

Hyperspectral Infrared Characterization of Extremely Thin Films with 10 nm Spatial Resolution

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Molecular Vista Inc (Introduction to the Company)





Chemical Mapping: Elemental Analysis via Electron Microscopy

Atomic Resolution Elemental Mapping on SrTiO3 crystal by Super X EDS (EDX) system on Titan 80-300 Aberration Corrected Scanning Transmission Electron Microscope



Image credit: North Carolina State Univ. Analytical Instrumentation Facility https://www.aif.ncsu.edu/tem-lab/ Elemental mapping of a device structure by EDS (EDX)



Image credit: Nanolab Techologies

http://www.nanolabtechnologies.com/TEM-STEM-EELS-EDS

- Advanced capability for elemental mapping
- Atomic-scale resolution in certain circumstances



FTIR: Infrared absorption "chemical fingerprint" spectrum



Image credit: Wikipedia

Image credit: Mudunkotuwa et al., Analyst 139, 870-881 (2014).

https://en.wikipedia.org/wiki/Fourier_transform_infrared_spectroscopy#/media/Fi le:FTIR_Interferometer.png

- Detailed spectra for analysis and identification of molecular materials
- Spatial mapping resolution limited by optical diffraction limit ($\sim 1 \mu m$)



$\mathsf{PiFM}\ \mathsf{Measurement}-\mathsf{Sideband}\ \mathsf{Bimodal}^{\mathsf{TM}}$



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Agreement between Nanoscale PiFM and Bulk FTIR Spectra



PiFM and FTIR of PES (Polyethersulfone)











Interfacial Chemistry (QCL: 760 – 1960 cm⁻¹)





Exceptional Spatial Resolution in Chemical Mapping

Ps-*b*-PMMA Block Copolymer, $L_0 = 22$ nm





Surface Sensitivity





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Complements other Analytical Techniques

	IR PiFM	Raman	FTIR	TOF-SIMS	XPS	TXRF	SEM/EDS	TEM	Auger
Species Detected	M.I.	M.I.	M.I.	M.I.	M.I.	E.I.	E.I.	E.I.	E.I.
Imaging/Ma pping	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Lateral Resolution	< 10 nm	> 0.5 μm	> 10 µm	> 0.2 μm	10 μm – 2 mm	~ 10 mm	1 nm* 0.5μm EDS	0.2 nm	> 10 nm
Depth Probed	20 nm	> 500 nm	1 µm	1 nm	10 nm	10 nm	1 µm	~ 100 nm	10 nm

* Imaging

M.I. Molecular information

on E.I. Elemental information



Semiconductor Applications



Area Selective Deposition (ASD)





Characterization of EUV Resist Exposure



Chemically amplified photoresist (tBOC) Exposed to EUV light (λ = 13.5 nm) at **ALS Lawrence Berkeley National** Laboratory.

Exposure creates shrinkage, resulting in depression in topography (a).

Blue – Unexposed Orange – Exposed

6E-04

5E-04

4E-04

3E-04

1E-04 0E+00

1200

2E-04 S

R Pif



Visualization of Local Strain





800

Imaging Buried Conductive Layer





Working with 1D/2D Materials



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Summary

- AFM IR technique, PiFM, is introduced.
- PiFM measures sample's complex polarizability via mechanical force detection.
- It provides for exceptional spatial resolution (< 10 nm), excellent surface sensitivity (monolayer), and ease-of-use.
- Vista-IR is a turnkey PiFM systems with visible to mid-IR lasers.
- Vista-IR can chemically map and identify organic and inorganic materials via localized IR spectrum (from 10 nm x 10 nm region by monolayer volume).
- PiFM is useful for many semiconductor applications.

