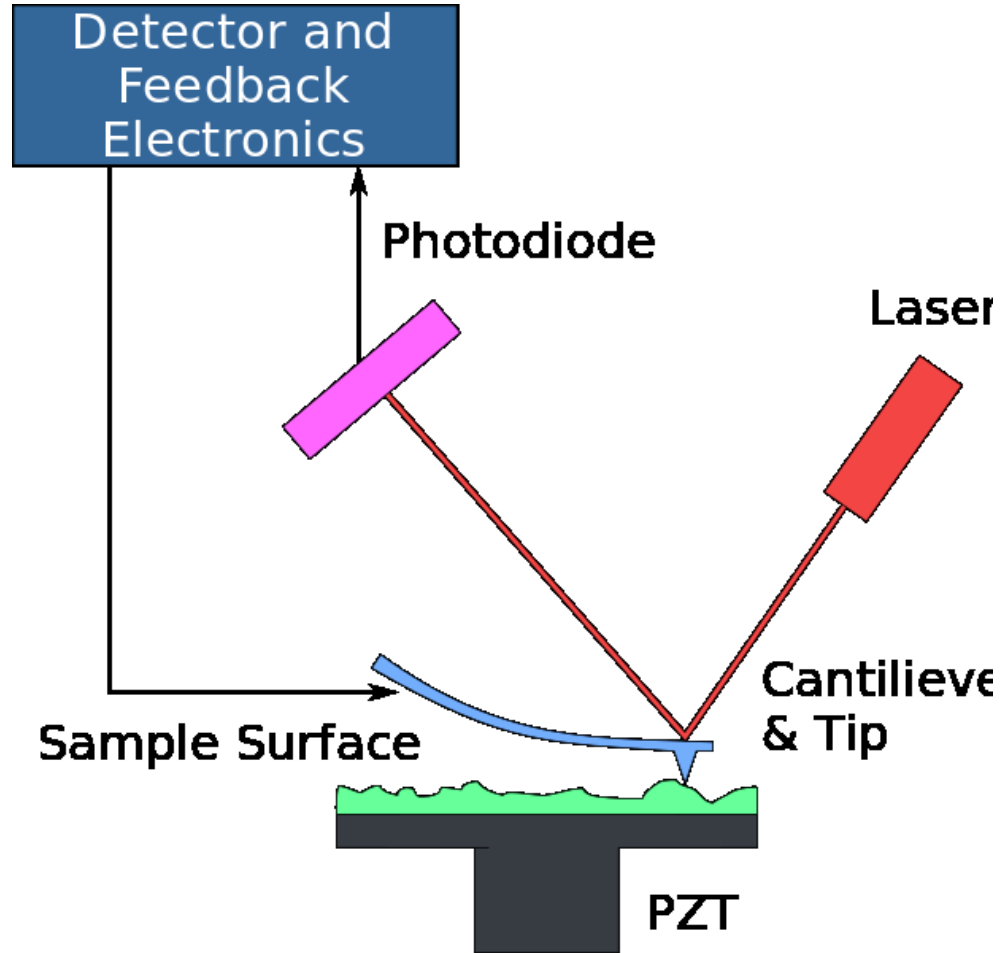


Tip-Enhanced RAMAN Spectroscopy (TERS) Probe Development Project in Artech Carbon OÜ

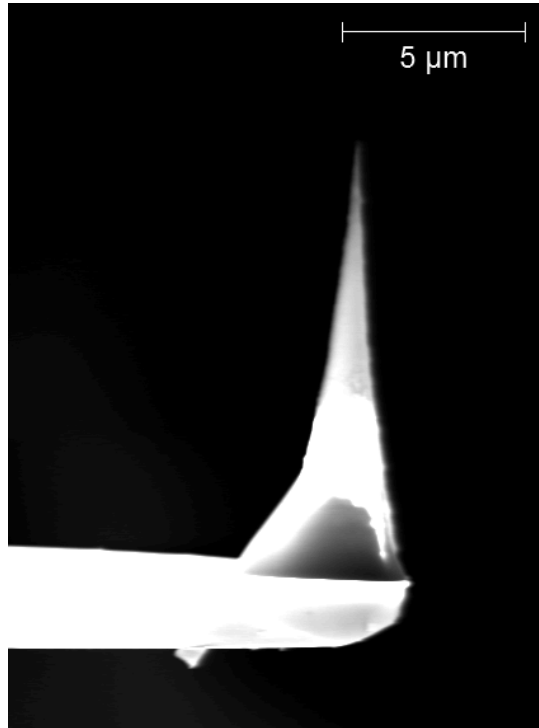
June 6, 2017

Tallinn

What is SPM?



Single Crystal Diamond AFM Probes



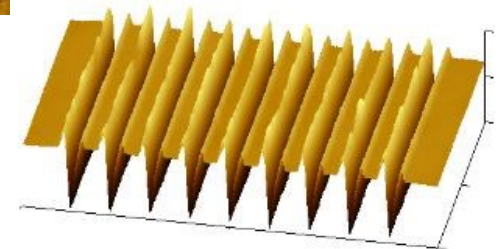
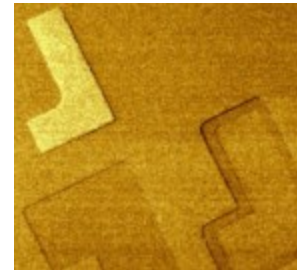
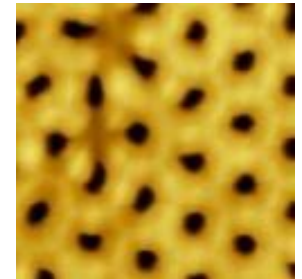
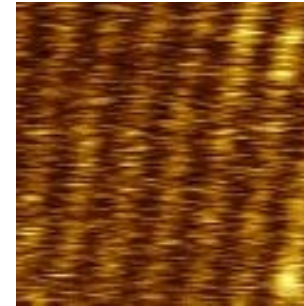
Tip radius 10 nm
Tip height 12..14 μm
Tip cone angle 10° (5:1)

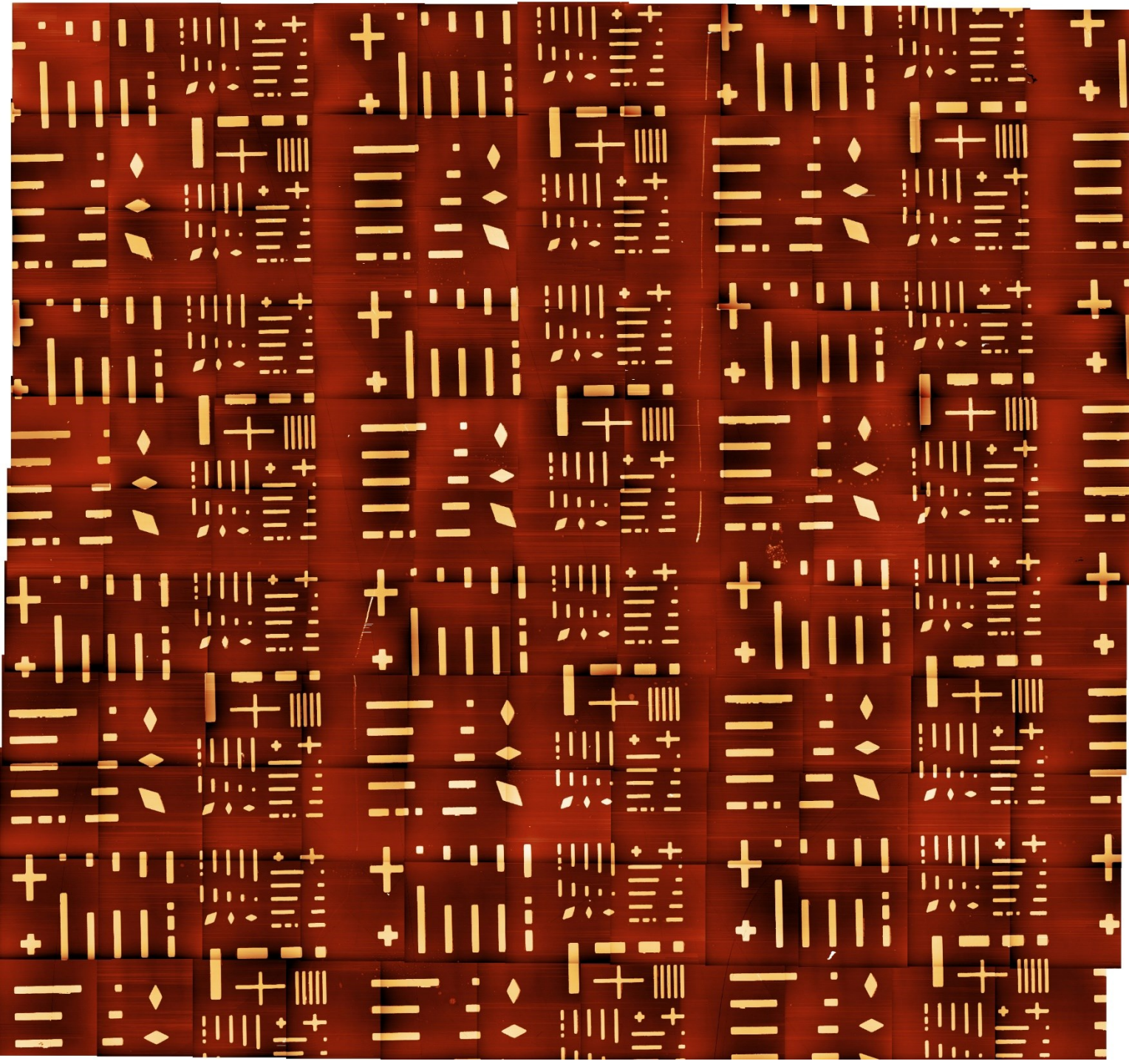
Tip material – diamond, $\langle 100 \rangle$ along the tip axis

The tip is specially grown and glued to Si cantilever
Glue is non-conducting, temperature stability - 70°C

Featuring Applications

- Long life and forgiving operation mistakes in tapping and contact modes while providing high resolution
- Imaging high aspect ratio features on surface
- Mechanical measurements on hard surfaces
- Nanoindentation, scratching, force lithography





Long Scanning

6 meter path in
contact mode

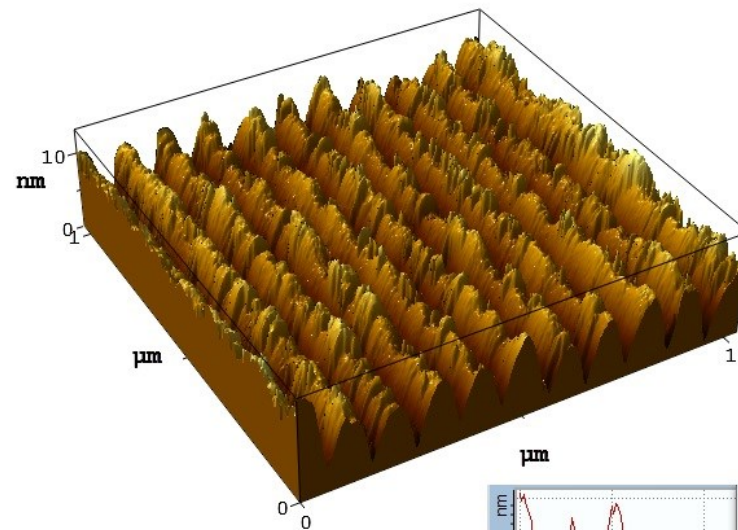
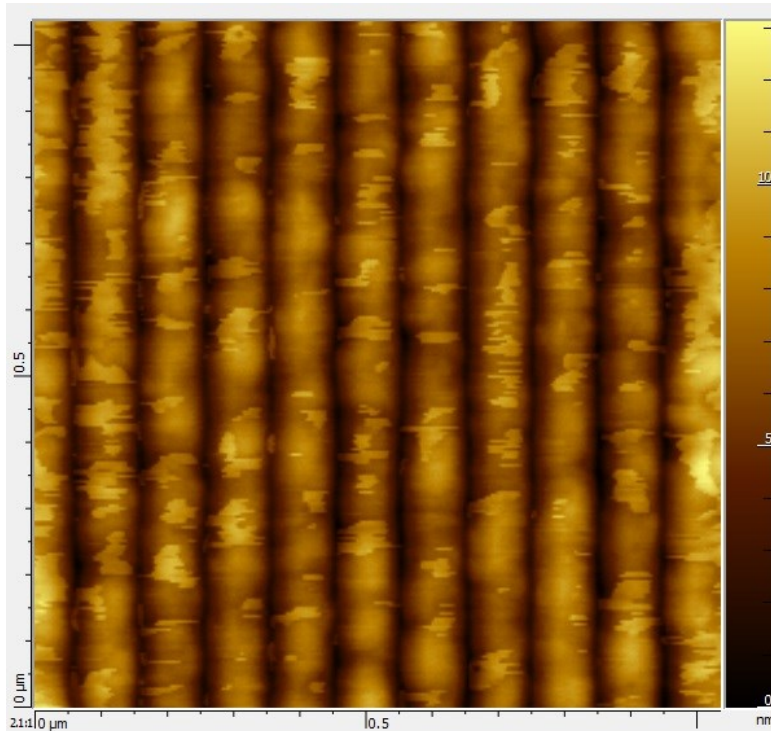
5 N/m
Cantilever

Mosaic size
1x1 mm

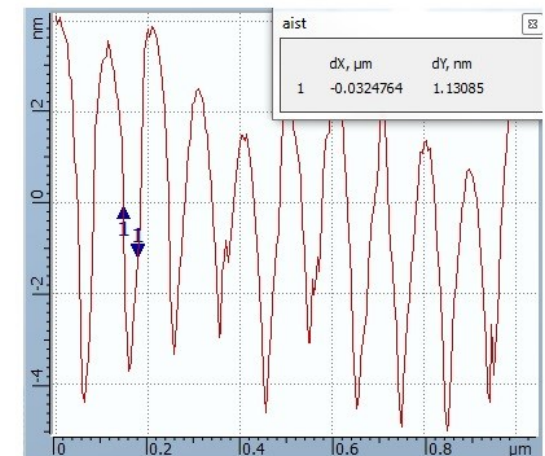
Co film on Si

Courtesy:
A. Temiriazhev

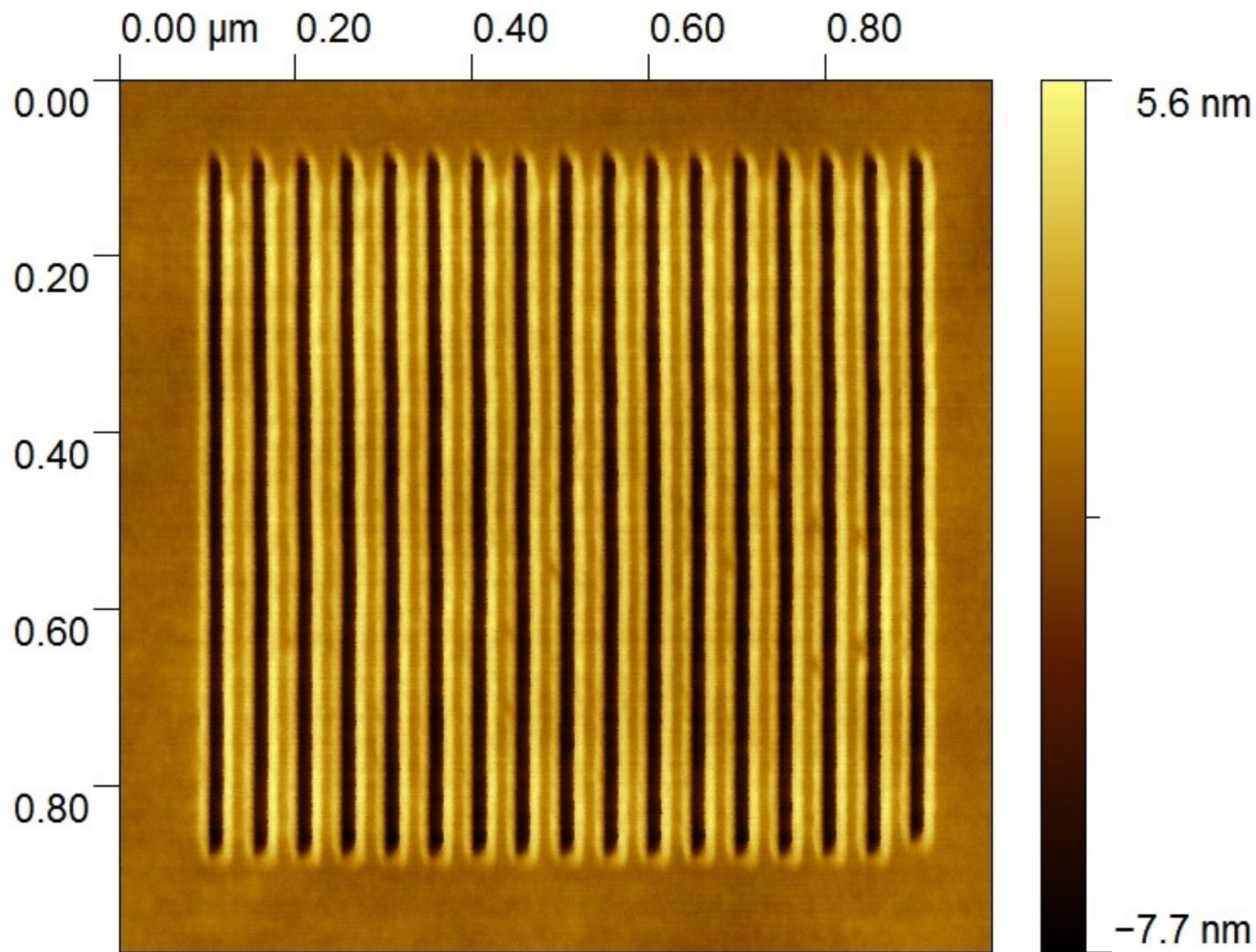
Scratching and force lithography



Amount = 65536
Average value = 6.10963 nm
Maximum = 13.1179 nm
Minimum = 0 nm
Median = 6.34205 nm
Ra = 1.90596 nm
Rms = 2.28873 nm
Skew = -0.169889
Kurtosis = -0.70621
Projected Area = 1.07161 μm^2
Inclination φ = -144.312°

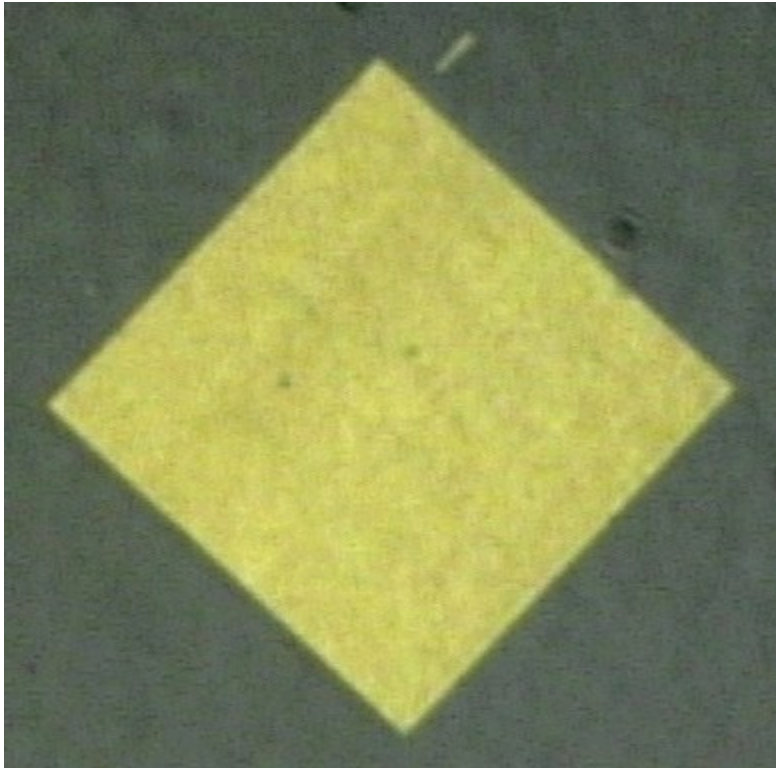


Contact mode scratching
Film hardness 600 MPa
Courtesy Emil Huseinov

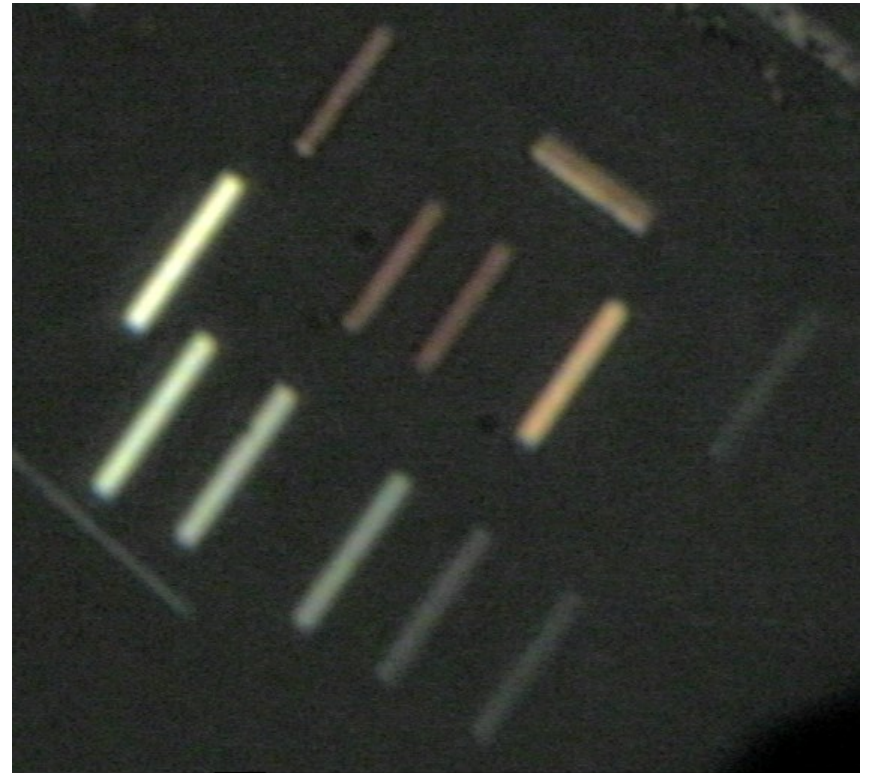


Optical properties of a grating

Optical images



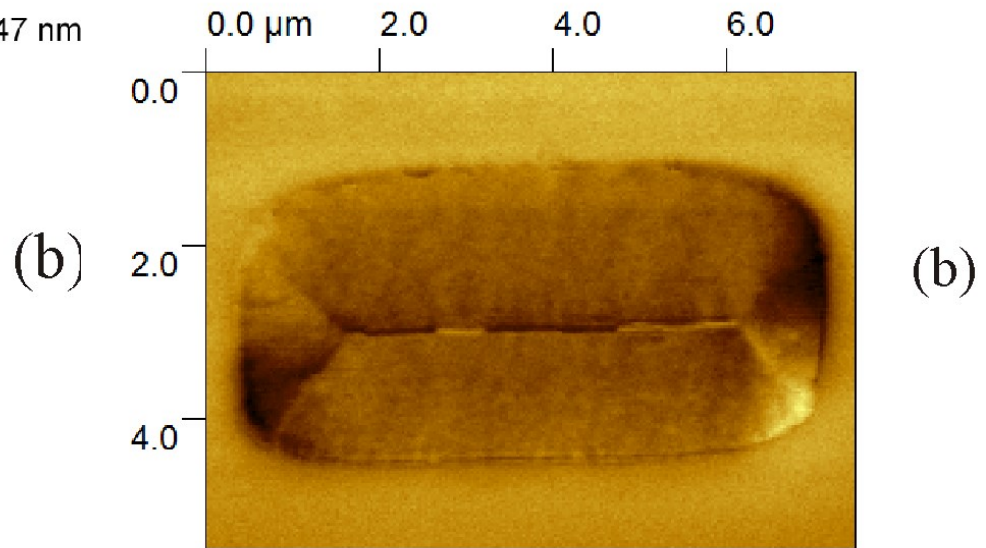
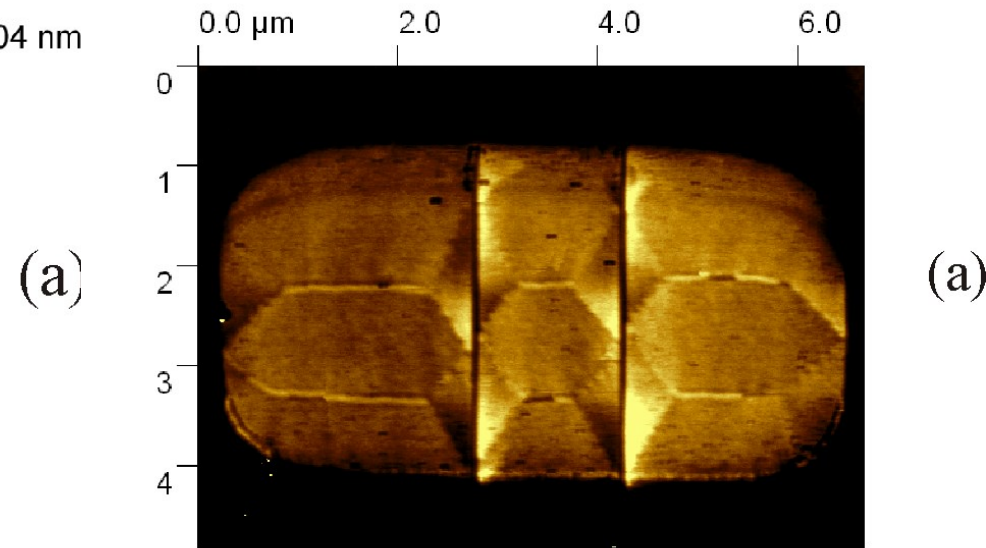
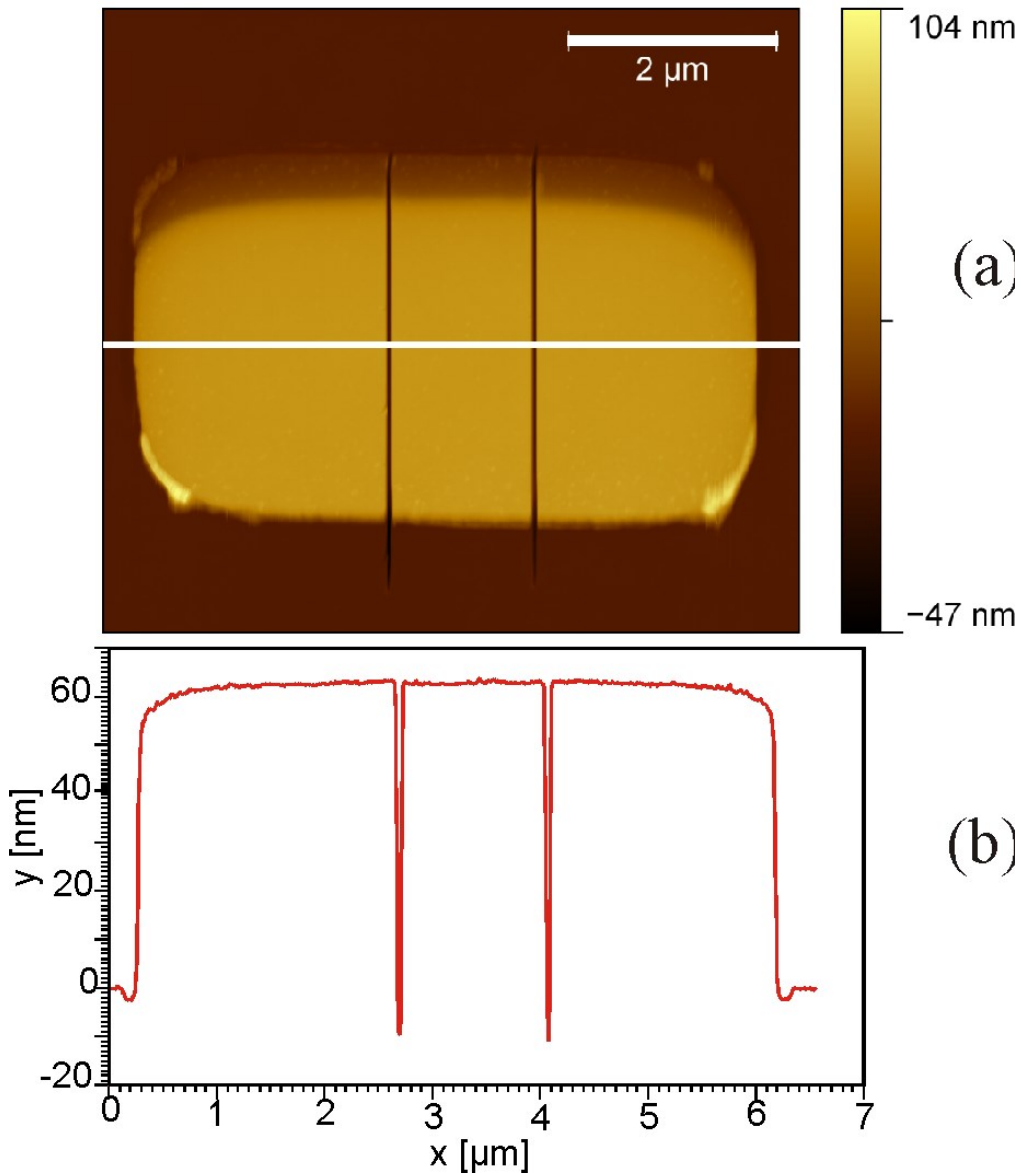
50x50 μm , 100-nm period



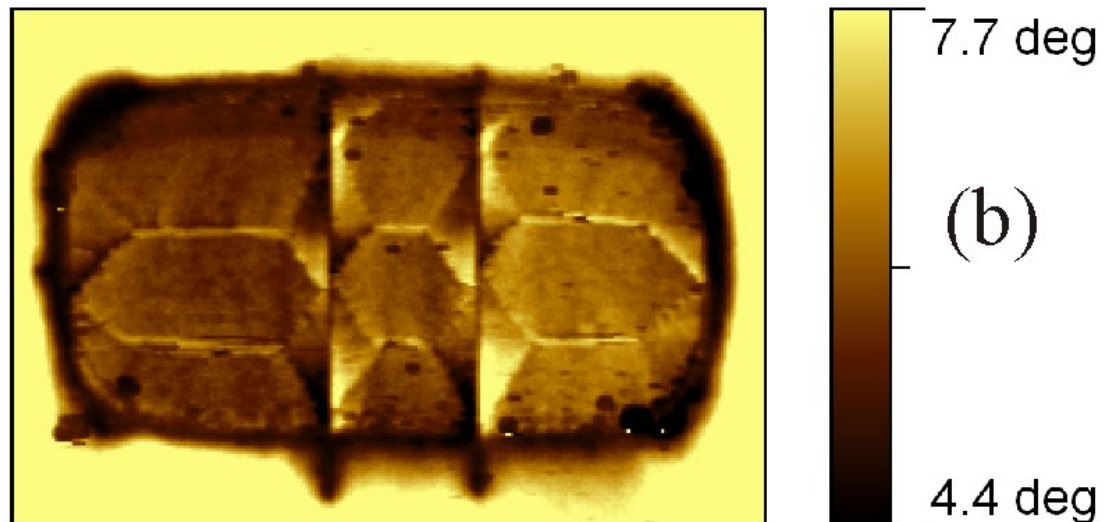
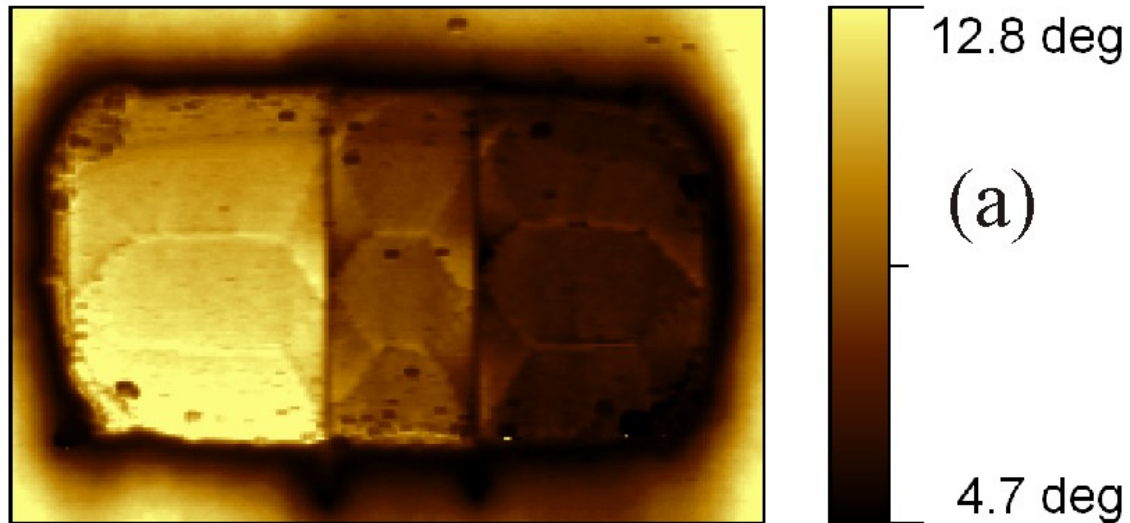
75x68 μm , different periods

Courtesy: A. Temiriazhev

Co domain cut



Electric isolation of the parts

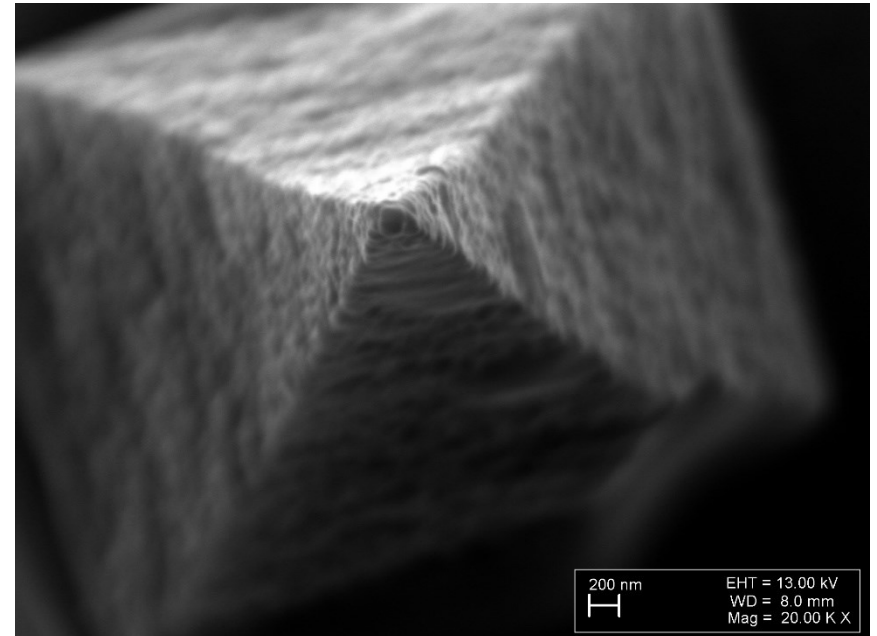
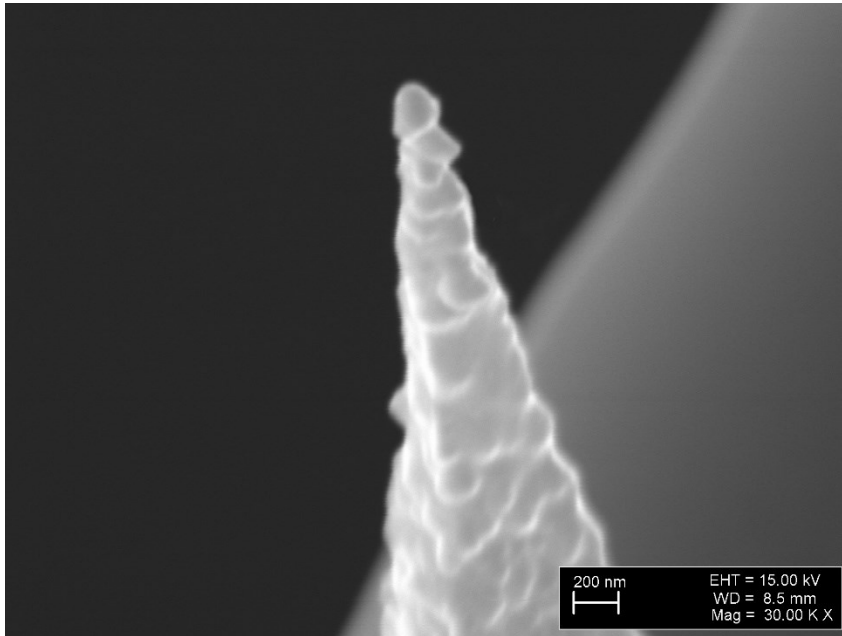


Courtesy:
A. Temiriazhev

TERS project: chronology

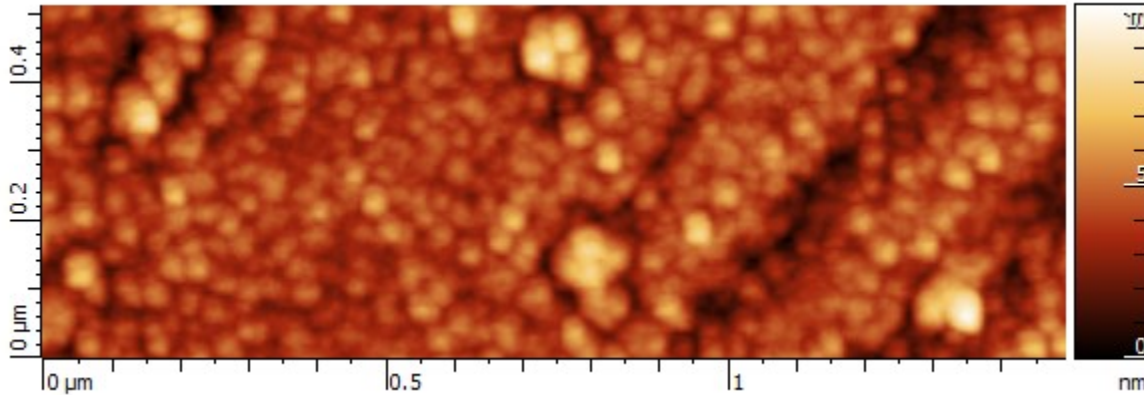
- Summer 2014: Artech Carbon gets a special order on TERS-active probes
- Spring 2015: preliminary project, supported by EAS, fund: 6000 Eur.
- First sales of TERS-active probes via our partner in 2015.
- Jan-Dec 2016: second project, supported by EAS, fund: 29 050 Eur.
- Artech Carbon's sales of TERS-active probes to the partner are about 45 000 Eur in 2016.

TERS probes made by Artech Carbon

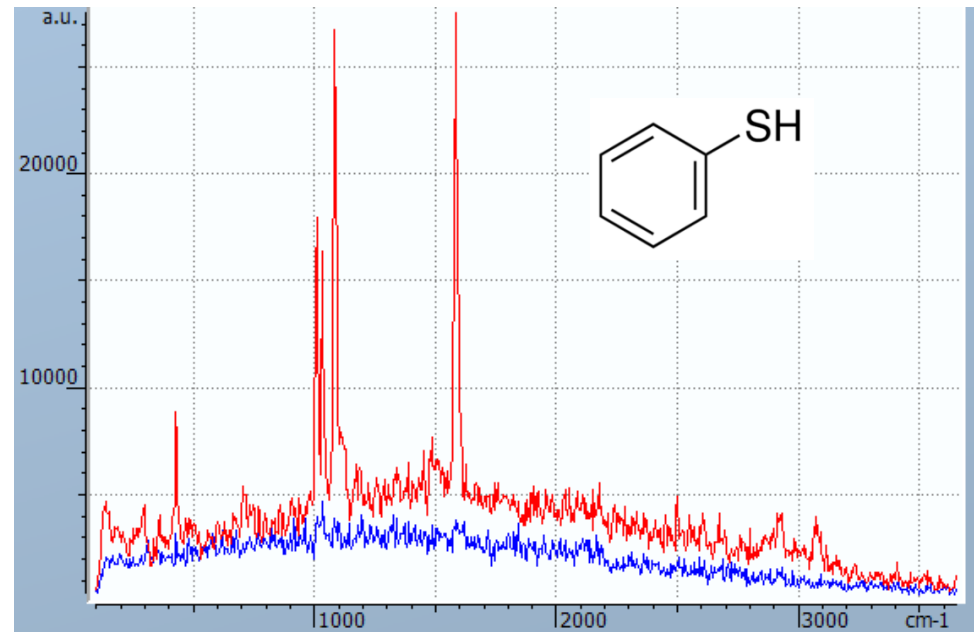
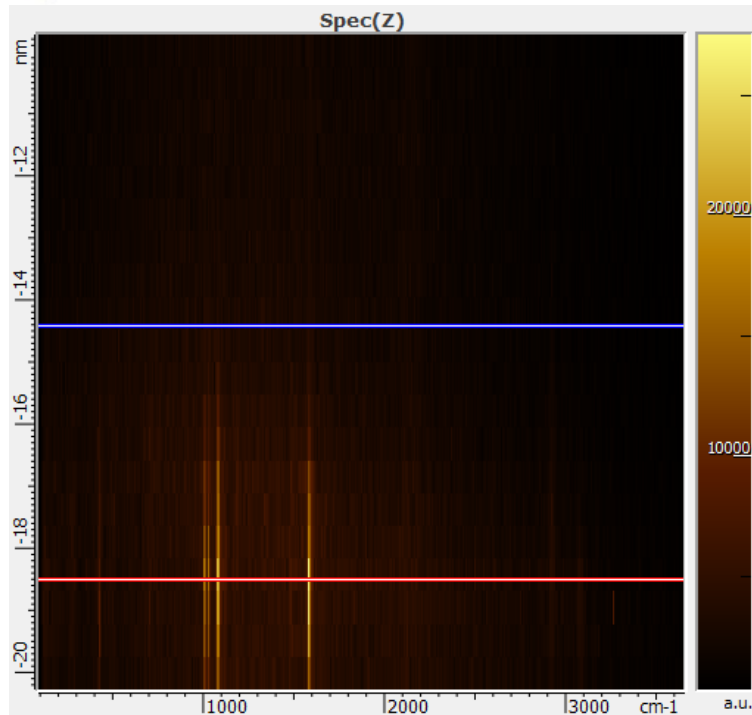


- TERS is known for more than 15 years.
- However, there were no regular sales of TERS probes until 2014 when Artech Carbon with its partners brought its solution to the market for 200 USD/tip.
- Manufacture costs: 20 USD/tip. OEM sale price: 100 USD/tip.
- In 2016, the market becomes competitive as Ag-coated probes announced by Horiba Scientific.

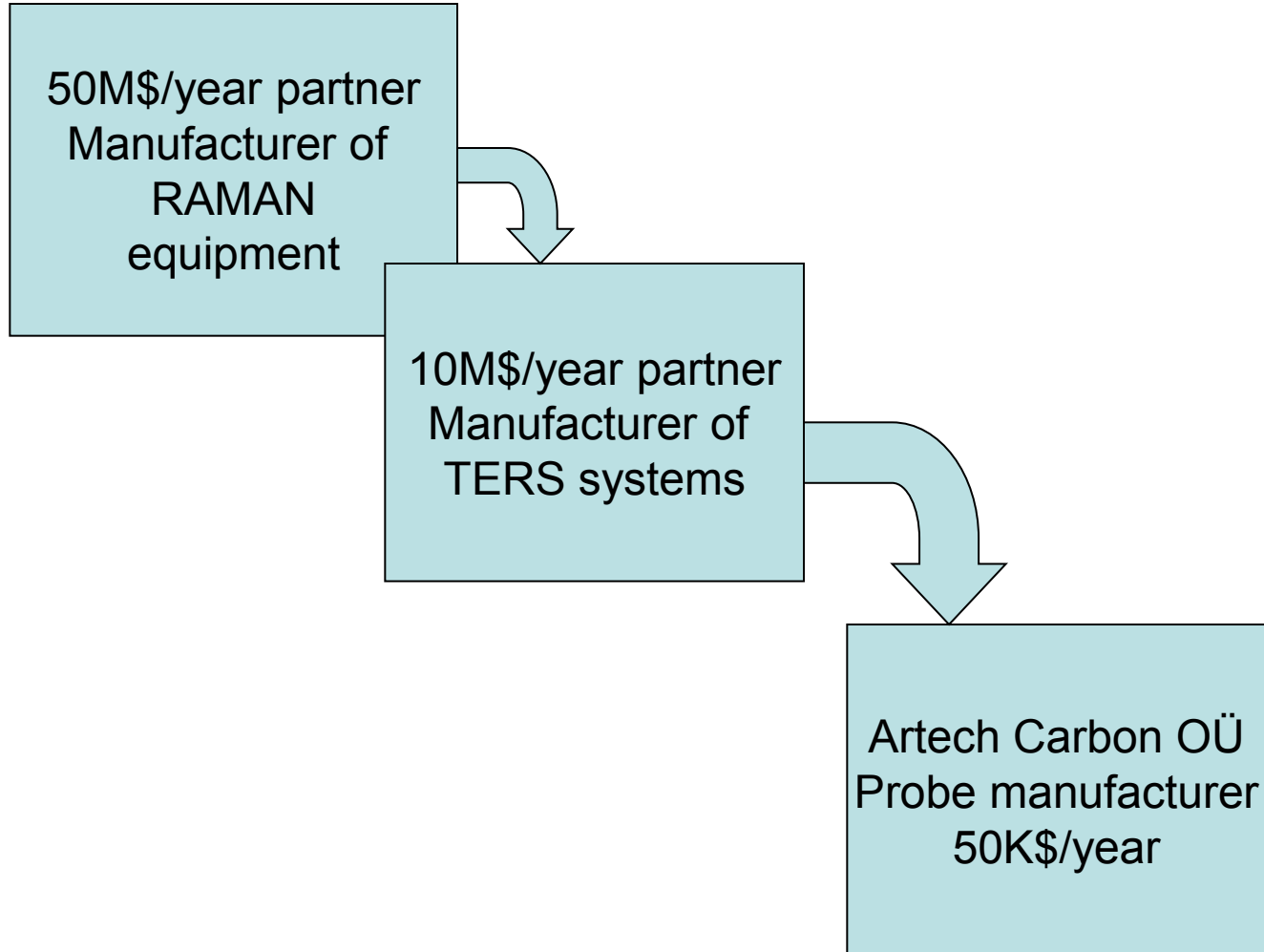
Application example



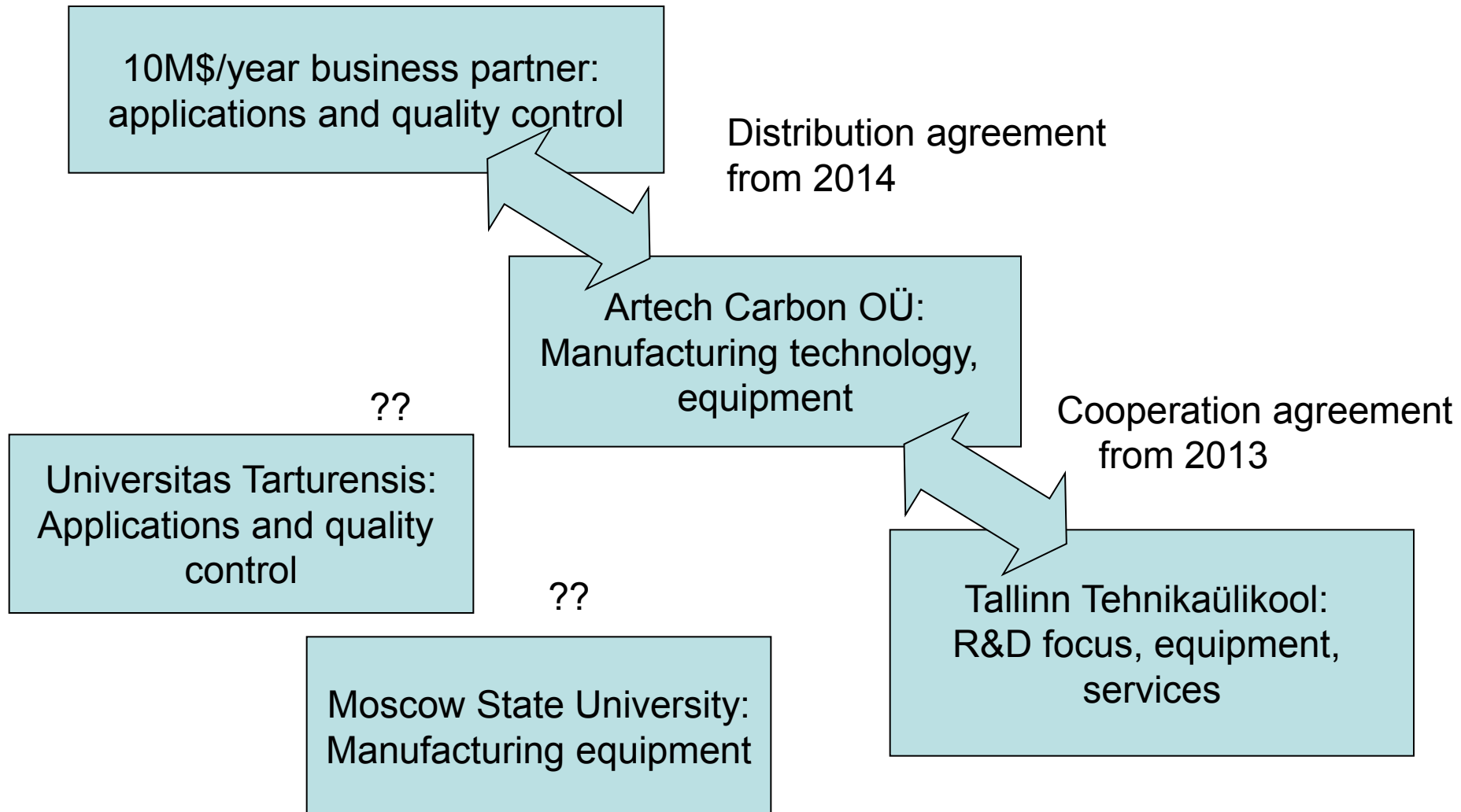
Topography image of gold film functionalized with thiophenol molecules. Distance dependence of TERS spectra intensity and typical spectra.



Market Cooperation



Technological cooperation



Next step

Competitors

Horiba: Horiba has both Au and Ag coated TERS probes made by applying coatings on Si probes. Large tip radius: about 300 nm.

Bruker: promises “at least 5 out of 10 probes reach >10x contrast”, works only with STM tuning fork type IRIS systems.

NT-MDT (Spectrum): Au coating technology on Si no regular sales.

Artech Carbon

Artech Carbon's technology provides stable amplification from tip to tip, on some samples reaching 50x.

The technology is only stable with Au. Use of Ag may improve the sensitivity of TERS method about 4-6 times.

Ag –based probes were prototyped in 2015. Stable production is requested by the partner.

Thank you!

<http://scdprobes.com>

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