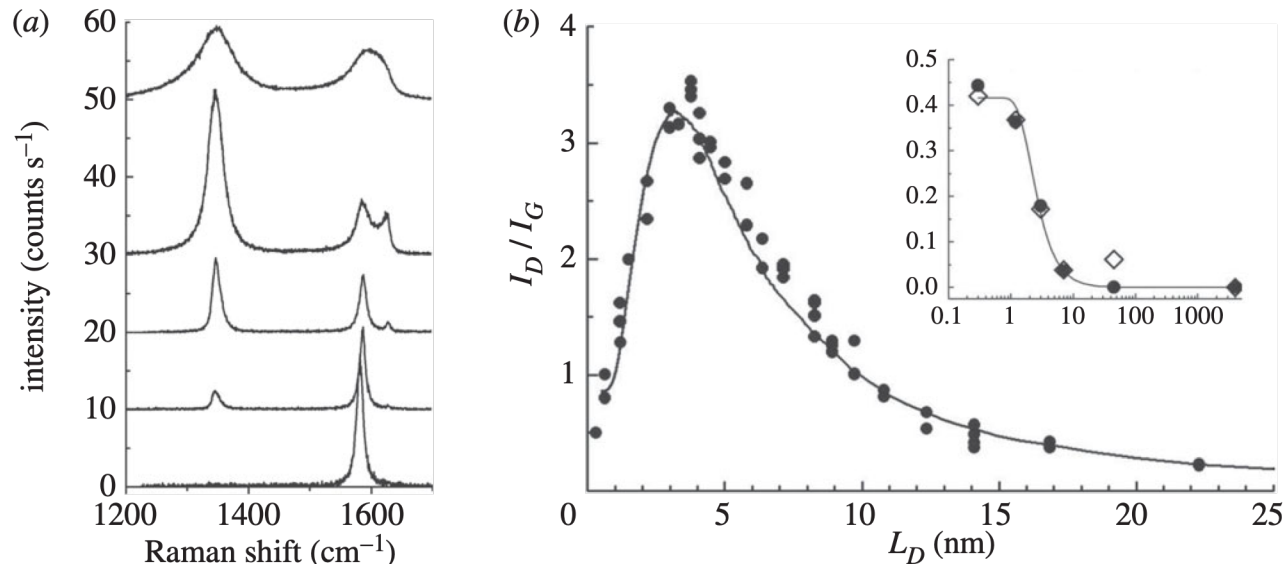


Figure 3. (a) Evolution of the first-order Raman spectra (using a $\lambda = 514$ nm laser) taken from a graphene monolayer sample deposited on an SiO_2 substrate, subjected to Ar^+ ion bombardment. The ion doses are from the bottom to the top, 10^{10} , 10^{11} , 10^{12} , 10^{13} and 10^{14} $\text{Ar}^+ \text{cm}^{-2}$ (Lucchese *et al.* 2010). (b) The I_D/I_G data points from three different monolayer graphene samples as a function of the average distance L_D between defects. The solid line is a modelling of the experimental data with equation (3.1). The inset shows a plot of I_D/I_G versus L_D on a log scale for L_D for two samples: (i) open points for an approximately 50-layer graphene sample and solid circles are for a small piece of HOPG near a graphene piece and (ii) solid diamond points, for a 2 mm thick bulk HOPG sample, the measured values of which are here scaled by $(I_D/I_G) \times 3.5$ (Lucchese *et al.* 2010).

Ejemplo 4: Nanotubos de Carbono

Fig. 5.1 Different carbon allotropes with nanometer-scale phases ranging from 0D C60 fullerenes, 1D carbon nanotubes, 2D graphene, to 3D diamond and graphite

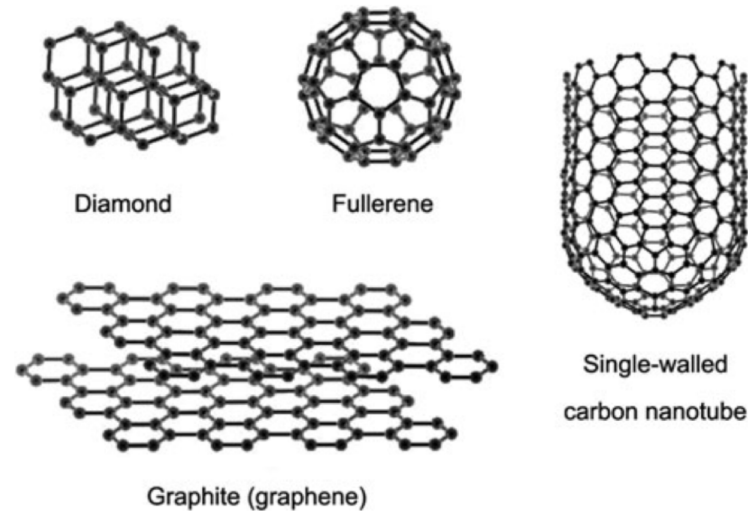
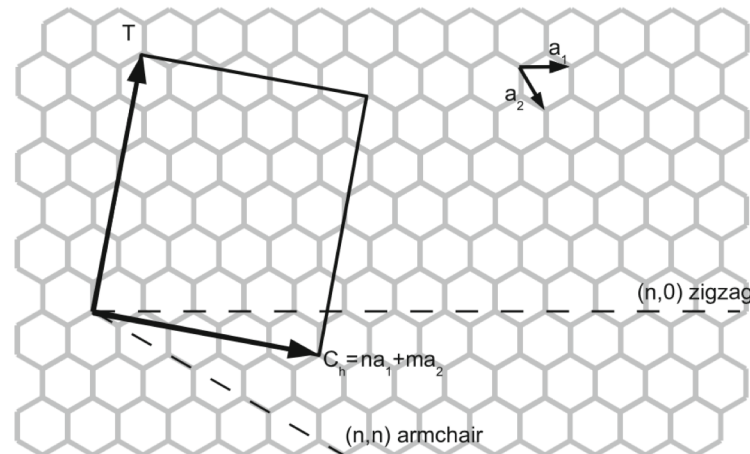
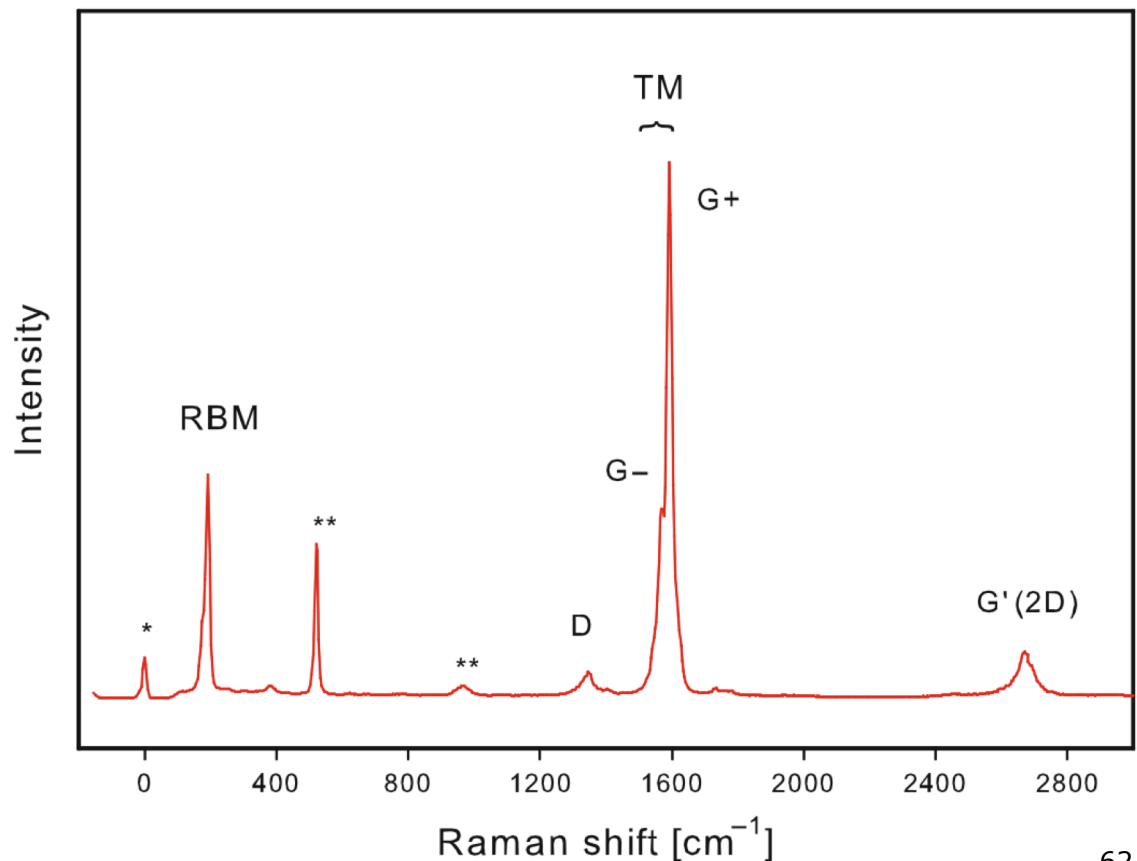


Fig. 5.2 The vector C_h describes how a sheet of graphene is rolled up to create a carbon nanotube [6]



Ejemplo 4: Nanotubos de Carbono

Fig. 5.3 Typical Raman spectrum of an individual single-walled carbon nanotube recorded with a confocal micro-Raman spectroscope using a green 532 nm laser. The feature marked “*” is the attenuated elastically scattered Rayleigh line. Features marked “**” come from the Si support



Ejemplo 4: Nanotubos de Carbono

$$\omega_{\text{RBM}} = \frac{c_1}{d_t} + c_2$$

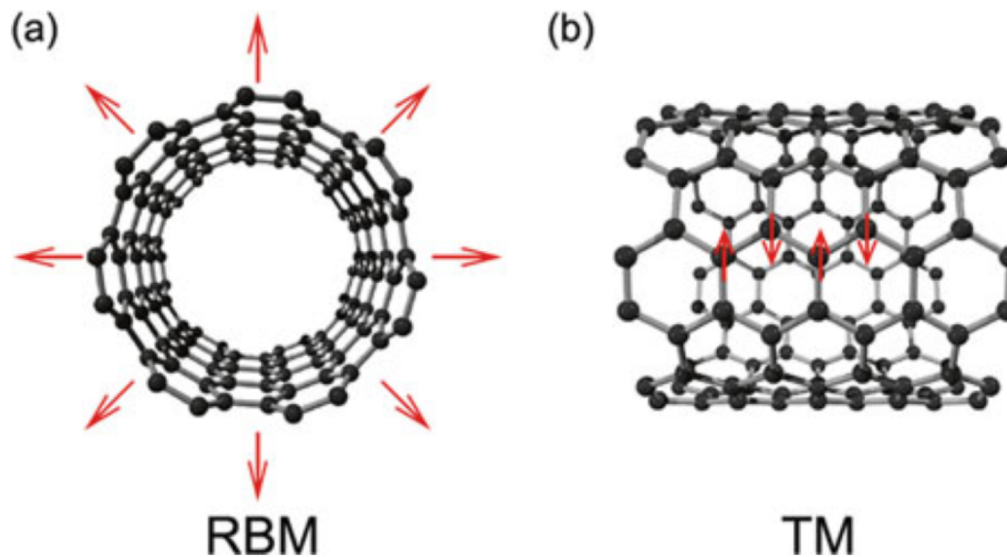
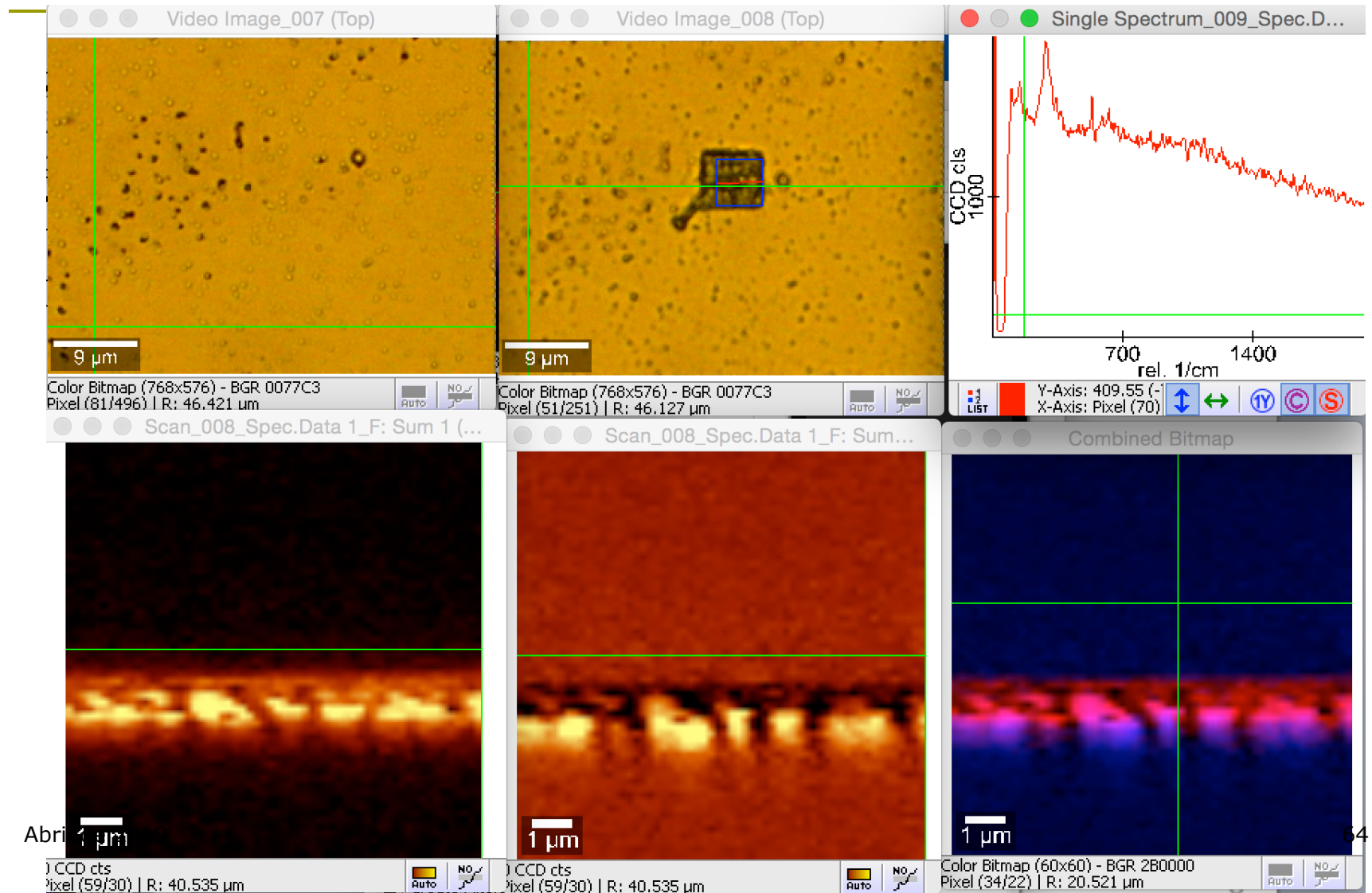


Fig. 5.4 Raman-active vibrational modes of carbon nanotubes. (a) The so-called radial breathing mode (RBM) is a prominent feature of the tubular nanostructure and not present in planar graphite. The Raman shift of the RBM is approximately inversely proportional to the tube diameter. (b) An example of a tangential mode (TM). In analogy to graphitic Raman modes it is often also called G-mode or high-energy mode (HEM)

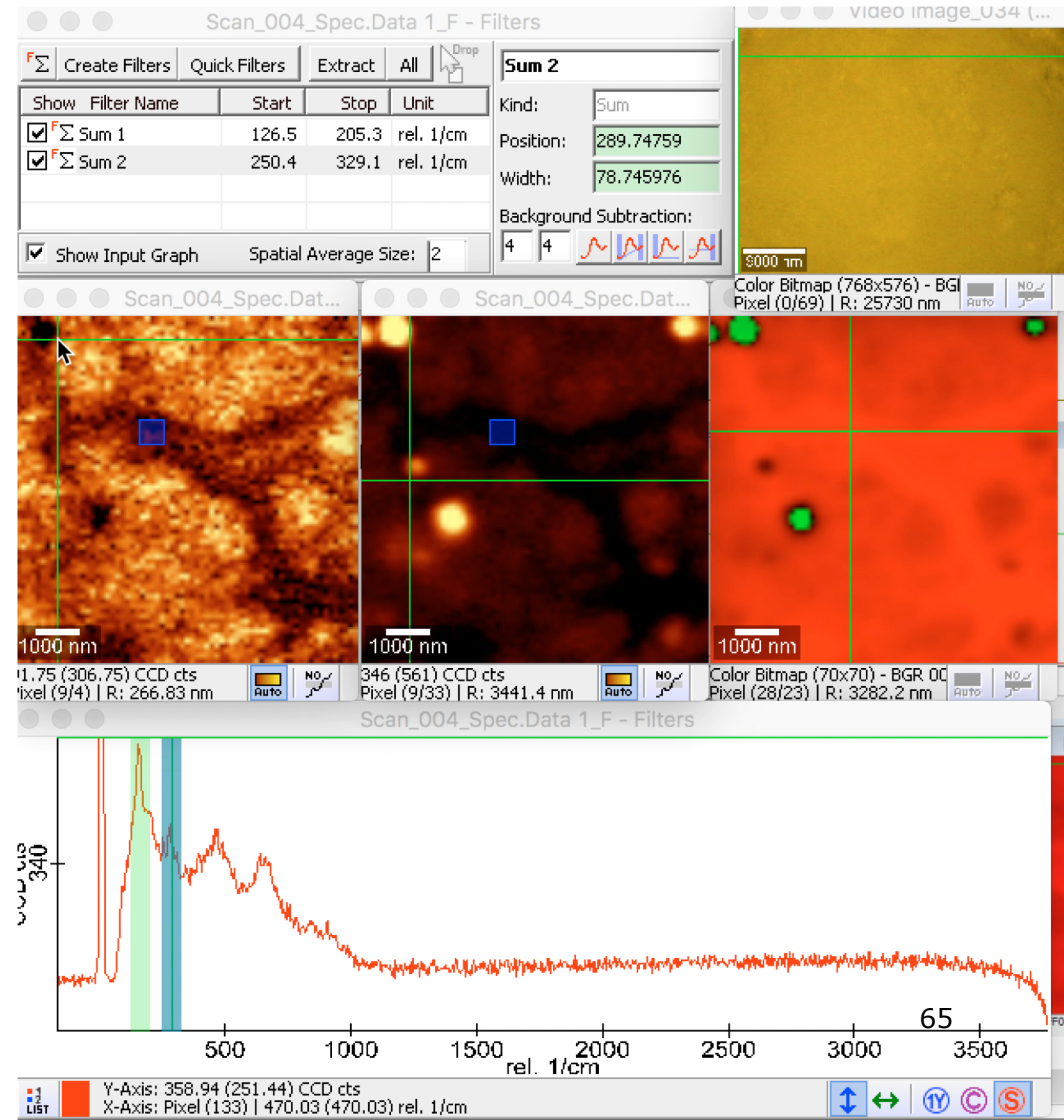
Ejemplo 6: Depth Scan Cu_2O



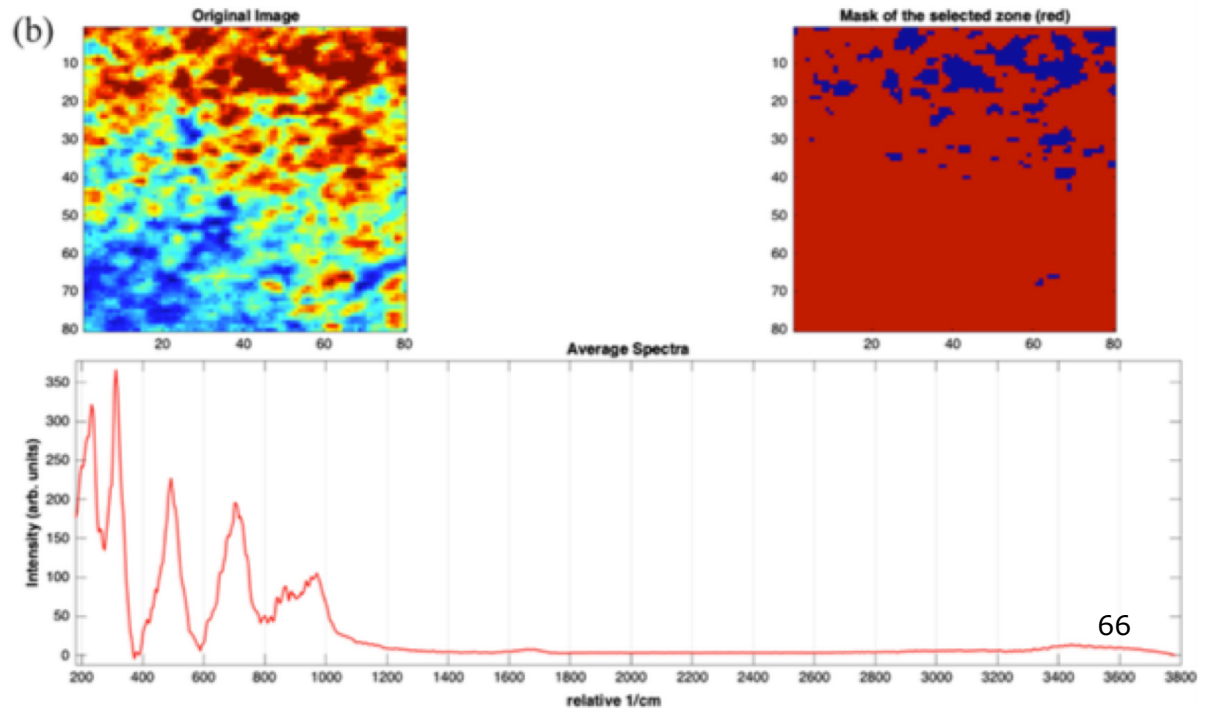
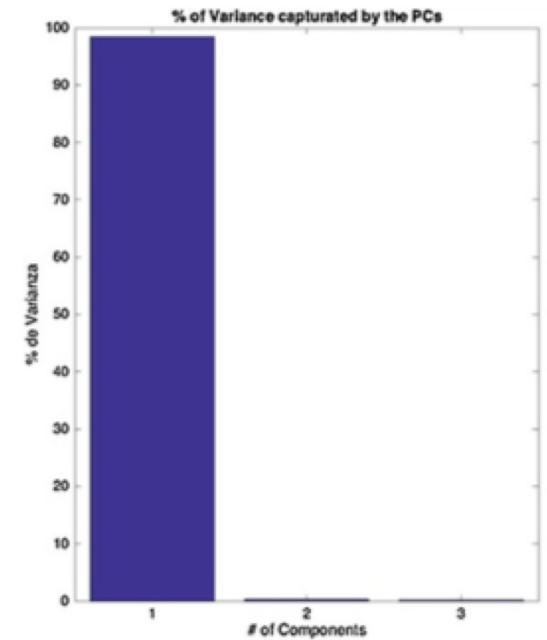
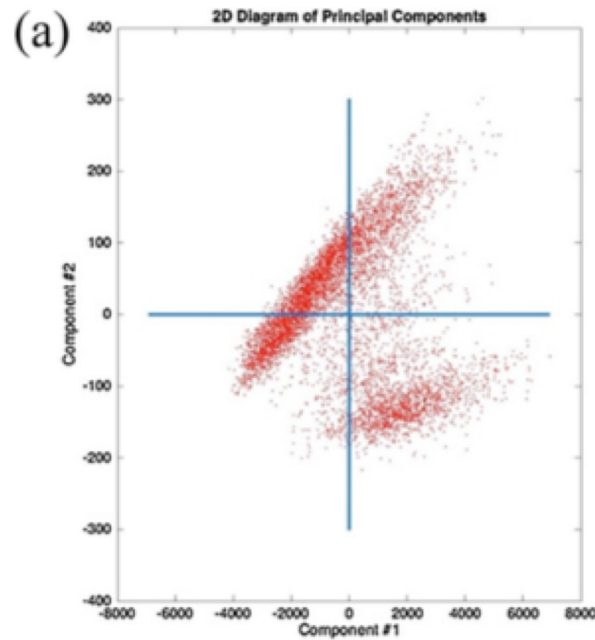
Ejemplo 7: Caracterización de NT

Ejemplo de Funcionamiento:

- Muestra de NT calentados a $T=200^{\circ}\text{C}$.
- Presencia de Nanopartículas de Anatasa en muestra de NT.

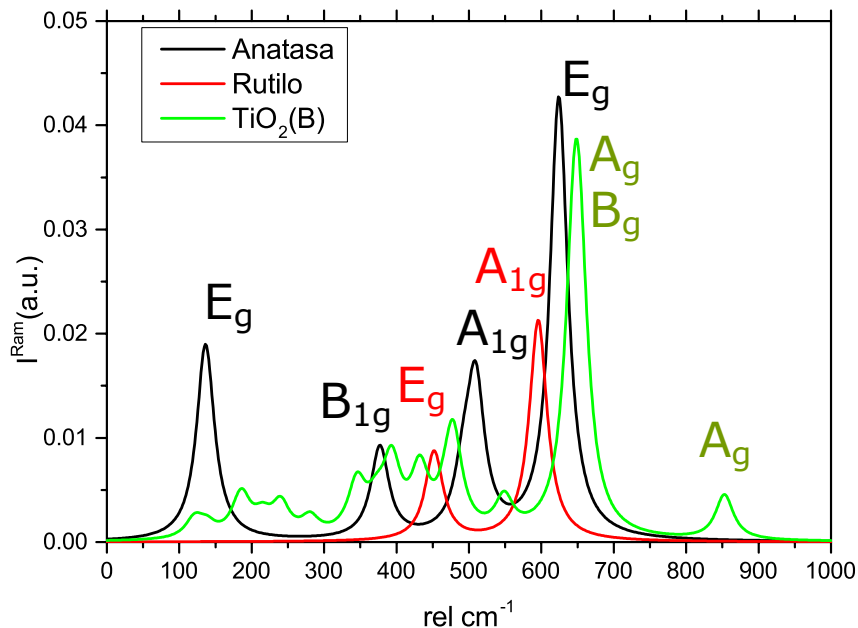


PCA para los fotoelectrodos de HTNT



Modelado: Espectros Raman de polimorfos de TiO_2

Espectros Raman Calculados

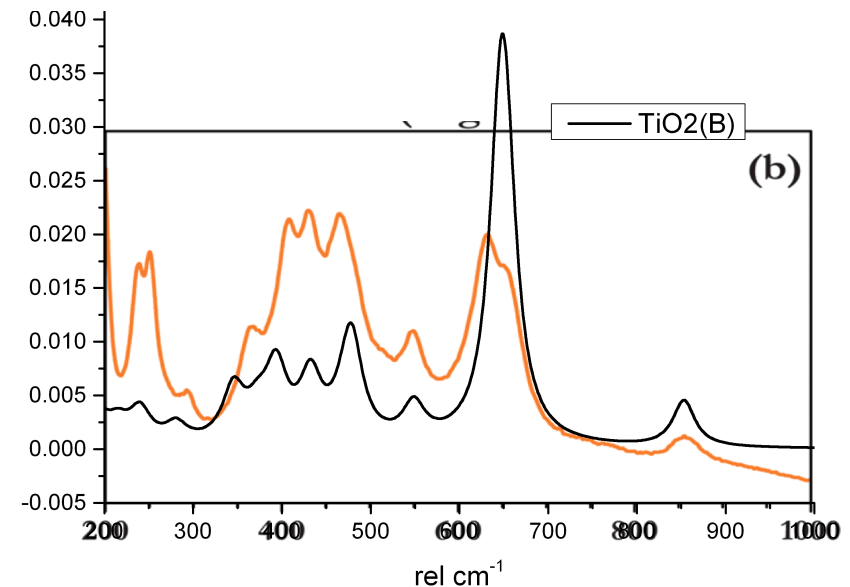


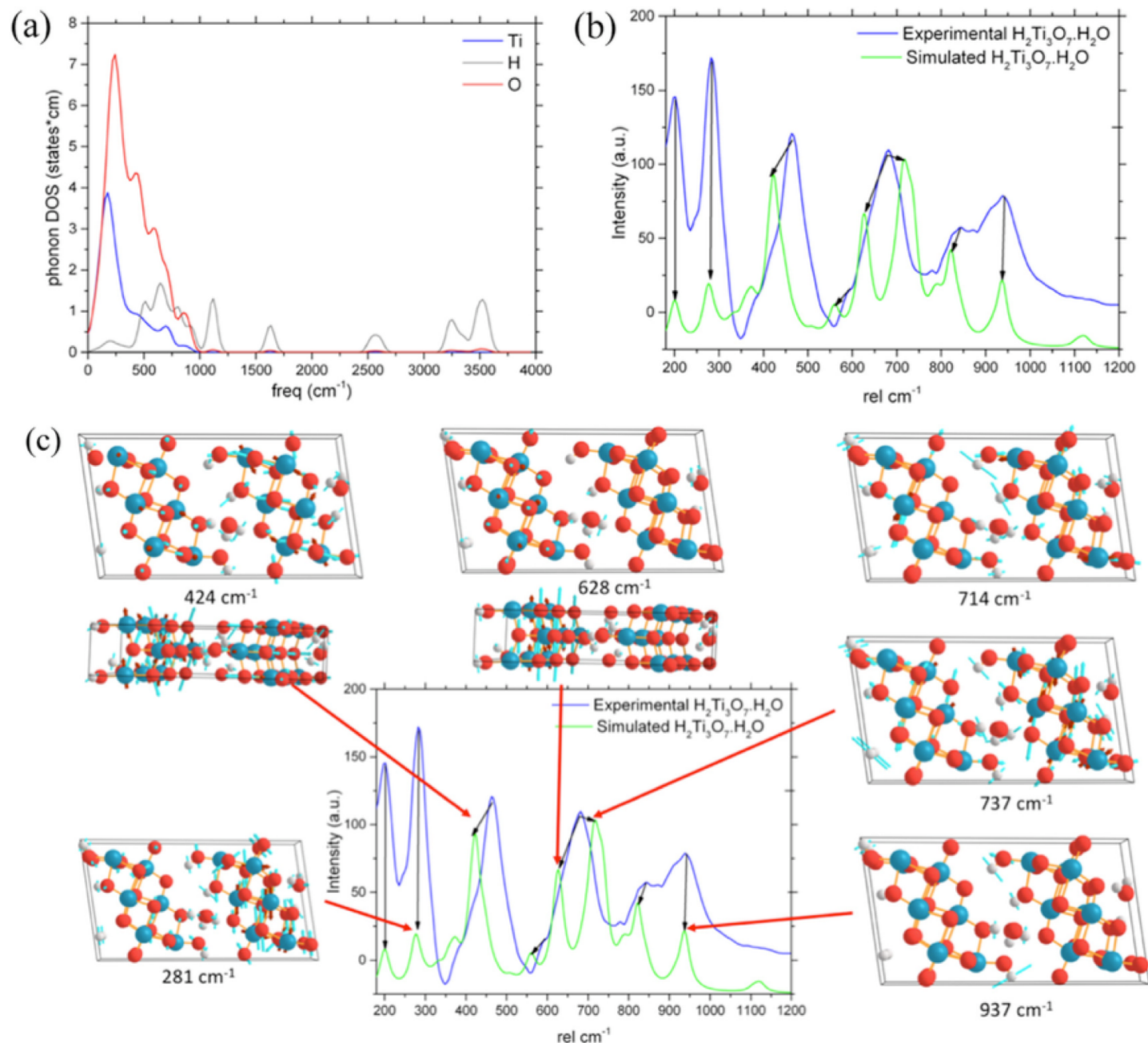
Cálculos DFT: Código VASP

$E_{\text{cut}}=400$ eV

Ondas Planas

DFPT fonones





Abril de 2019

Fig. 8. (a) Atom decomposed phonon density of states for $\text{H}_2\text{Ti}_3\text{O}_7 \cdot 0.67\text{H}_2\text{O}$. (b) Experimental and simulated Raman spectra for $\text{H}_2\text{Ti}_3\text{O}_7 \cdot 0.67\text{H}_2\text{O}$. The black arrows show the correspondence between experiment and simulation. Note: The intensity was normalized for an easy comparison. (c) Phonon eigenvectors obtained from DFT calculations, associated to the most relevant Raman peaks.

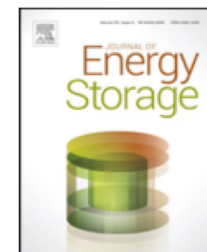
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Characterization of titanate nanotubes for energy applications

Luciana Fernández-Werner, Fernando Pignanelli, Benjamín Montenegro,
Mariano Romero, Helena Pardo, Ricardo Faccio*, Álvaro W. Mombrú

Abril de 2019

Centro NanoMat/CryssMat-Lab, DETEMA, Facultad de Química, Universidad de la República, Uruguay

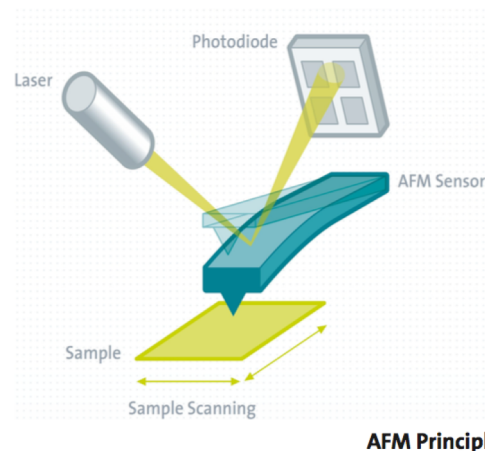
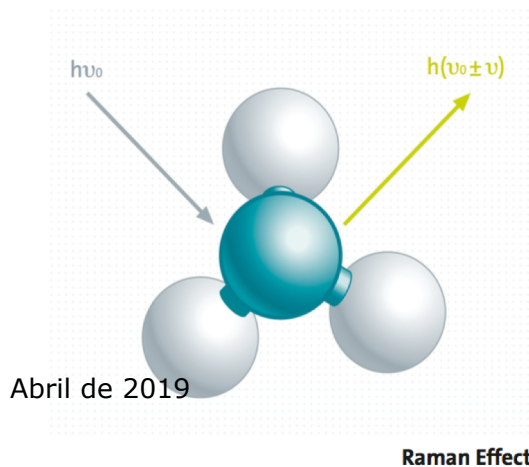
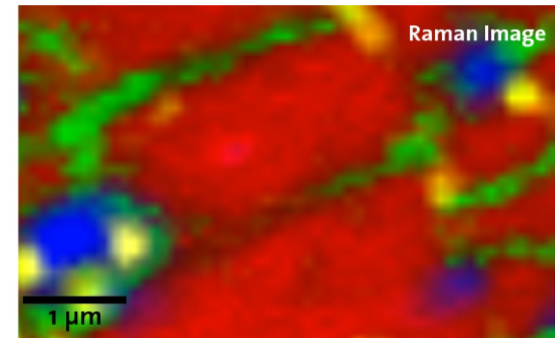
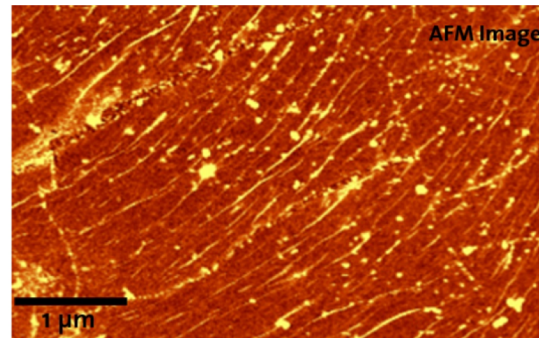
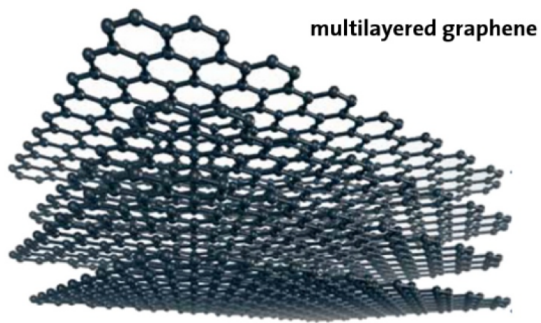


Resumen: Micro Raman Confocal

- ❑ No Destructivo
- ❑ Identificación Química Directa
- ❑ Identificación de Propiedades de Materiales
- ❑ Preparación sencilla de muestra
- ❑ Sólidos y Líquidos
- ❑ Detección 3-dimensional
- ❑ Combinación de detección química con AFM
- ❑ Variación de Temperatura (Linkam)

Micro Raman AFM Dual

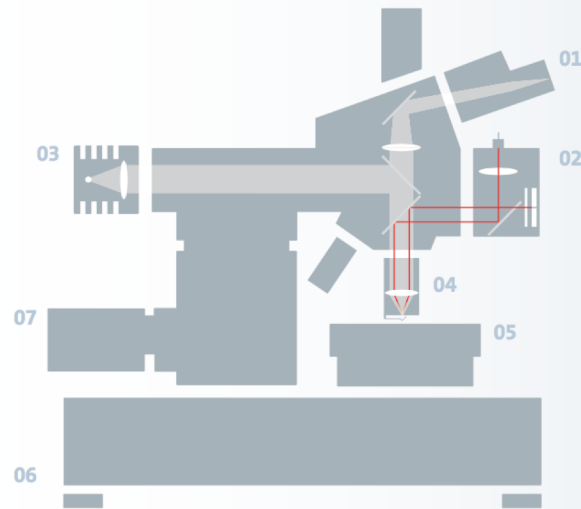
- Alpha 300R → Alpha 300RA
 - FSE_1_2014_1_102008 - ANII



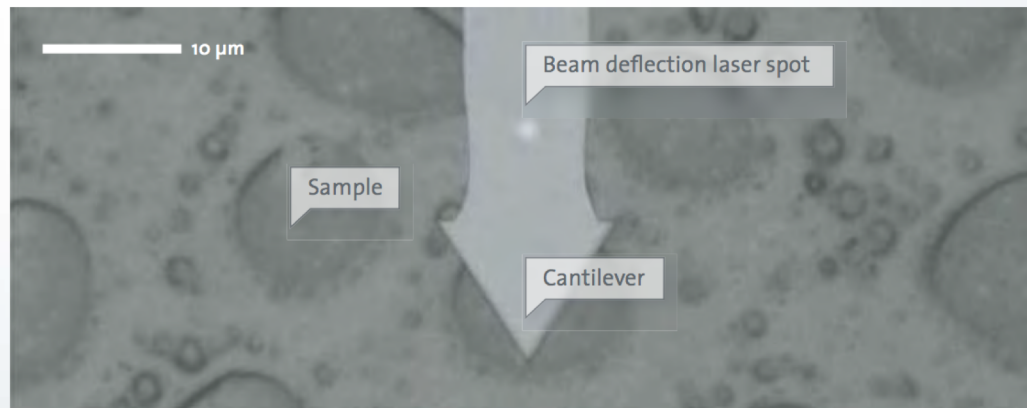
AFM y Raman

BEAM PATH

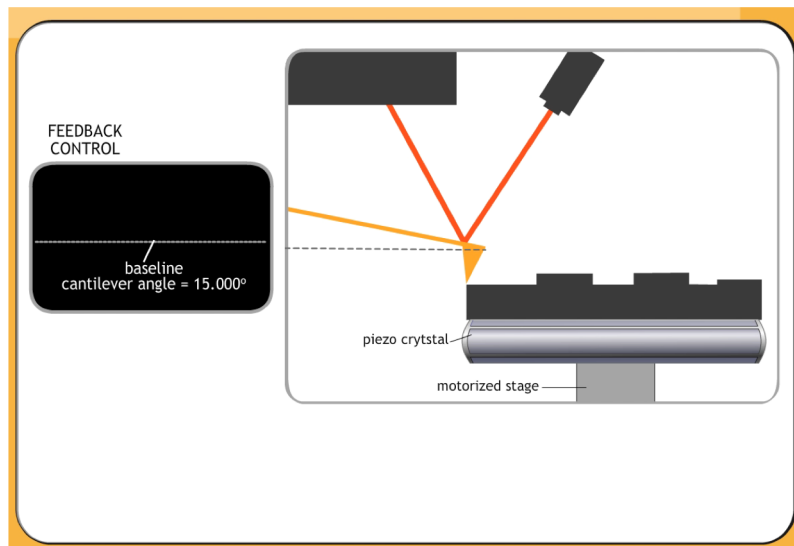
- 01 Video camera system
- 02 Beam deflection unit
- 03 LED white light illumination
- 04 AFM objective with cantilever
- 05 Scan-stage
- 06 Active vibration-isolation table
- 07 Z-stage for focusing



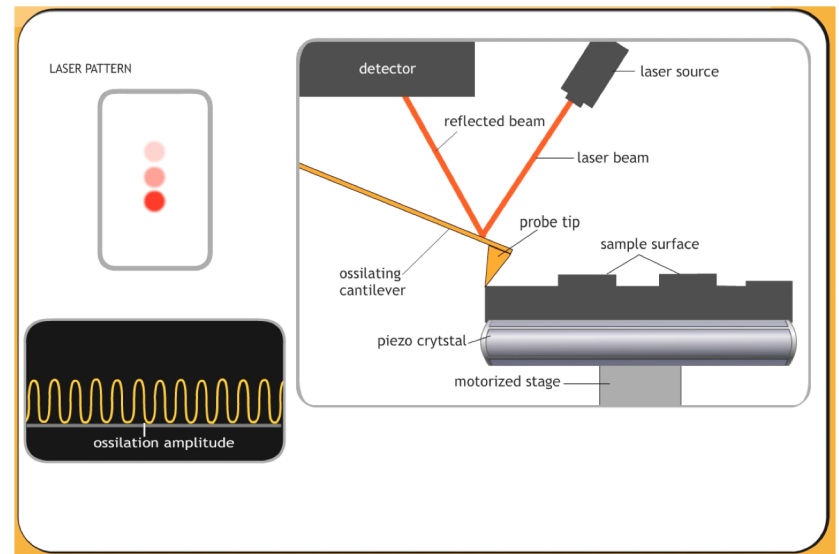
SIMULTANEOUS CANTILEVER AND SAMPLE VIEW



Métodos de Medida

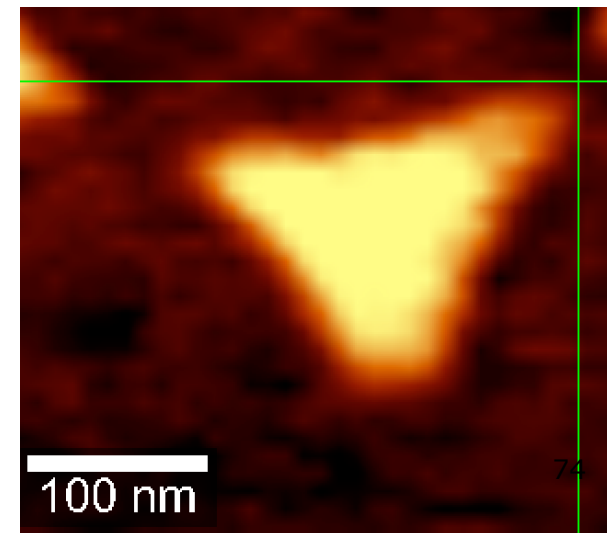
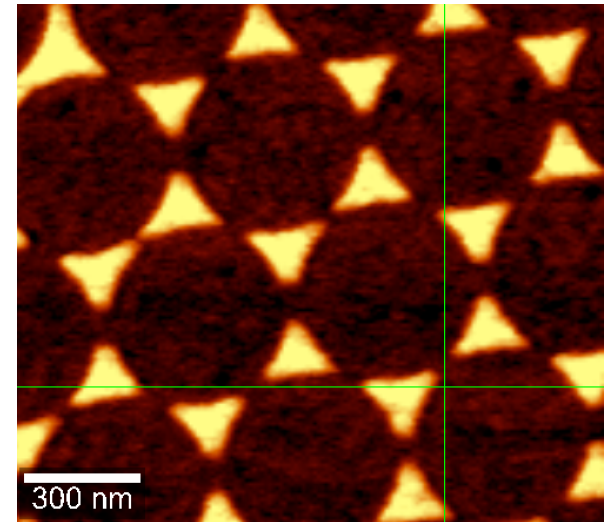
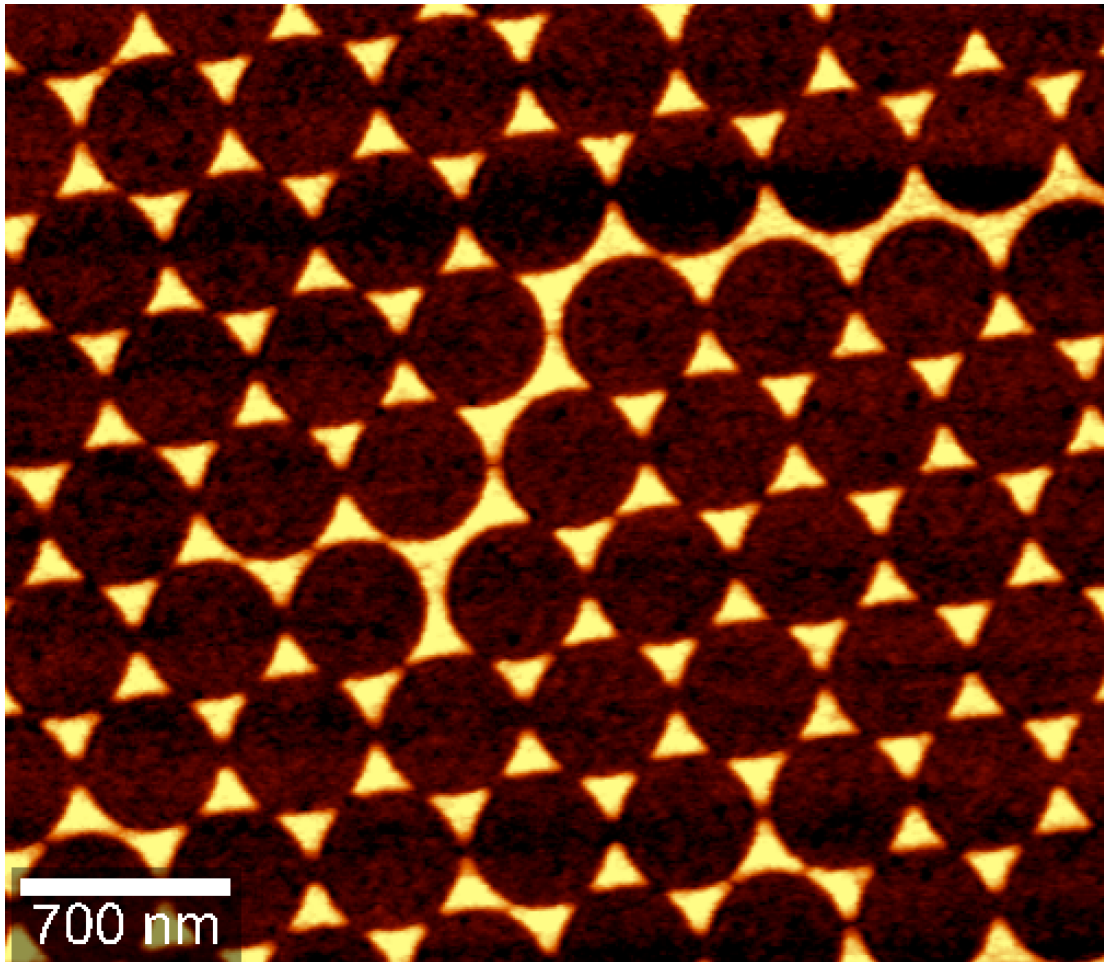


Contacto

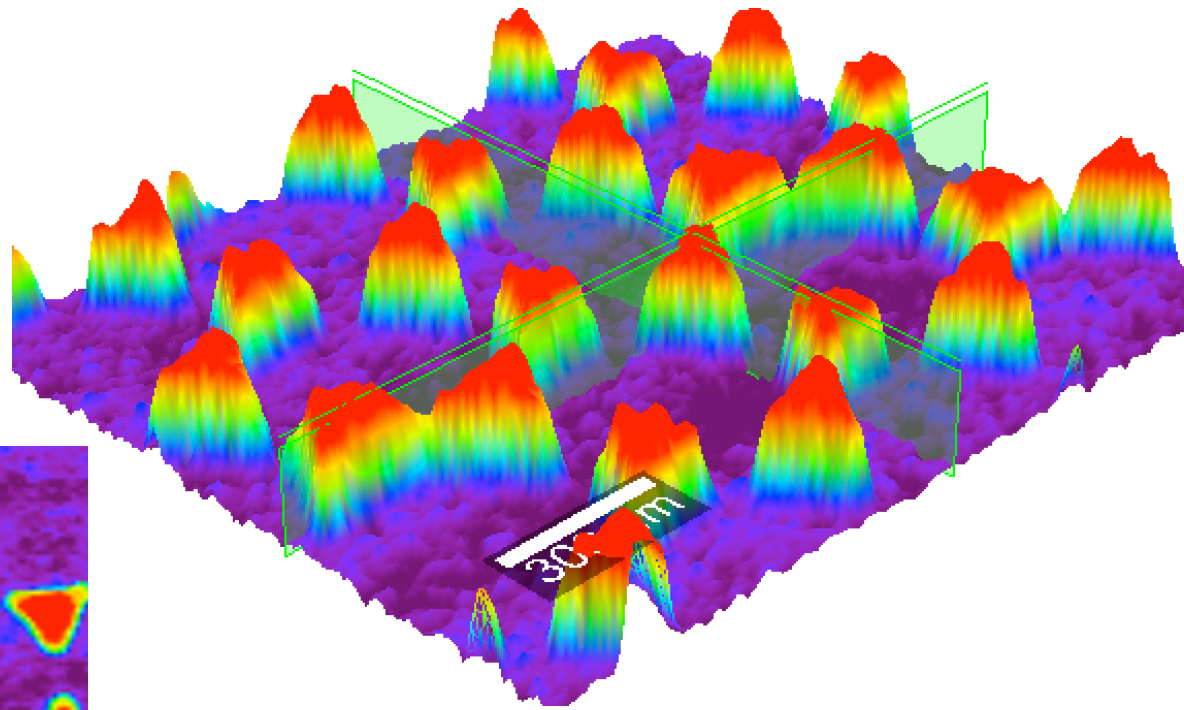
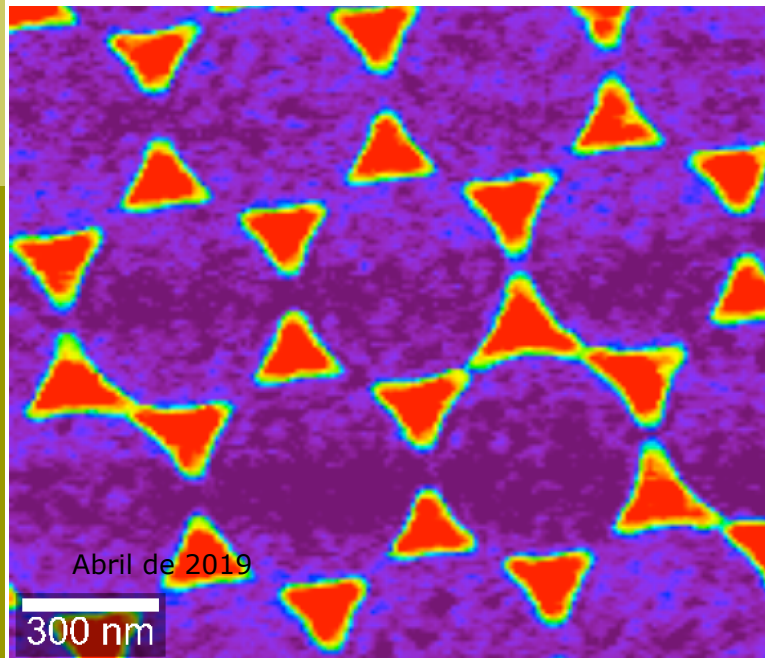


AC Mode

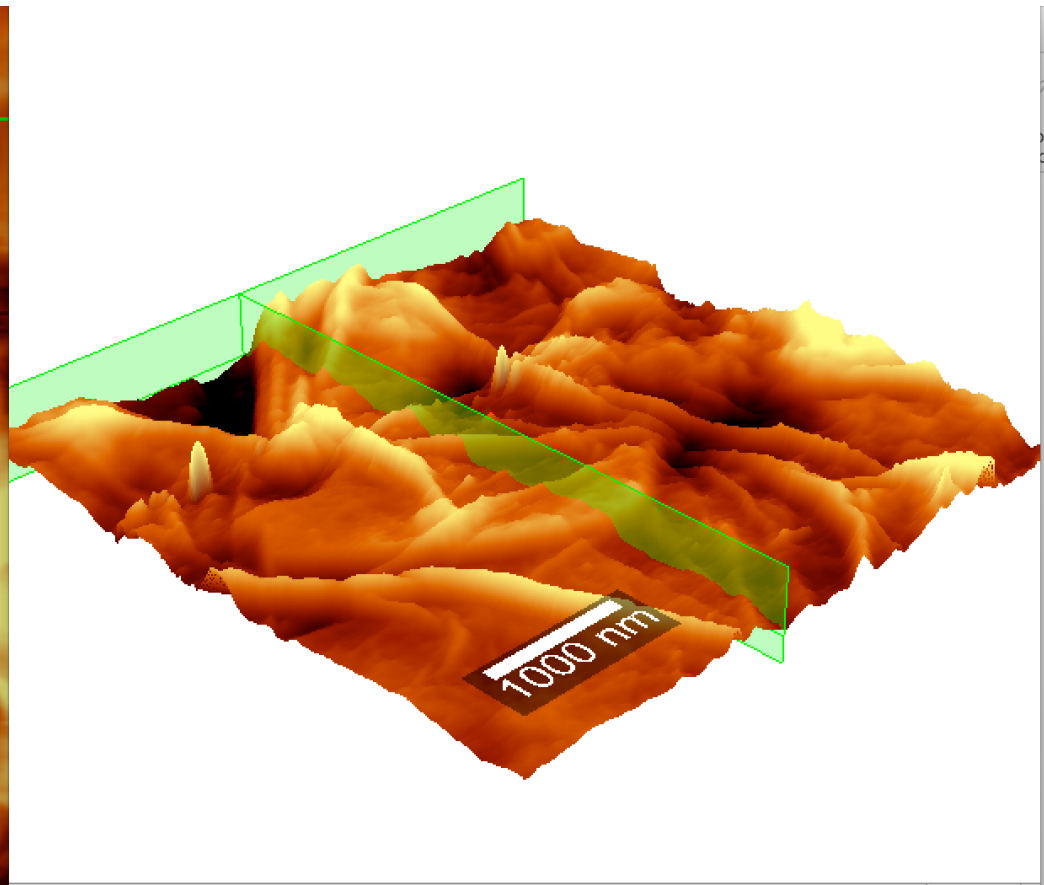
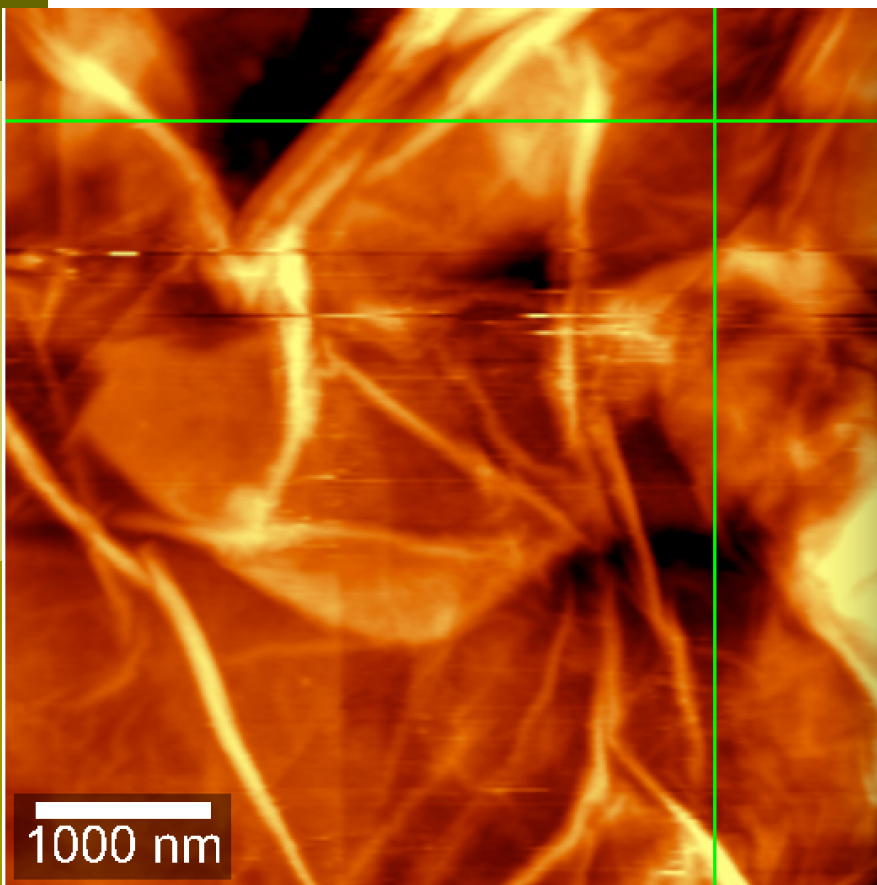
Contact mode: Triángulos de Al



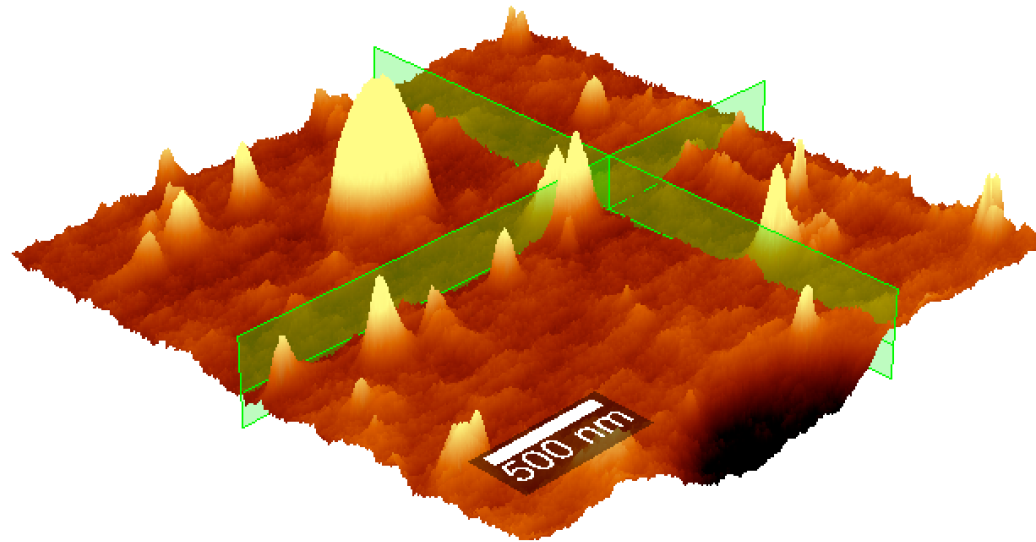
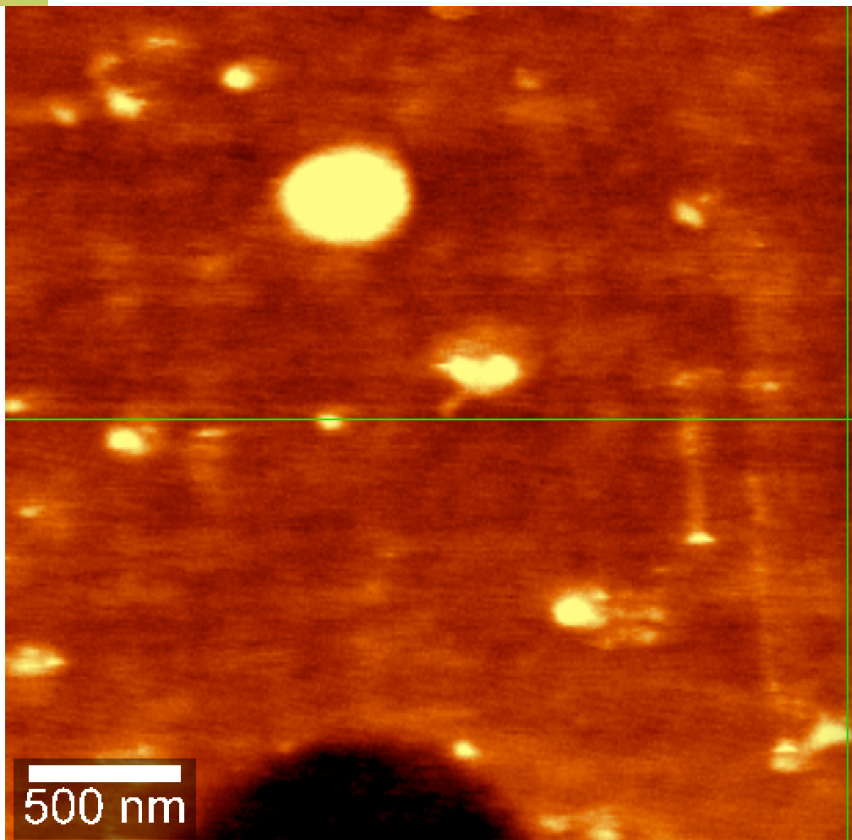
Contact mode: Triángulos de Al



Grafeno: Microscopia de Fuerza Atómica

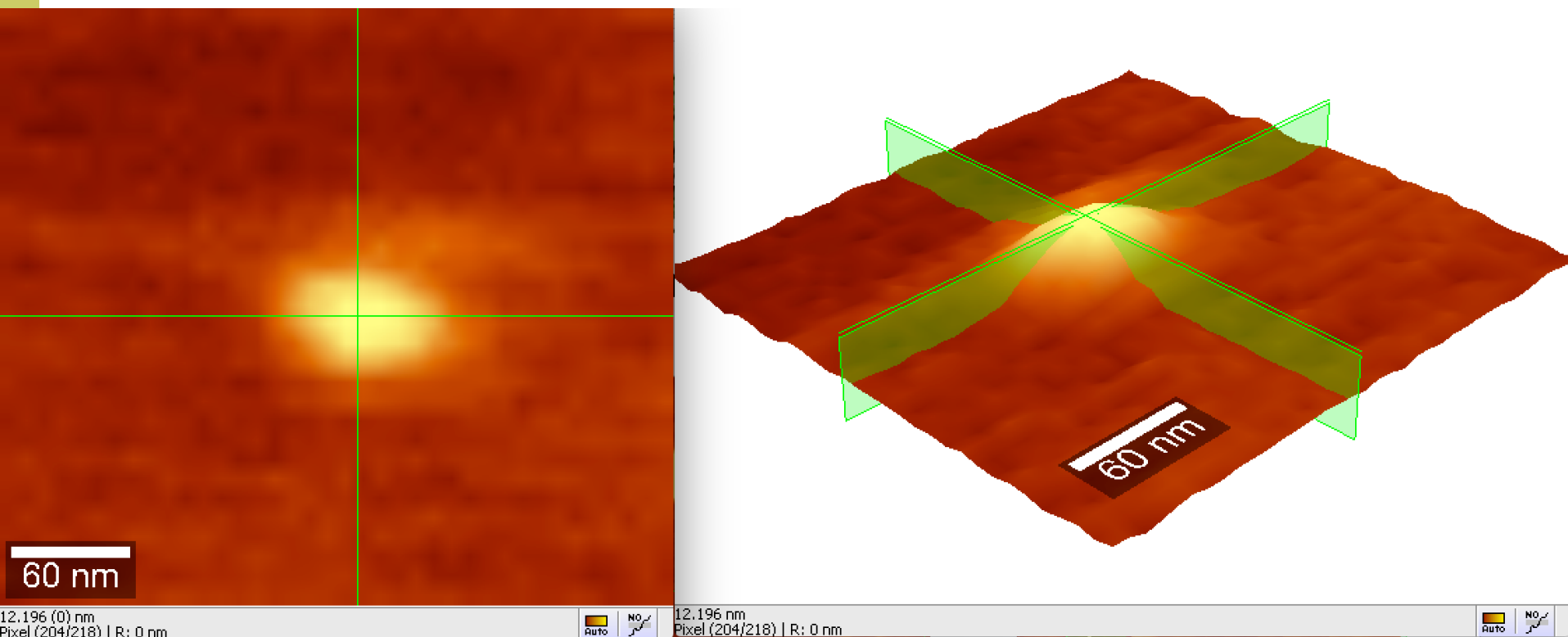


Grafeno: Puntos Cuánticos

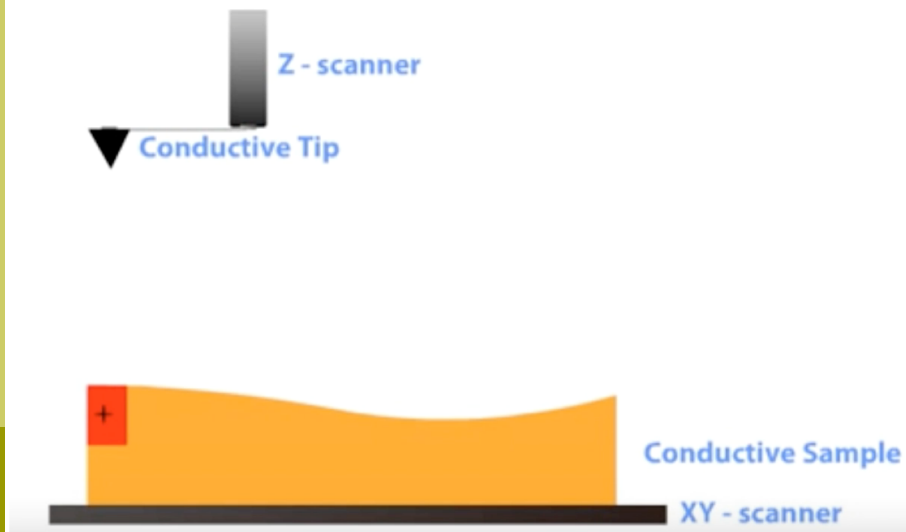


Grafeno: Puntos Cuánticos

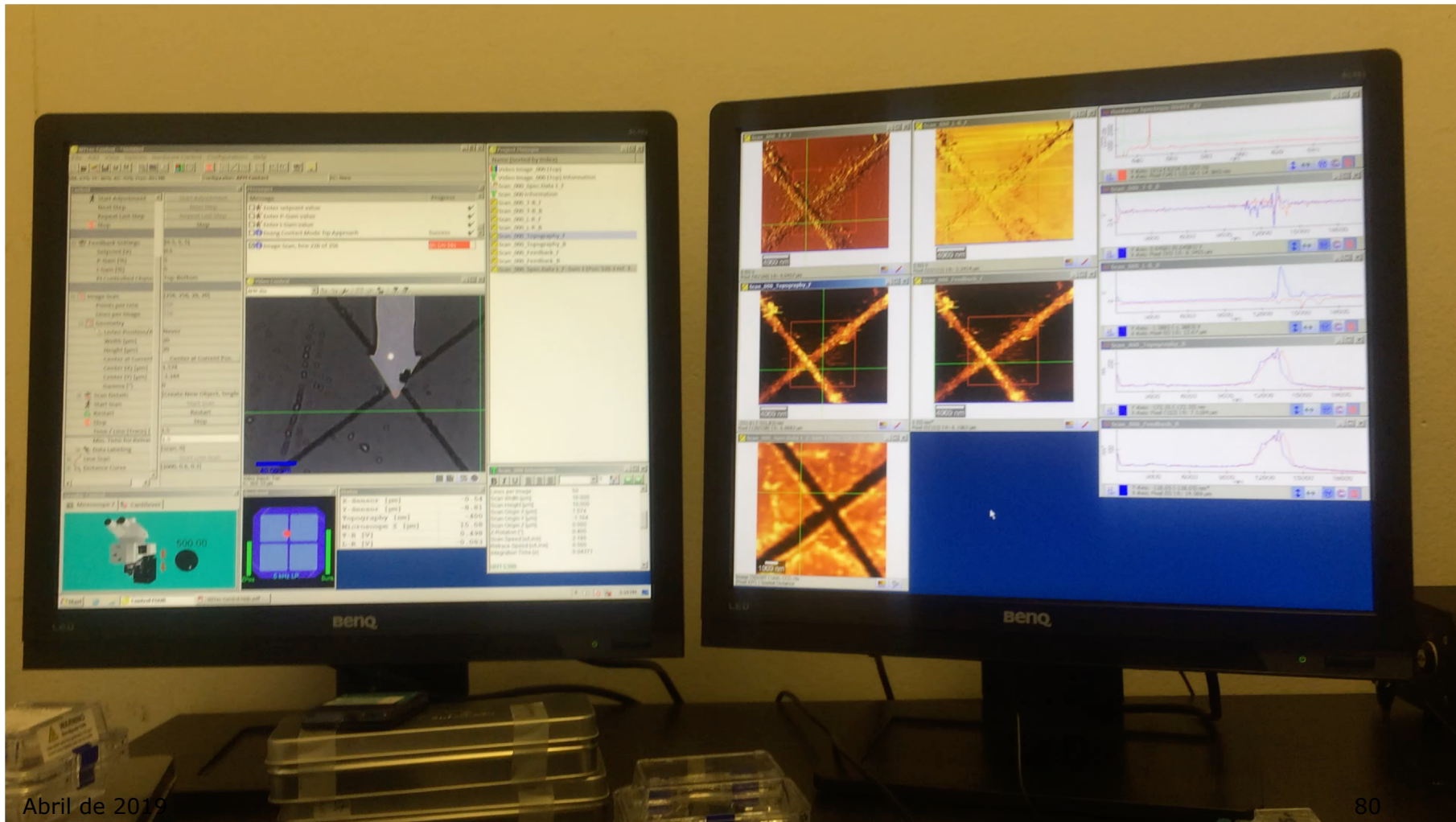
- ▣ 60 nm de diámetro y 13 nm de alto



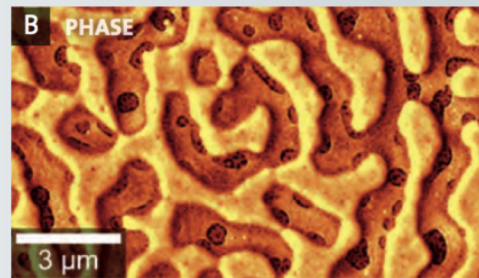
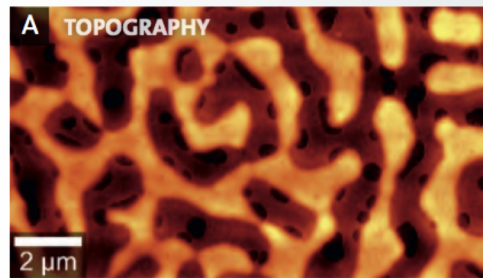
EFM & MFM



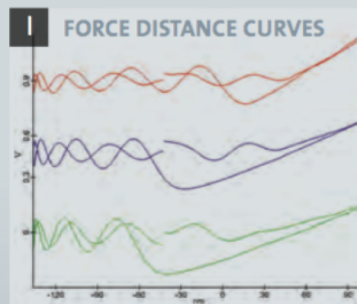
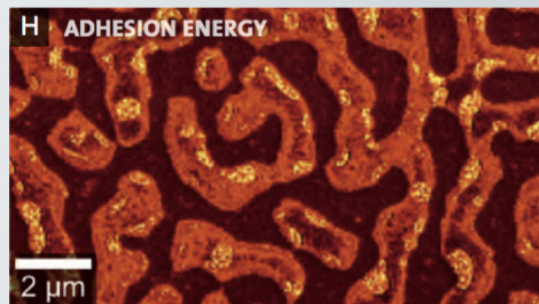
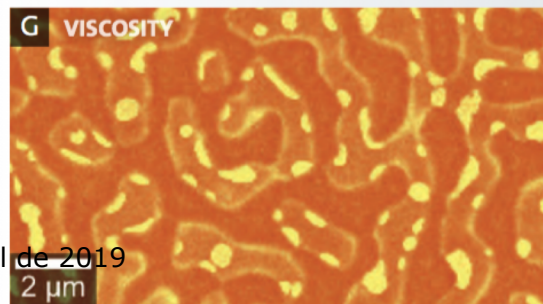
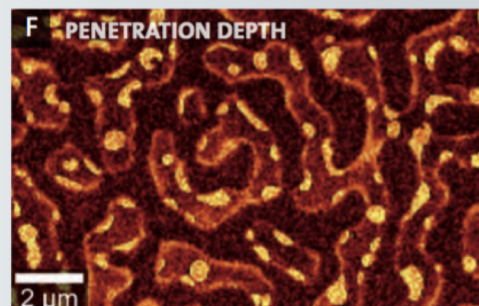
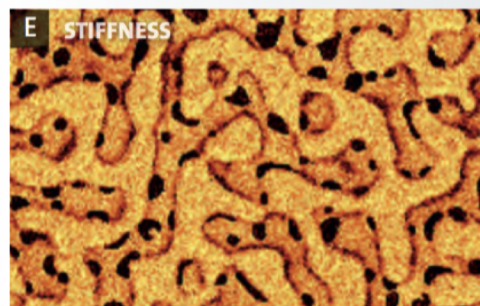
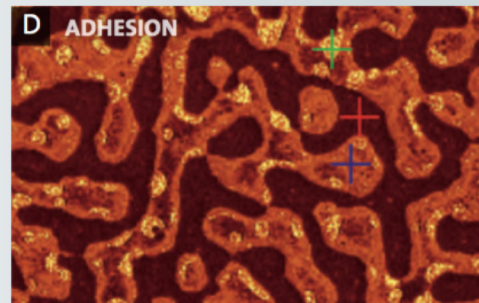
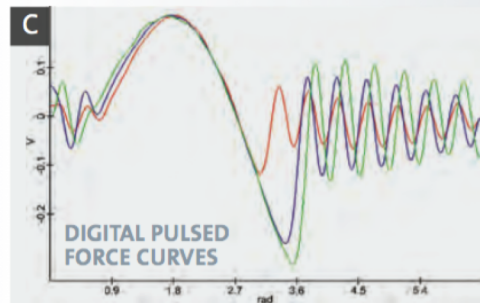
Raman & AFM Dual



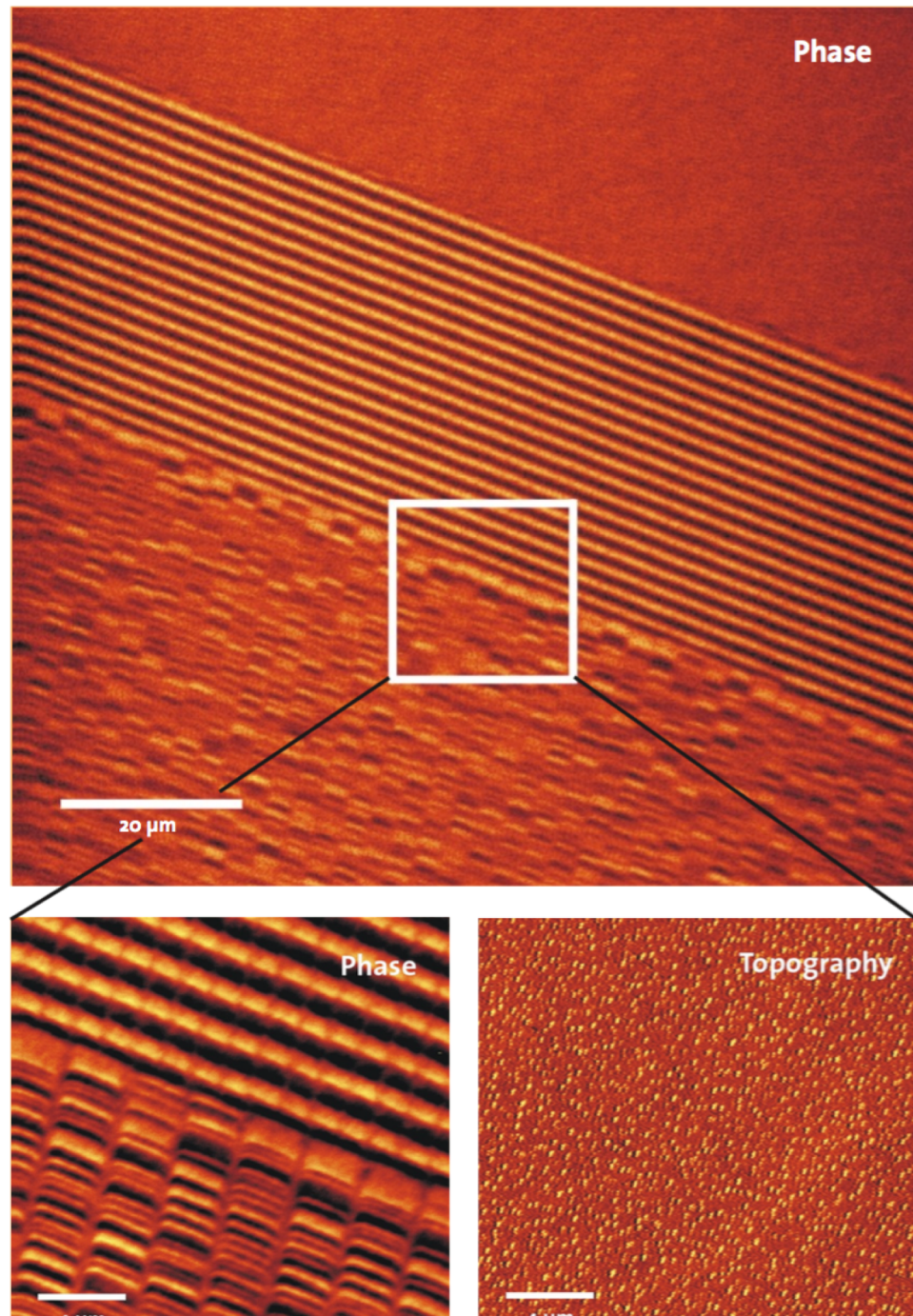
COMPREHENSIVE AFM-RAMAN STUDY OF A POLYMER BLEND (Polystyrene:Ethyl-Hexyl-Acrylate:Styrene-Butadien-Rubber; 1:1:1)



A) Topography image acquired in AC mode revealing a three level fine structure.
B) Simultaneously recorded phase image showing different viscoelastic properties at each topographic level.



□ MFM



Resumen: AFM/EFM/MFM

- Diferentes Modos de Medida:
 - *Contacto*
 - *No Contacto*
 - *Liftmode*
- AFM/EFM/MFM
- Topología y Propiedades Físicas:
 - *Dureza*
 - *Viscosidad*
 - *Adhesión*
- Posibilidad de medir en Líquidos

Agradecimientos



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DE INVESTIGACIÓN
E INNOVACIÓN

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 - Cátedra de Análisis Instrumental – FQ
 - Cátedra de Fisicoquímica -FQ
 - Laboratorio de Biomateriales – FCIEN



Gracias

