Lev Academic Center - JCT
Micro/NanoTechnology Center

Magnet Consortium:
Development of Technologies for Engineering and 3D Printing of Cells, Tissues and Organs

Proposed Project:
Developing Set of New Generic Technologies for High Resolution Characterization of Nano/Microstructures for Cells, Tissues and Organs, formed by 3D Printing

Tel Aviv, Israel

11.04.2018

The Objectives of the Proposed Project within the Magnet Consortium

The Project, proposed in the framework of the Magnet Consortium, will be focused on the following three most important objectives:

1. Developing Set of New Generic Technologies for High Resolution Measurements of Nano/Microstructures for Cells, Tissues and Organs, formed by 3D Printing.
2. Creating Basic Laboratory of 3D and 2D Characterization, Using the Equipment, Existing at the Micro/NanoTechnology Center, for all the Industrial and Academician Members of the Magnet Consortium.
3. Using the Personnel and Existing Infrastructure of the Micro/NanoTechnology Center as a Part of the Technological Base for the Industrial and Academician Members of the Magnet Consortium for Development and Fabrication of the Nano/Microstructures for Cells, Tissues and Organs, formed by 3D Printing.

Brief Description of the Basic Technologies, Characterization Techniques, Developed Electro-Optical Components and Materials available in the Micro/NanoTechnology Center:

Basic Micro/Nanotechnologies: 3D Micro/Nano-structuring; Gray Scale Micro-Lithography Method; Casting Technology using Cold Embossing Mold; Novel Liquid Crystal Materials and Technologies; Gap Micro-Lithography Method; Modified Proximity Micro-Lithography Method; Thermal Reflow Method; Precise Deep Wet Etching; 3D Double-sided Alignment; Technologies, Materials and Tools for Advanced Wafer Level Micro Scale Vacuum Packaging; Room Temperature Vacuum Sealing; Microfluidic Technology.

Basic Micro/Nano-characterization Techniques: Non-Contact 3D and 2D Micro/Nano-characterization based on the Micro-interferometry and Confocal Microscopy; Non-Contact Advanced High Resolution Optical Microscopy (Dark-Field, Phase Contrast, Bright-field, Fluorescence methods) and Non-Contact Atomic Force Microscopy.

Basic Developed Passive and Active Nano, Micro and Macroscopic Electro-Optical Devices for the UV, Visible and Infrared Ranges: Beam Shapers; Micro-lens Arrays; Micro-mirror Arrays; Fresnel Micro-Lens Arrays; Micro-prism Arrays; Single Macroscopic Lenses and Macroscopic Lens Arrays; Optical Micro Waveguide Arrays; Optical Micro Routers.

Basic Materials for Passive and Active UV, Visible and IR Nano, Micro and Macroscopic Electro-Optical and Electronic Components: Liquid Crystals; Nano-colloids; New Organic and Inorganic Photosensitive Materials; Silicon (Si): Transmission range of 1.2 to 7.0 µm; Gallium Arsenide (GaAs): Transmission range of 2 to 15 µm; Germanium (Ge): Transmission range of 2 to 14 µm; Fused Silica (SiO_2), IR Grade: Transmission range of 0.25 to 3.5 µm; BK7 Schott Glass: Transmission range of 0.35 to 2.0 µm; Optical Polymers: Transmission ranges: of 0.35-2.0 µm; 3.7-5.0 µm; Chalcogenide $As_{40}Se_{60}$: Transmission range of 0.9 – 14 µm; Indium Tin Oxide: Transmission range of 350 – 700 nm; Aluminum for Nano-antenna and Micro-antenna Arrays.

Research Facilities

The Micro/NanoTechnology Center, equipped with all the research facilities needed for performing Projects in the Micro/NanoTechnology Area, occupies a space of 150 sq. meters, including the clean room area of 80 sq. meters: Class 100 – for micro and nano processing and Class 10,000 - for general technology processing.

Existing infrastructure and equipment

Research and Educational Labs

The Current R&D Projects carry out at the Micro/NanoTechnology Center of the Lev Academic Center – JCT, consisting of the jointly acting Active Micro-Optics Lab, Micro/Nano Structuring Lab, 2D and 3D Micro/Nano Characterization Lab, Micromechanics and Electronic Design Lab, Micro/Nano/Chemistry Lab, Educational Lab: Fundamentals of Micro/NanoTechnology.

List of the Clean Room Equipment Available at the Micro/NanoTechnology Center:

Zygo NewView 8300 Surface Nano-Profiler for 3D and 2D nano-characterization; Computerized Optical Measurement Station based on Modified Multifunctional Measuring Microscope Olympus BX51 using Reflection Phase Contrast, Dark-field, Bright-field, Infrared
Imaging, Fluorescence and 2D Measurement Modes, Transmittance and Polarization Modes.
3D Measurement System based on Multi-wavelength Confocal Microscope CHRIS, STIL S.A.(France); Microscope Balplan using Transmittance, Reflection Dark-field, Phase Contrast and Bright-field Modes, Polarization Mode, 2D characterization; Micro/Nanoscope Leitz LABORLUX S using Reflection Bright-field and Transmittance Modes, 2D nano-characterization; Computerized Atomic Force Microscope (Topometrix, Santa Clara, USA) for 3D and 2D nano-characterization; Vacuum System with two 3D Manipulators for Preparation and Storage of Micro Scale Samples.
Conventional Mask-aligner; Double-sided Mask-aligner; Exposure System for micro-resist processing based on Oriel Series SS 1000 Light Source; Micro-resist Spinner; two Vacuum Systems for thermal evaporation of metals and dry micro- and nano-resists, with deposition rates and film thickness measurements during evaporation using an Inficon XTM Thickness Monitor; System for Assembly and Sealing of Stressed Liquid Crystal Cells; Liquid Crystal Cell Assembly System; Computerized Ultra Clean 100 oven; Digital Hotplate; Set-up for Rubbing of Aligning Layer; System for UV Curing of optical polymers; Solar Spectrum Simulator Oriel Series SS 1000; Measurement System based on Computerized 3D Zygo Micro-interferometer; two Interference Microscopes MII – 4 for 3D Measurement; Set of Optical Microscopes: Microscope Biolam – M, Microscope MBS – 9, Microscope “Riechert”; two Optical Tables TMC, model # 788 – 455 – 12 with set of electro-optical, electronic and mechanical devices; Two Set-ups for Electro-optical Measurements; Magnetic Stirrer with Heating AREC.T; CNI Laser, MGL-III-532-5mw; HeNe Lasers 0.5MW; Beam Profiler BM-USB-SP928-OSI BeamMic; Si Detector, DET10A/M, 200-1100 nm, 1 ns Rise Time, 0.8 mm2; Filter-wheel type monochromator; Electronic and electric measurement instruments: Pintek HA-405 High Voltage Amplifier; Agilent DS06012A Oscilloscope; Keithley Model 2000 - a 6½-digit high-performance digital multimeter; Liquid Nitrogen and Oxygen Dewars as sources of clean dry gases for thermal and cleaning processes.

Non-Contact Micro/NanoCharacterization Equipment Available at the Micro/Nano Technology Center for the Implementation of the Proposed Project "Developing Set of New Generic Technologies for High Resolution Characterization of Nano/Microstructures for Cells, Tissues and Organs, formed by 3D Printing" within the Magnet Consortium "Development of Technologies for Engineering and 3D Printing of Cells, Tissues and Organs"

Zygo New View 8000 Non-Contact 3D Nano-Profiler Available at the Micro/NanoTechnology Center

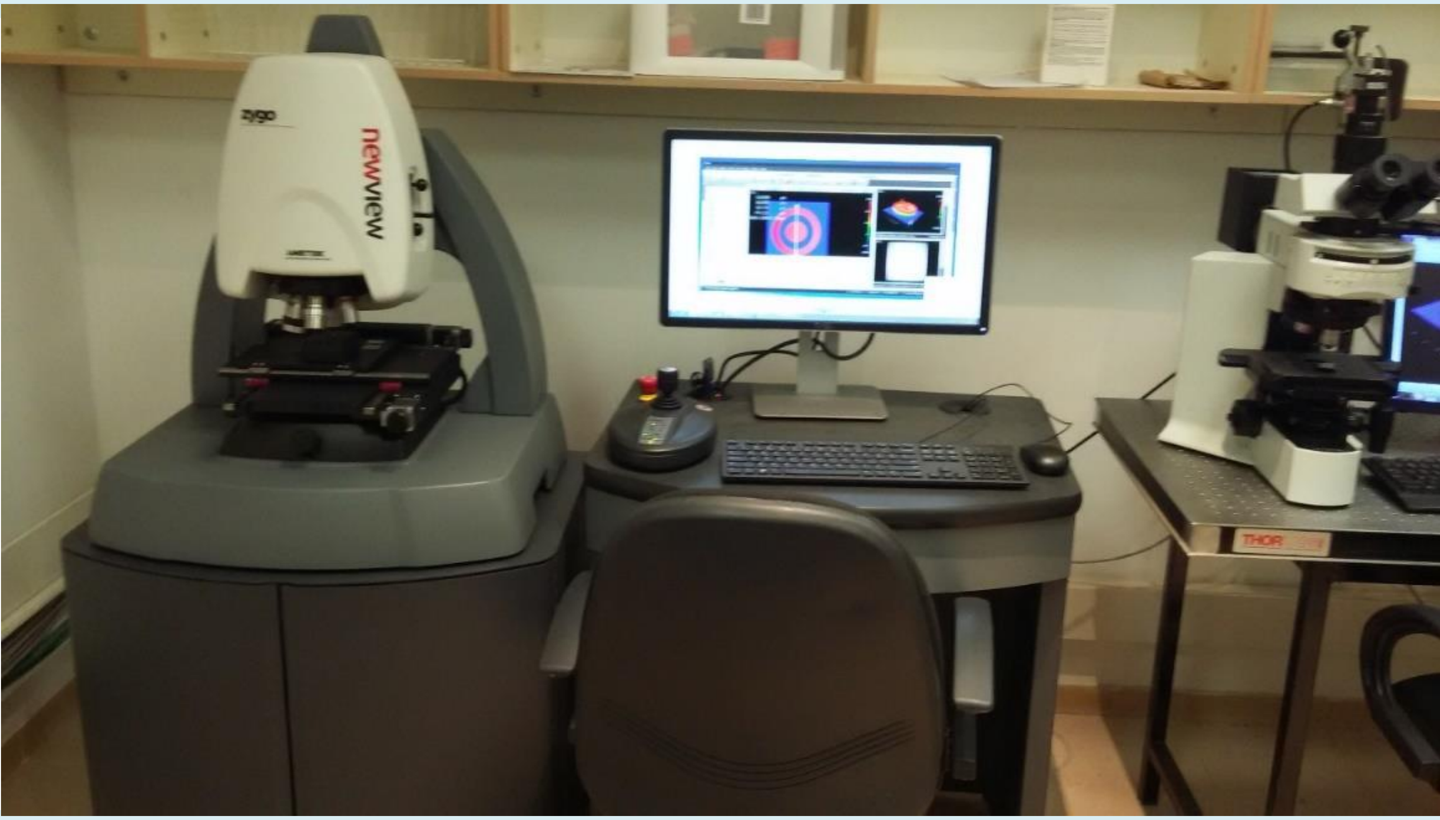


Figure 1. Zygo New View 8000 Non-Contact 3D Nano-Profiler.

Non-Contact Modes: 3D Nano-Characterization, 2D Nano-Characterization, Integrated Field Stitching and Reflection Bright-field

Primary Parameters:

Maximum Optical Magnification: 2000^x
Z Resolution: 0.1 nm
X-Y Resolution (Spatial Sampling using 100^X objective 2^X zoom): 40 nm
Repeatability of RMS: 0.01 nm
Height/Depth of Profile of Test Sample (Scan Range along Z Axis): up to 22 mm
Field of View: Objective and zoom selectable from 40 µm to 16 mm
Maximum Integrated Field Stitching 150mm x 150mm
X-Y Optical Lateral Resolution: 340 nm

Modified Multifunctional Measuring Microscope Olympus BX51 Available at the Micro/NanoTechnology Center

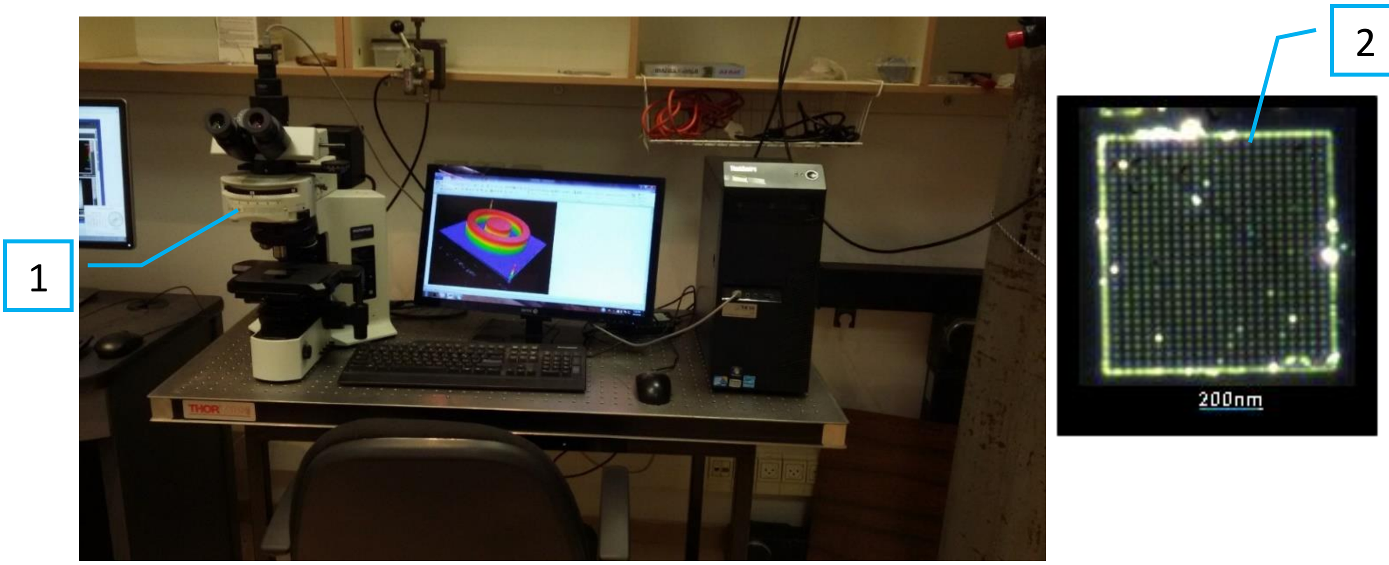


Figure 2: 1 - Modified Multifunctional Measuring Microscope Olympus BX51; 2 - Sample, comprising Array of 30 30 Nanoparticles with Size of 20 nm and Pitch of 50 nm. The Sample was developed, fabricated and measured using Dark-field Mode of Microscope Olympus BX51 in the Micro/Nano/ Technology Center [1].

The Non-Contact Modes Available at the Micro/NanoTechnology Center: 2D Measurement, 3D Measurement, Transmittance, Reflection, Reflection Phase Contrast, Dark-field, Bright-field, Polarization.
Optional Non-Contact Modes: Infrared Imaging, Ultra Violet Imaging, Fluorescence Imaging.

The primary parameters:
Maximum Optical Magnification: 2000^x
Optical Magnification Range: 150^x, 200^x, 300^x, 400^x, 750^x, 800^x, 1500^x, 2000^x
Best X-Y Axes Measuring Resolution of Ocular-Micrometer: 63 nm
Maximum X-Y Axes Optical Lateral Resolution using Dark-field Mode: ~ 20 nm
Maximum X-Y Axes Optical Lateral Resolution: 361 nm
Working Distance at Maximum Optical Magnification: 3.30 mm
Best Z Axis Measuring Resolution: 1 μm

[1]. Proof of Concept for High Efficiency Solar Energy to Electricity Nanoconverter, Scientific Report on Research Project, the Ministry of Infrastructures, Energy and Water Resources, State of Israel, 2015 – 2016, Principal Investigator Prof. M. Manevich.

3D Micro Measurement System based on Multi-Wavelength Confocal Microscope CHRIS STIL S.A. Company" (France) Available at the Micro/NanoTechnology Center

Figure 3. 3D Micro Measurement System available at the Micro/NanoTechnology Center for 3D and 2D Characterization.

Primary Parameters:

1. Non-Contact Modes: 3D Measurement, 2D Measurement, Reflection Bright-field.
2. X-Y Resolution: 100 nm
3. Z Resolution: 1 nm
4. Height/Depth of Profile of Test Sample (Scan Range along Z Axis): up to 50 mm
5. Scanned Area: 100 mm × 100 mm.

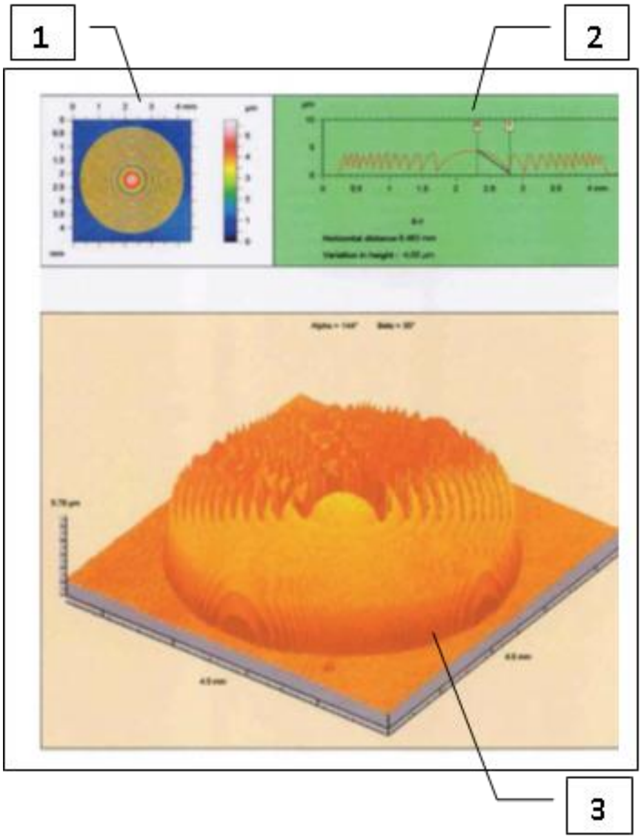


Figure 4. Sample, comprising Fresnel Micro-lens with Profile Height of 4.15 µm and Diameter of 4 mm. The Sample was developed, fabricated and measured using 3D Micro Measurement System based on Multi-Wavelength Confocal Microscope CHRIS, STIL S.A. Company" (France) in the Micro/NanoTechnology Center: 1 - 2D Image of Fresnel Micro-lens - Top View; 2 – Micro-Profile Measurement; 3 - 3D Image of Fresnel Micro-lens [2].

[2]. Liquid Crystal Devices for Laser Micromachining – LC4LM, Scientific Report on **Joint R&D Project with Orbotech Ltd funded by the Israeli Ministry of Industry and Trade, Magneton Program,** 2011 – 2013, Principal Investigator Prof. M. Manevich.

Figure 5. Modified Measuring Nanoscope LEITZ LABORLUX S, <u>available in the Micro/NanoTechnology Center</u>.

The primary parameters:

Maximum Optical Magnification: 2000^x

Optical Magnification Range: 25^x, 37.5^x, 150^x, 200^x, 600^x, 800^x, 900^x, 1200^x, 1500^x, 2000^x

Best X-Y Axes Measuring Resolution of Ocular-Micrometer: 63 nm

X-Y Axes Optical Lateral Resolution: 289 nm

Z Axis Measuring Resolution: 1 µm

Non-Contact Modes: 2D Measurement, 3D Measurement and Transmittance.

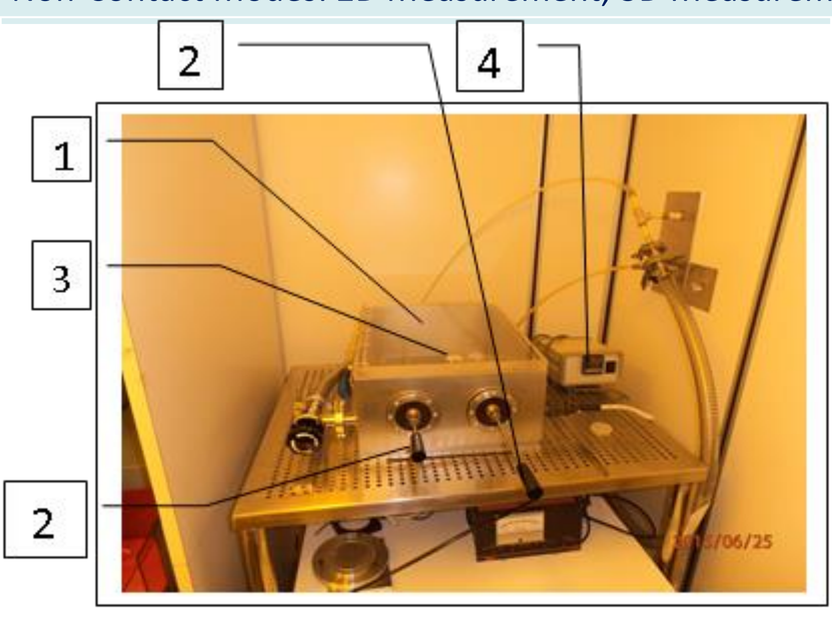


Figure 6. Vacuum System for Sample Preparation and Storage, available in the Micro/NanoTechnology Center:

1 – Vacuum Chamber;

2 – 3D Mechanical Manipulator;

3 - System of Temperature Stabilization and Sample Storage in Vacuum Environment;

4 - Electronic Power Supply for the System of Temperature Stabilization and Sample Storage in Vacuum Environment.

Modified Measuring Microscope Balplan Available in the Micro/NanoTechnology Center

Figure 7. Modified Measuring Microscope Balplan

The primary parameters:

Maximum Optical Magnification: 800^x

Optical Magnification Range: 75^x, 100^x, 150^x, 200^x, 300^x, 400^x, 600^x, 800^x

Maximum X-Y Axes Optical Lateral Resolution: 445 nm

Best X-Y Axes Measuring Resolution of Ocular-Micrometer: 157 nm

Z Axis Measuring Resolution: 1 µm

Non-Contact Modes: 2D Measurement, 3D Measurement, Transmittance, Reflection, Polarization, Reflection Phase Contrast, Dark-field, Bright-field, Fluorescence.

Figure 8. Atomic Force Microscope (Topometrix, Santa Clara, USA), available in the Micro/NanoTechnology Center, equipped with a specially modified optical probe operated in non-contact and contact modes for 3D Measurement and 2D Measurement.

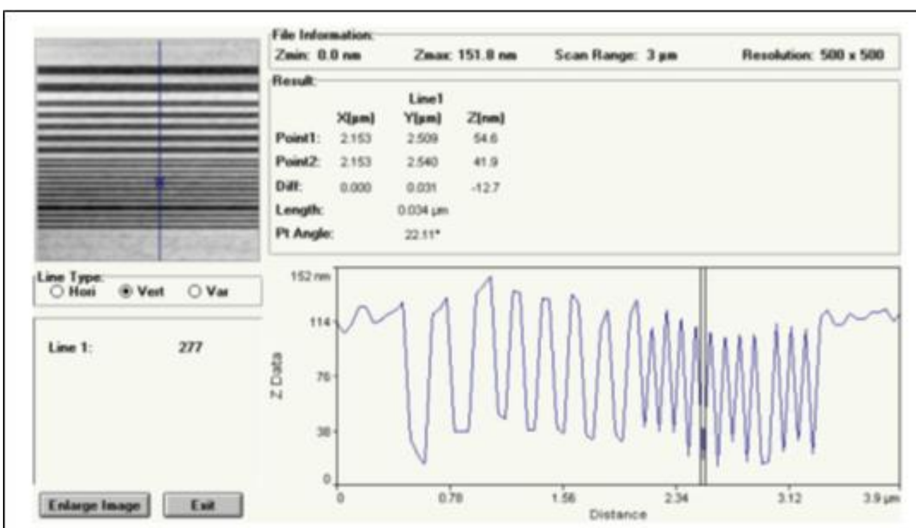
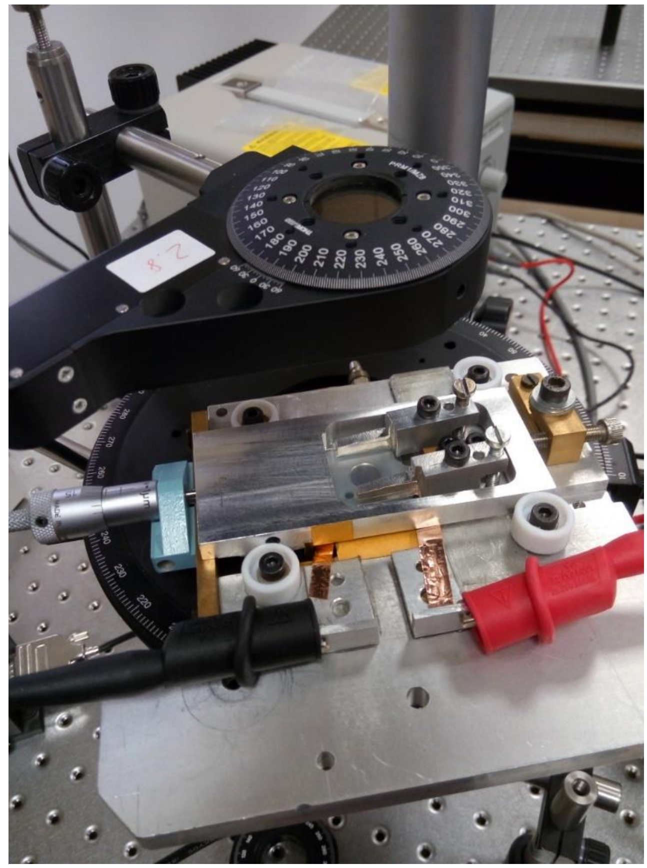


Figure 9. Analysis of a cross section of the Grating Sample developed, fabricated and **measured using Atomic Force Microscope (Topometrix, Santa Clara, USA) in the Lev Academic Center [5].**
Measuring the 31nm line width with a depth of 90 nm, giving a very high aspect ratio of 1:3.

[5]. E. Flaxer, M. Klebanov, V. Lyubin, **M. Manevich,** S. Noach, Thermal and optical nanolithography using a scanning near-field optical microscopy, Chapter in book “Microscopy: Science, Technology, Applications and Education”, A. Méndez-Vilas and J. Díaz (Eds.)

Measuring Setup



Experimental Sample

Figure 10. Setup for Measuring Electro-Optical Properties of Nanomaterials Available at the Micro/NanoTechnology Center

Thank you for your attention!

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The relevant and more detailed information about the Personnel, Projects, Developed Technologies, Existing Infrastructure, etc. of the Micro/NanoTechnology Center can be found by clicking on the link: http://www.jct.ac.il/he/node/478