



# CONFOCAL SPECTROMICROSCOPY OF MICRO AND NANO-STRUCTURED MATERIALS

A. Kuzmin, R. Kalendarev, A. Kursitis, J. Purans

*E-mail: [a.kuzmin@cfi.lu.lv](mailto:a.kuzmin@cfi.lu.lv)*



## Microscopes Development Tendency



**Optical  
Lense**



**Optical  
Microscope**



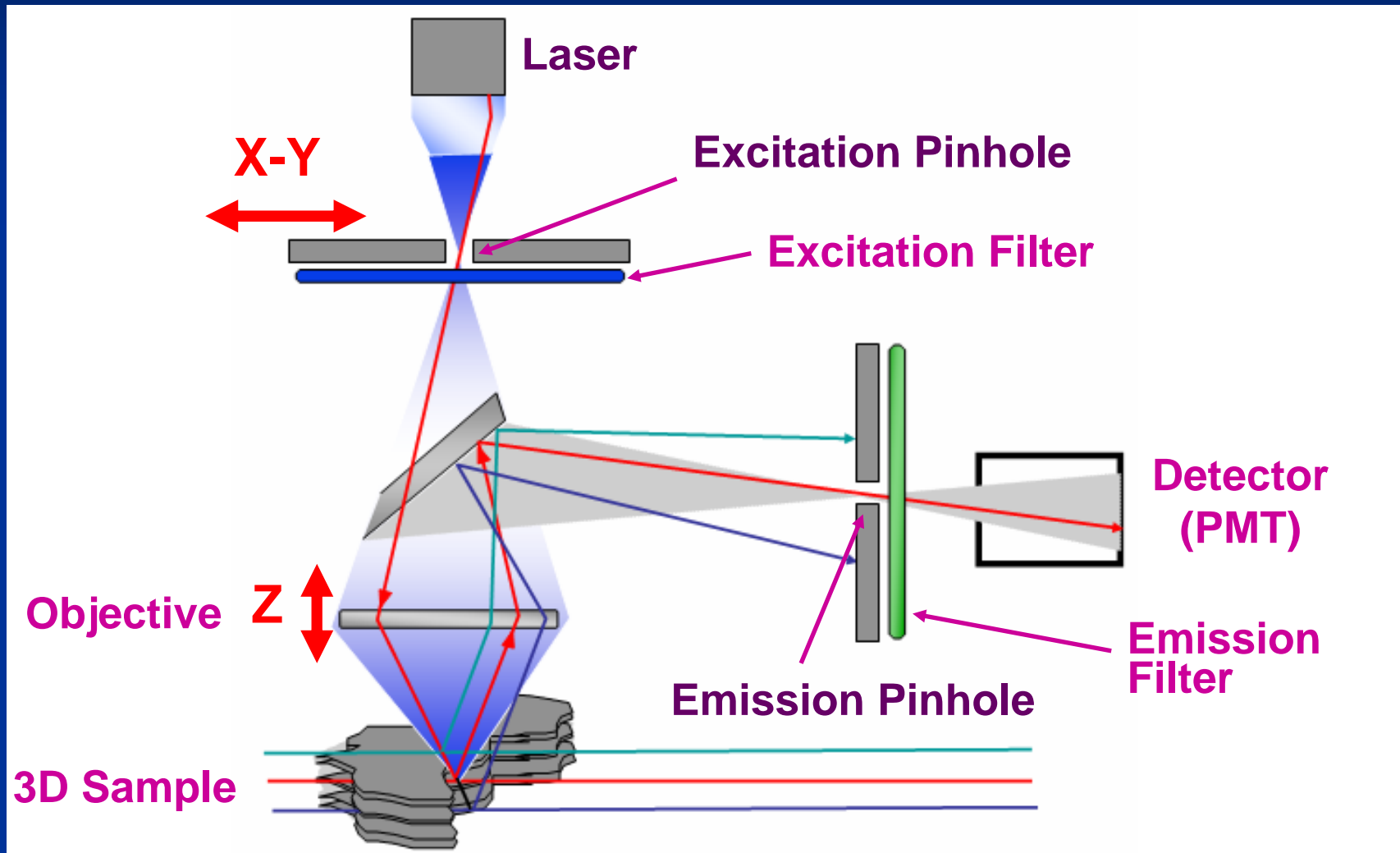
**Fluorescence  
Microscope**



**Confocal  
Microscope**



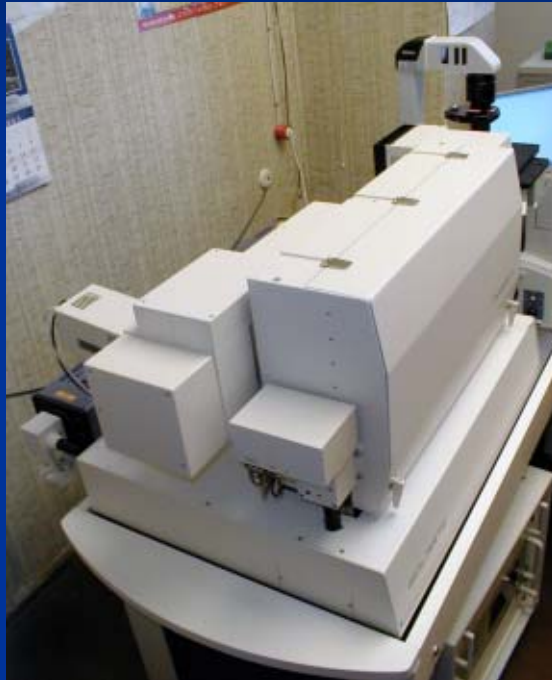
## Principle of Confocal Microscopy





## **Nanofinder-S**

[www.solartii.com](http://www.solartii.com)

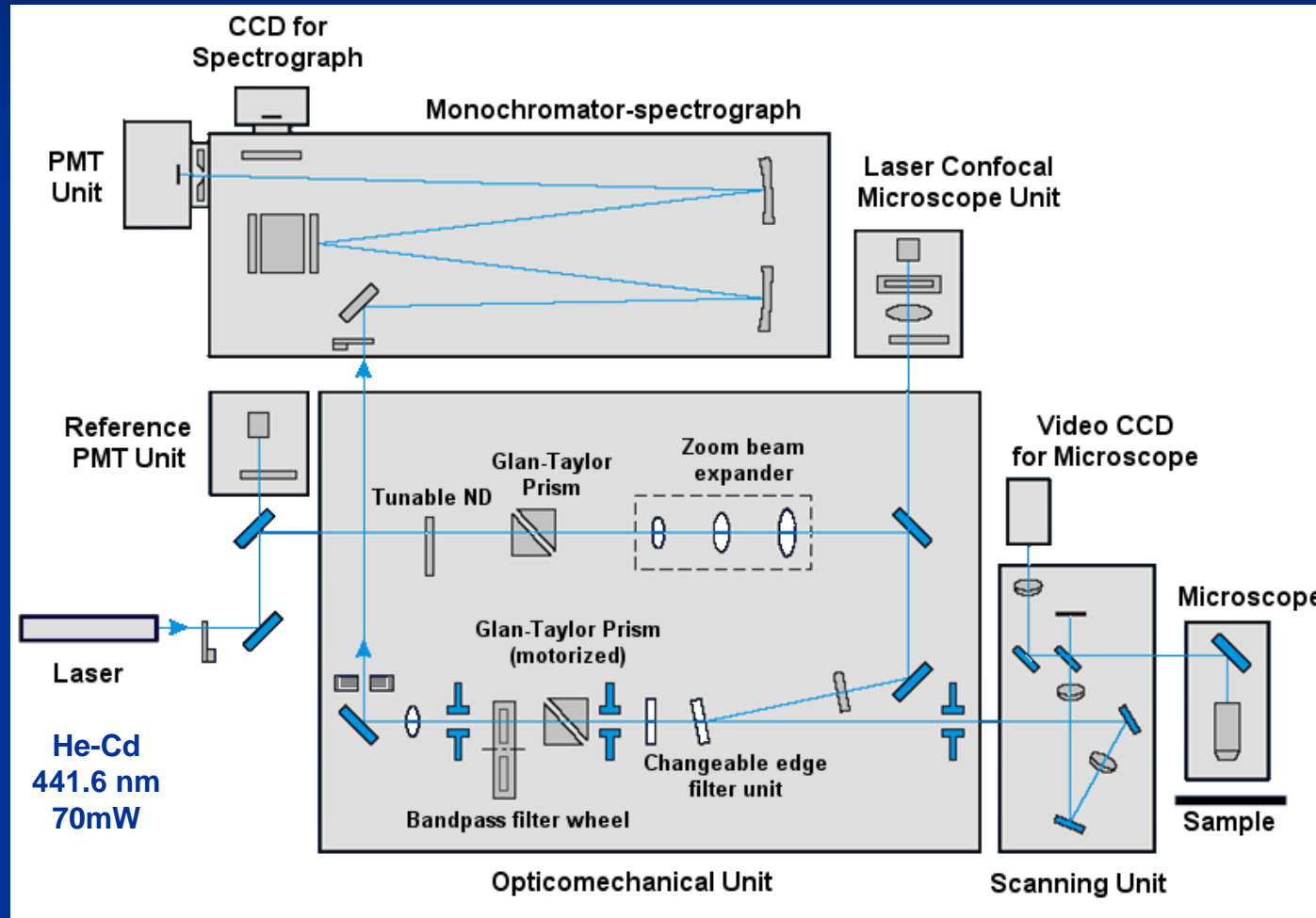


### **Simultaneous / Multifunctional Analysis:**

- Optical and Confocal Microscopy
- Raman Spectroscopy
- Luminescence Spectroscopy
- 0D, 1D, 2D & 3D High-speed Imaging and Spectroscopy



# Nanofinder-S modular optical layout





## Inverted Nikon ECLIPSE TE2000-S microscope



- Works in Reflection & Transmission
- High-performance Objectives
  - Plan Fluor 10X/0.30
  - Plan Fluor 40X/0.75
  - CF Plan Apo 100X/0.95
- Coupled with color CCD camera Kappa DX 20 H
  - SONY ICX 285 CCD Sensor
  - 2/3" Interline, Progressive Scan
  - 1384 x 1032 pixel
  - 0.0016 Lux at 10 sec integration
  - 12 bit digital
  - Signal-to-noise ratio 63 dB

	10x	40x	100x
Video Image size ( $\mu\text{m}$ )	890 × 660	222 × 165	89 × 66
Confocal Image size ( $\mu\text{m}$ )	1320 × 1100	330 × 275	132 × 110



## MONOCHROMATOR-SPECTROGRAPH MS5004i



**Configuration:** vertical  
**Focal length:** 520 mm  
**Ports:** 1 input, 2 output  
(CCD & PMT)  
**Grating mounts:** 4-position turret  
**Slit control:** 0.0-2.0 mm, step size 0.5 mm

<b>Gratings (grooves/mm):</b>	150	600	1800	75
<b>Blaze wavelength (nm):</b>	500	500	500	Echelle-type
<b>Dispersion (nm/mm):</b>	12.7	3.17	0.94	0.149 – 0.504
<b>Spectral resolution (nm):</b>	0.24	0.06	0.02	0.0052 – 0.0176
<b>Wavelength accuracy (<math>\pm</math>nm):</b>	0.32	0.12	0.04	0.013 – 0.047
<b>Wavelength repeatability (<math>\pm</math>nm):</b>	0.089	0.022	0.007	0.0016





## SCANNING UNITS

- 1. Scanning unit with galvanometer mirror scanners (X and Y)**  
132  $\mu\text{m}$   $\times$  110  $\mu\text{m}$  (*with 100x objective*)  
spatial optical resolution 200-250 nm
- 2. Piezo-scanner (Z)**  
0 - 80  $\mu\text{m}$  (*with 100x objective*)  
spatial optical resolution 500 nm

## DETECTORS

- 1. Digital Slow Scan CCD Camera PROSCAN HS-101H**  
A high sensitive back-thinned CCD sensor 1024  $\times$  58 pixels  
Spectral response range from 200 nm to 1100 nm  
Peltier cooling with thermo stabilization to  $-10^{\circ}\text{C}$
- 2. Three photomultiplier tubes (PMT) Hamamatsu R928**  
Spectral response range from 185 nm to 900 nm





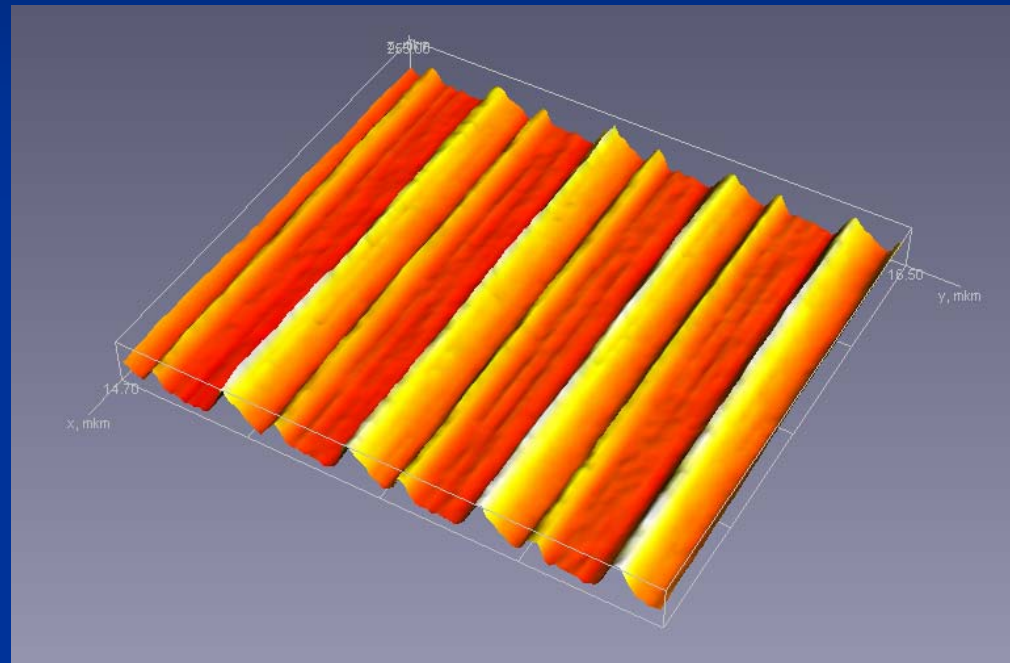


## EXAMPLES OF APPLICATIONS

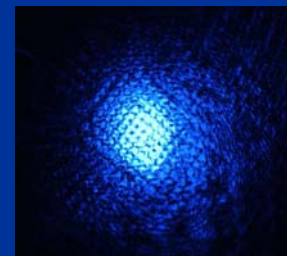
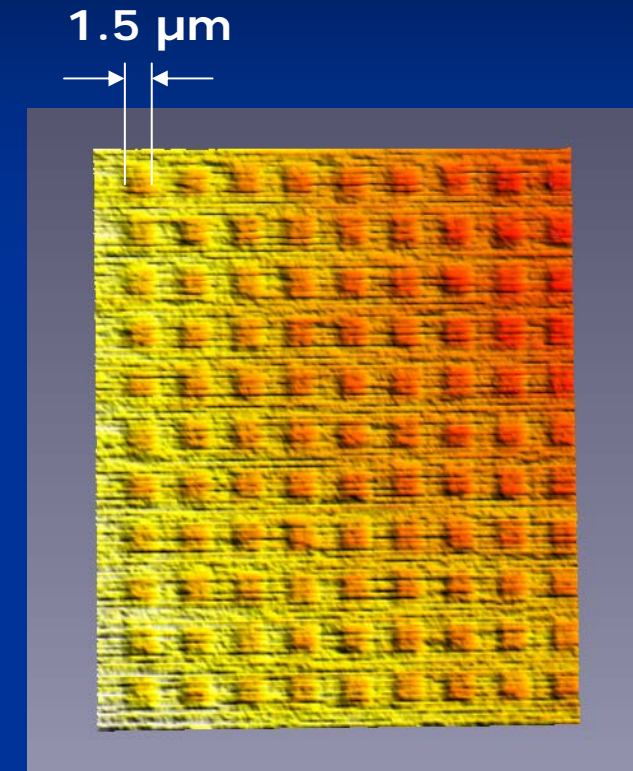
- **Imaging of Silicon Gratings for Scanning Probe Microscopy**  
"calibration"
- **Optical Lithography**  
"information storage"
- **2D Confocal Imaging and Raman Spectroscopy**  
"chemical phase mapping"
- **3D Confocal Microscopy**  
"optical tomography"
- **2D Luminescence Imaging**  
"light mapping"



## Calibrating Silicon Gratings for Scanning Probe Microscope



**TGG1:**  
image size 36.8×34.8  $\mu\text{m}$

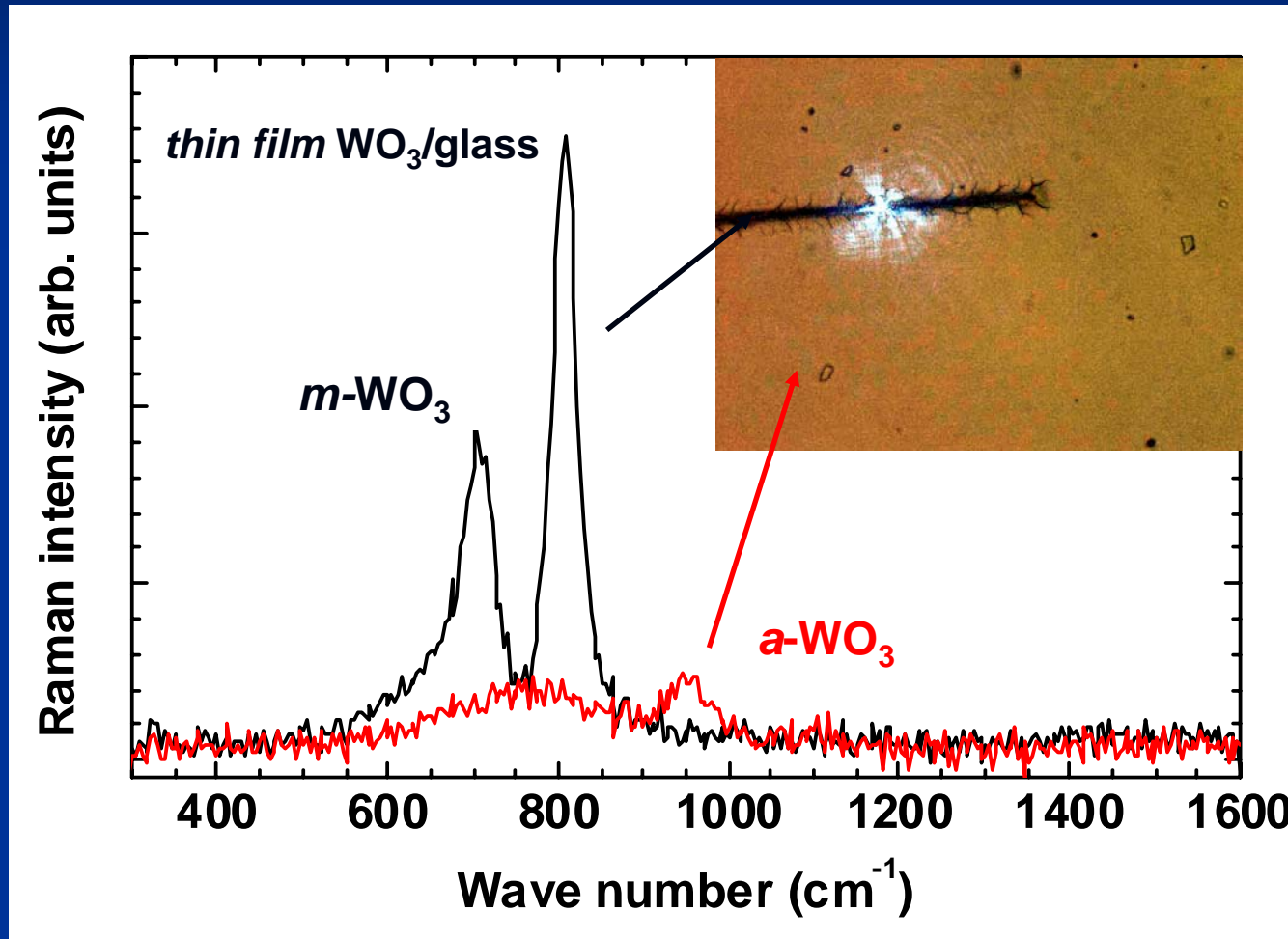


**TGQ1:**  
image size 27.0×34.5  $\mu\text{m}$



## Optical Lithography:

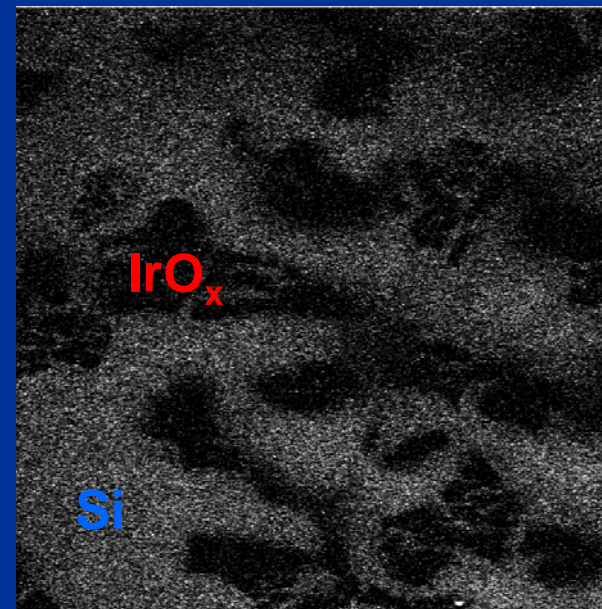
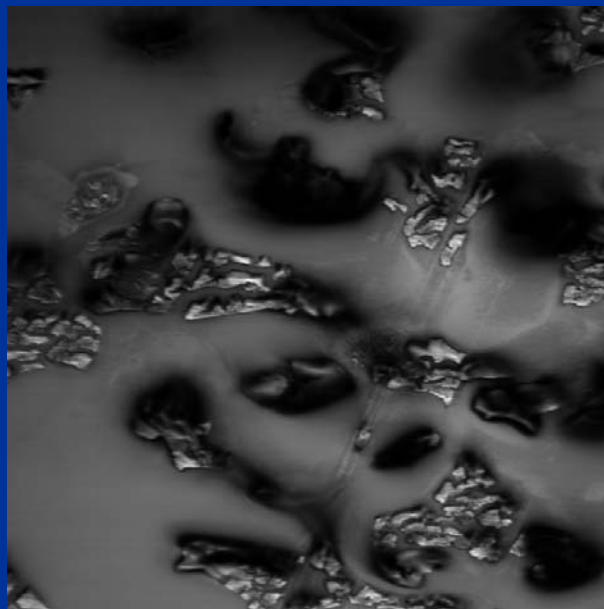
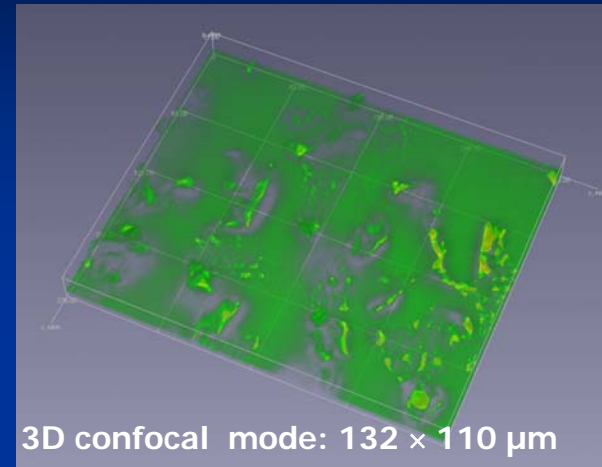
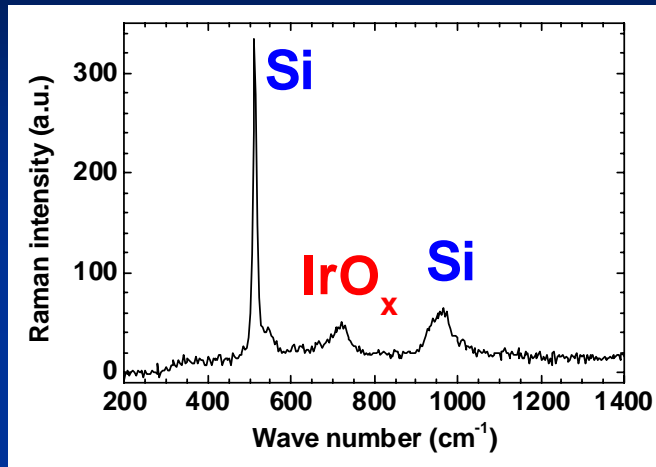
$a\text{-WO}_3 \rightarrow m\text{-WO}_3$  phase transition under laser irradiation



Objective 40 $\times$ ; laser power: 70 mW for writing, 12 mW for reading; detection by CCD.



## 2D Chemical Phase Mapping in Oxide Films



2D confocal mode:  $132 \times 110 \mu\text{m}$

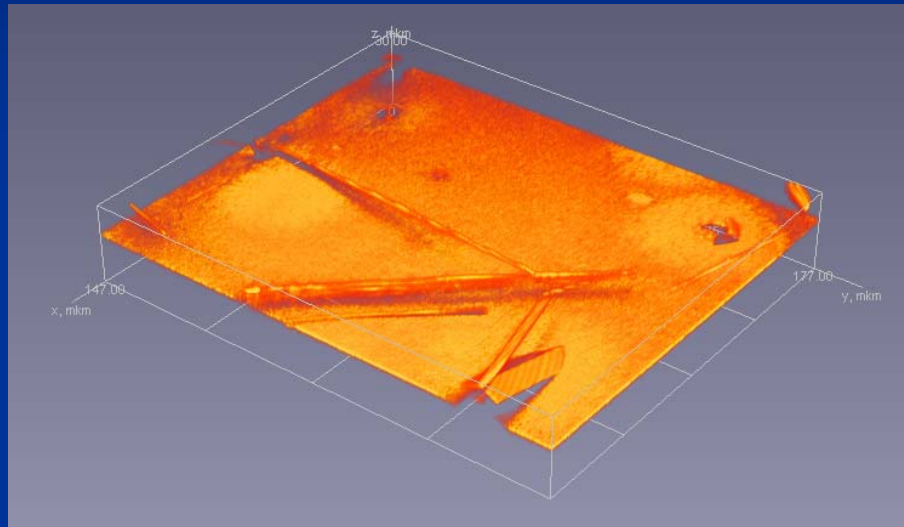
Raman mapping at  $520 \text{ cm}^{-1}$





## 3D Confocal Microscopy

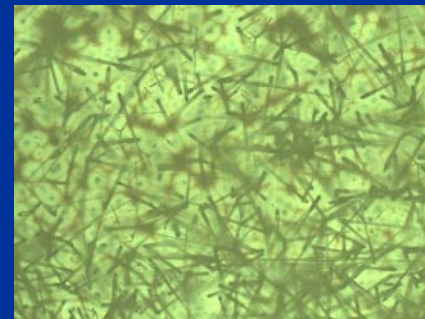
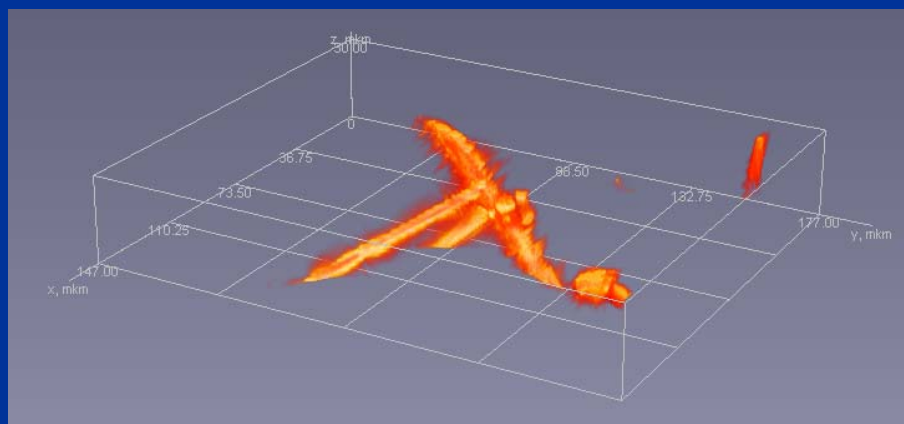
Atmospheric pressure chemical vapour deposition (APCVD) of ZnO microcrystals on Si substrate



3D confocal images:

$132 \times 110 \times 30 \mu\text{m}$

2D optical images



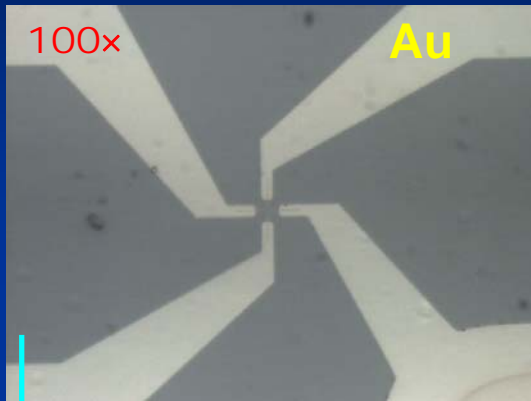
$890 \times 660 \mu\text{m}$



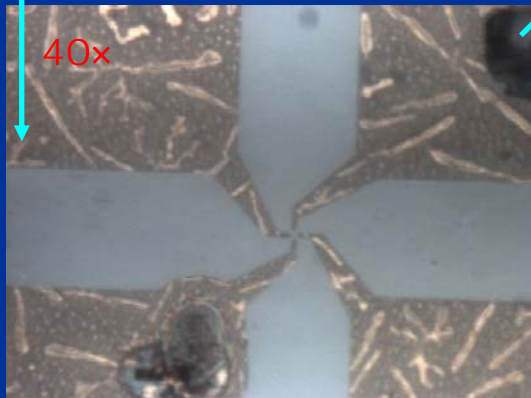
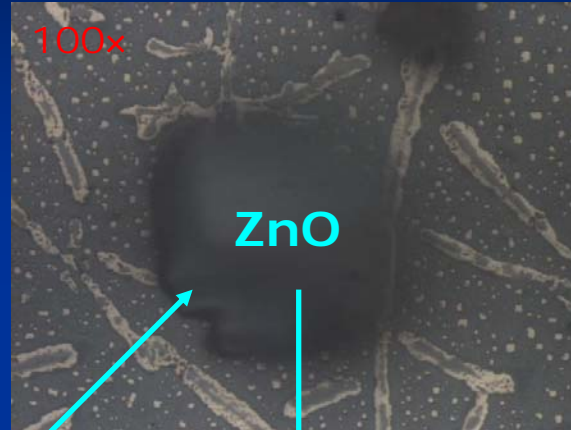
$89 \times 66 \mu\text{m}$



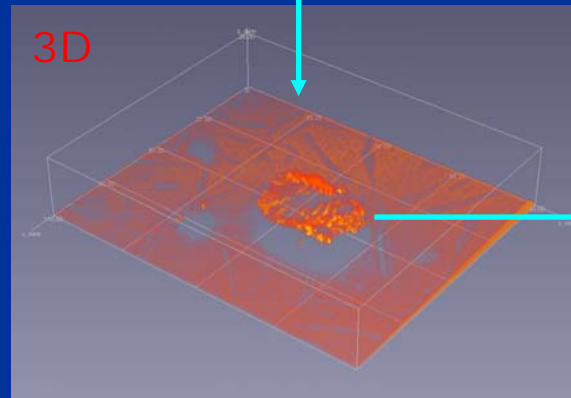
## 2D & 3D Imaging of Technological Process



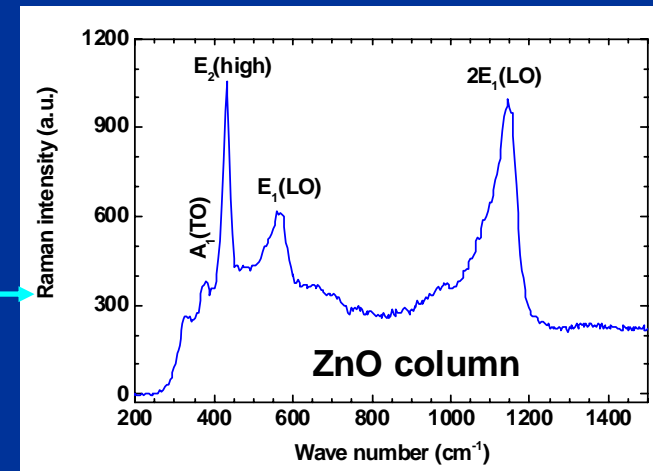
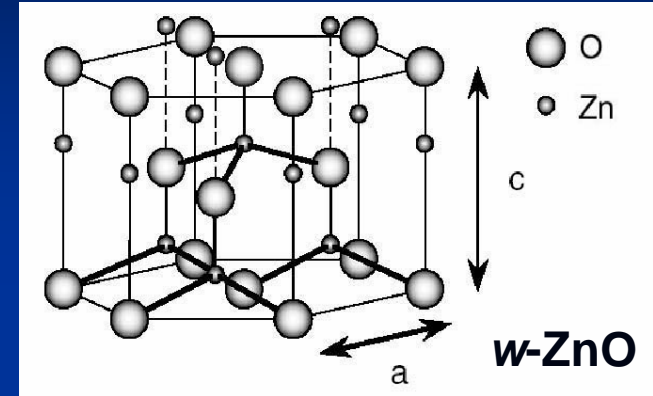
Gold contacts on silicon



Contacts after heat treatment at 700°C and ZnO deposition



133 × 110 × 26 μm





## 2D Video and Photoluminescence Imaging of ZnO micro-needles



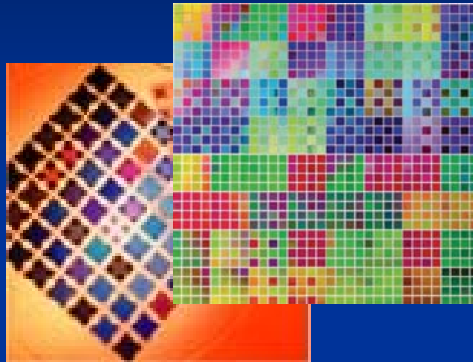
**Blue** exciton and **green** defect photoluminescence is observed under 266 nm laser excitation.

The inset shows green luminescence distribution in the perpendicular section at the middle of a needle.

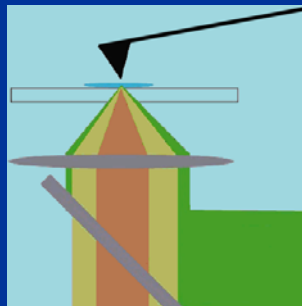




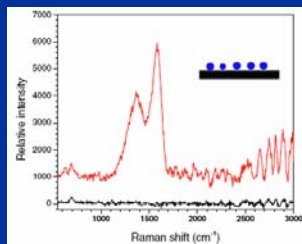
## Future Developments



Combinatorial or high-throughput approach to new materials synthesis



Apertureless Raman Spectroscopy by joint use with AFM



Surface Enhanced Raman Spectroscopy (SERS)



Institute of Solid State Physics, University of Latvia

*Thank you !*

Get more at

<http://www.cfi.lu.lv/exafs/>

Supported by



LZP



LR IZM



PROJEKTU LĪDZFINANSĒ  
EIROPAS SAVIENĪBA