Roughness in nanotechnology: a new paradigm

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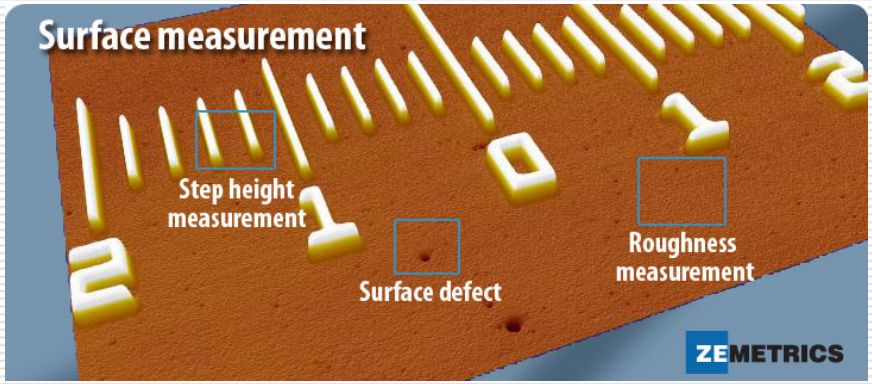


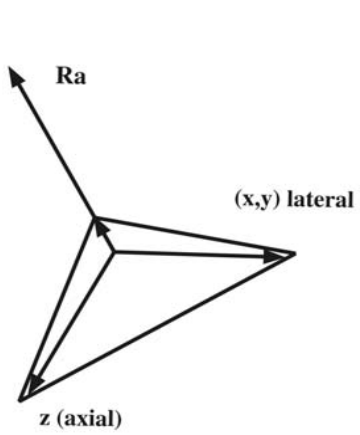


Fig. a

a) Microtehnology

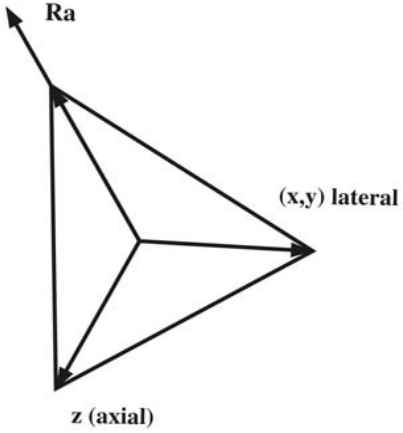


Fig. b

b) Nanotehnology

Paradigm

The historian of science Thomas Kuhn gave *paradigm* its contemporary meaning when he adopted the word to refer to the set of practices that define a scientific discipline at any particular period of time. Kuhn himself came to prefer the terms exemplar and normal science, which have more precise philosophical meanings.

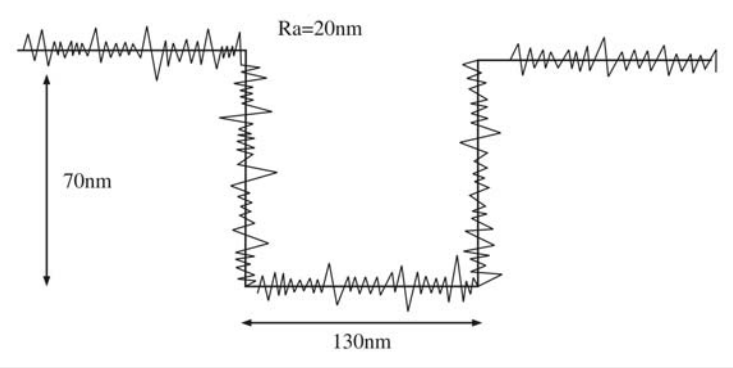
However in his book *The Structure of Scientific Revolutions* Kuhn defines a scientific paradigm as:

- *what* is to be observed and scrutinized
- the kind of *questions* that are supposed to be asked and probed for answers in relation to this subject
- *how* these questions are to be structured
- *how* the results of scientific investigations should be interpreted

Thus an additional component of Kuhn's definition of paradigm is:

***how* is an experiment to be conducted, and *what* equipment is available to conduct the experiment.**

The ideal inspection technique for surface roughness measurement (indeed, for measurements of almost any parameter) would be truly contactless, objective, reproducible, and ideally assess the full necessary area, at least, a statistically significant fraction of it.



- **The stylus instruments are the most popular between scientists!**
- **A force measuring instrument (Atomic Force Microscope) is used to investigate the roughness at nanometric scale.**

Definition of the roughness parameters

- **Ra** (*roughness average*)
  This is the average value of the absolute profile's data inside an evaluation length, divided by the total length.
- **Rq** (*root mean square*)
  This is the average of the square value of the data of the profile inside an evaluation length

$$\mathbf{Ra}=\frac{1}{L}\int|z(x)|dx$$

$$\mathbf{Rq}=\sqrt{\frac{1}{L}\int z^2(x)dx}$$

- **parametri masurati: Ra, Rz, Rt, Rp, Rv, RSm, Rq, Rku, Rmr (c), Rmr, Rδc, RΔq, Rc, Ry, Rmax, Rpm, Rk, Rvk, Rqk**
  Pa, Pz, Pt, Pp, Pv, PSm, Pq, Psk, Pku, Pmr (c), Pδc, pΔq, Pc, PPI
  Wa, Wz, Wt, Wp, Wq, Wmr (c), WSm, WcA, WcM, Sm, S, tp, Htp, Δq, Δa, HSC, λa, λq, Mr1, Mr2, A1, A2;

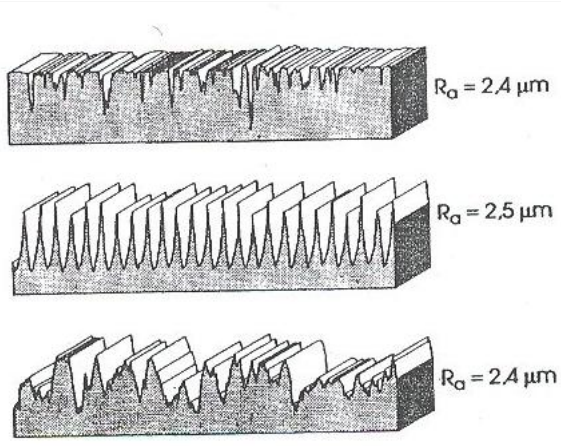
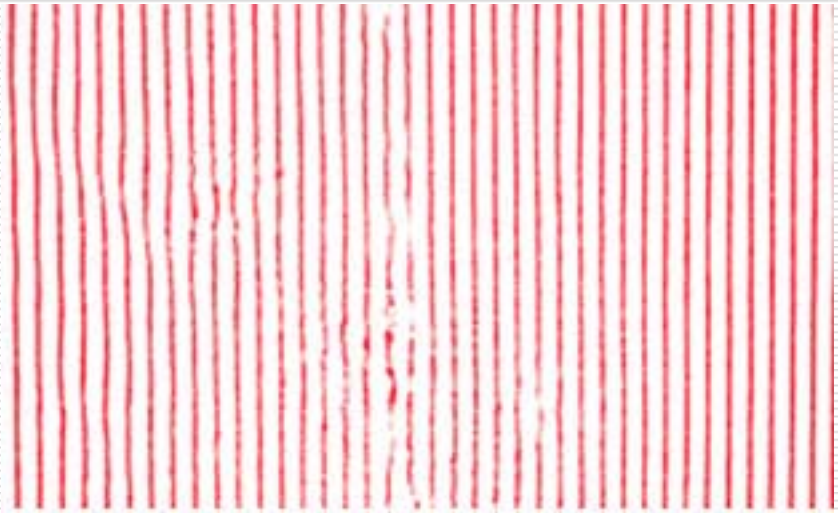


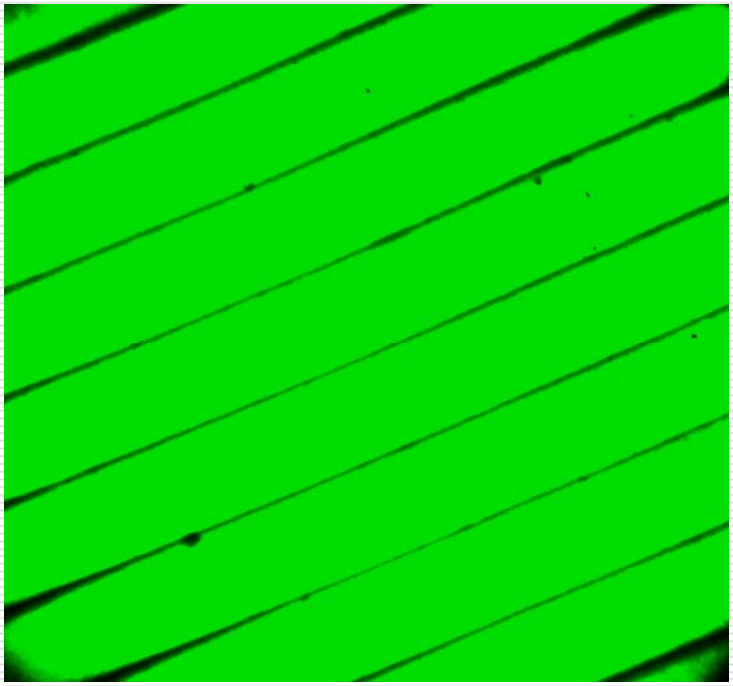
Figure 7.8. Three profiles with similar *Ra* values (Mummery 1990)

Fizeau -Tolanski

Roughness can be measured with angstrom sensitivity for many years. (See Tolansky S, Microstructure of surface using interferometry, Ed. Eduard Arnold, London, 1968).

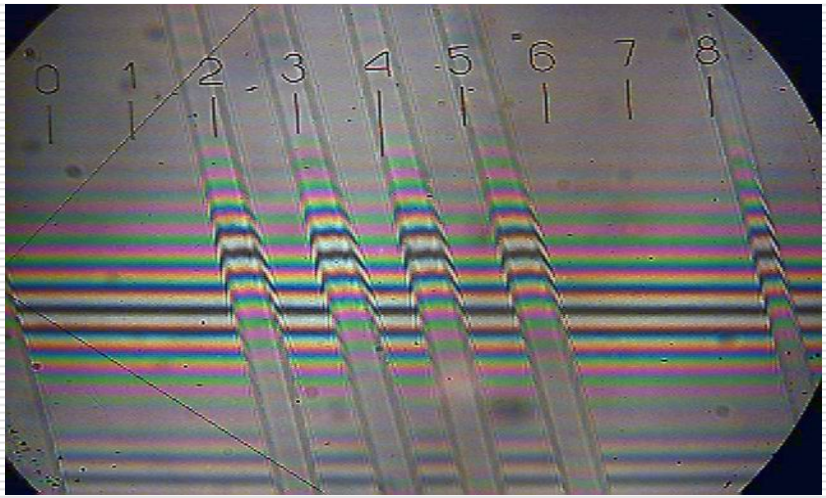
Shape / roughness>>>>>Linnik>>>>>phase shift interferometry (WLI)



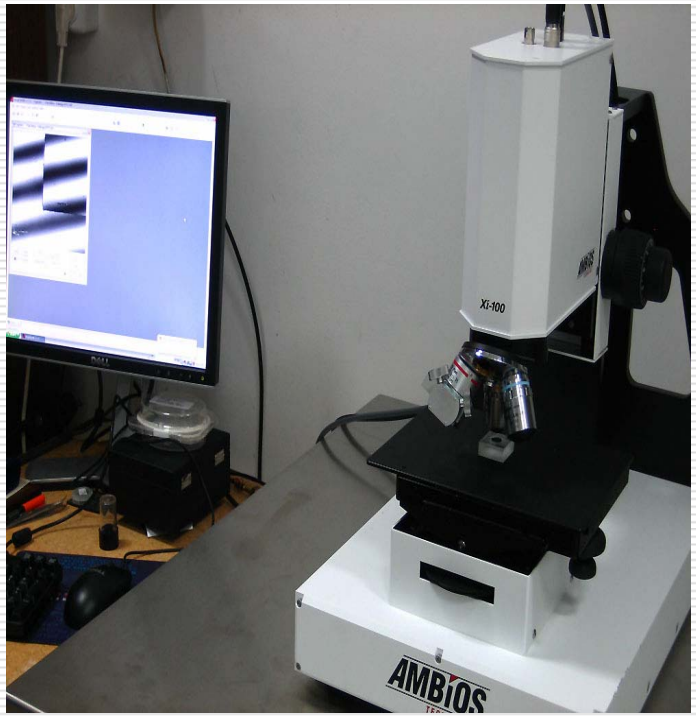


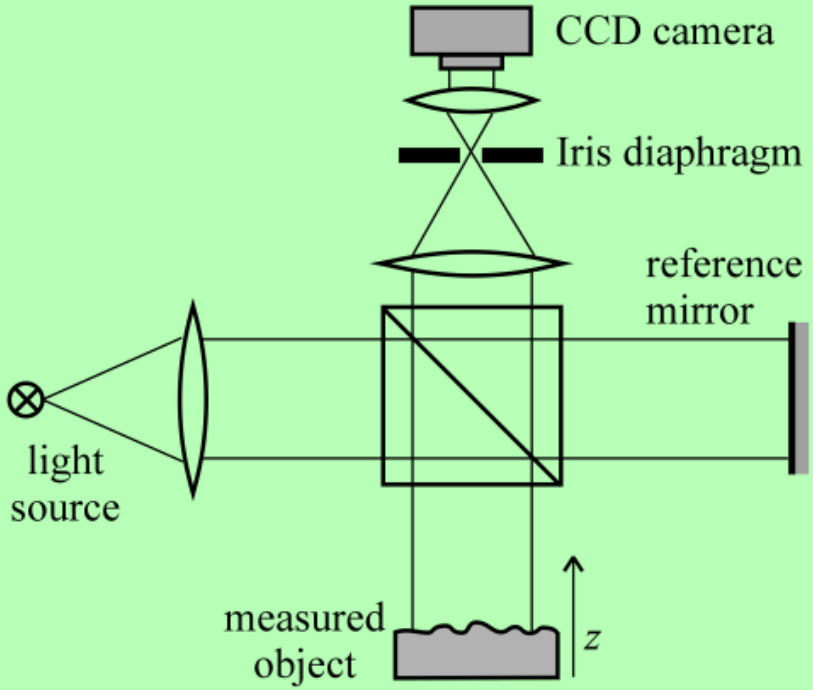
Linnik

- – **Large numerical aperture, large magnification**
- – **Expensive, matched objectives**

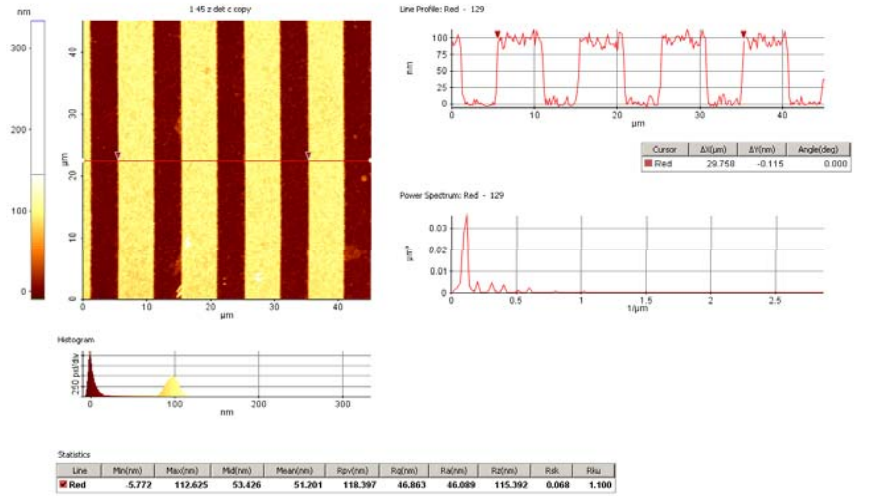


WLI (white light interferometry)

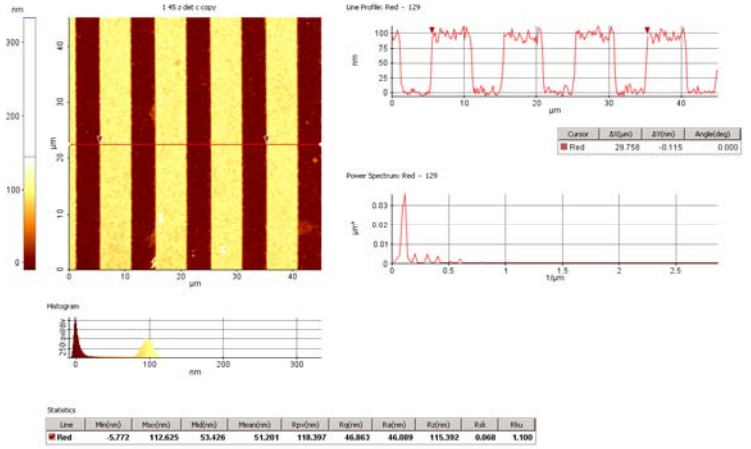


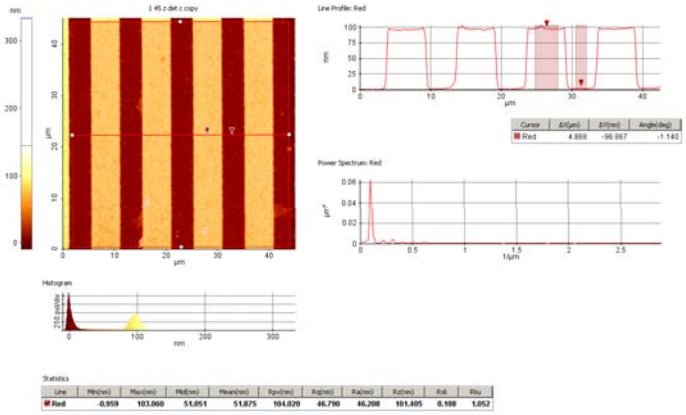


AFM quesant

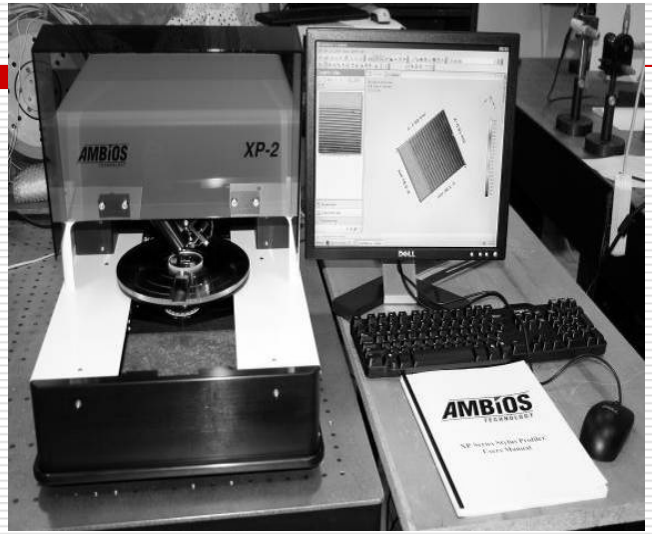

1 45 z det c copy
Line Profile: Red - 129
Power Spectrum: Red - 129
Histogram
Statistics
Line | Min(nm) | Max(nm) | Mid(nm) | Mean(nm) | Rpv(nm) | Rq(nm) | Ra(nm) | Rz(nm) | Rsk | Rku
Red | -5.772 | 112.625 | 53.426 | 51.201 | 118.397 | 46.863 | 46.089 | 115.392 | 0.068 | 1.100

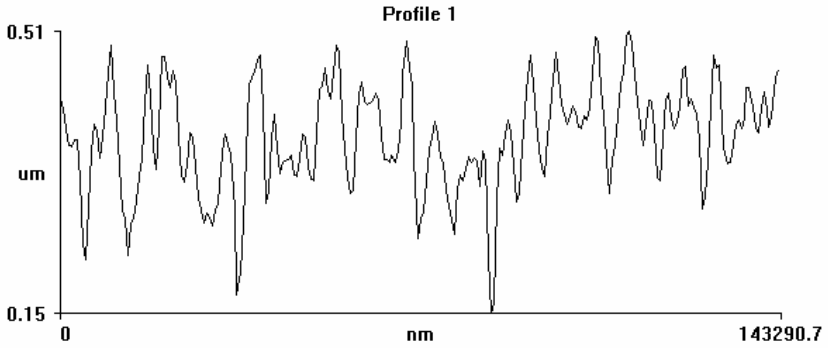
Efectele filtrarii





Stilus instrument



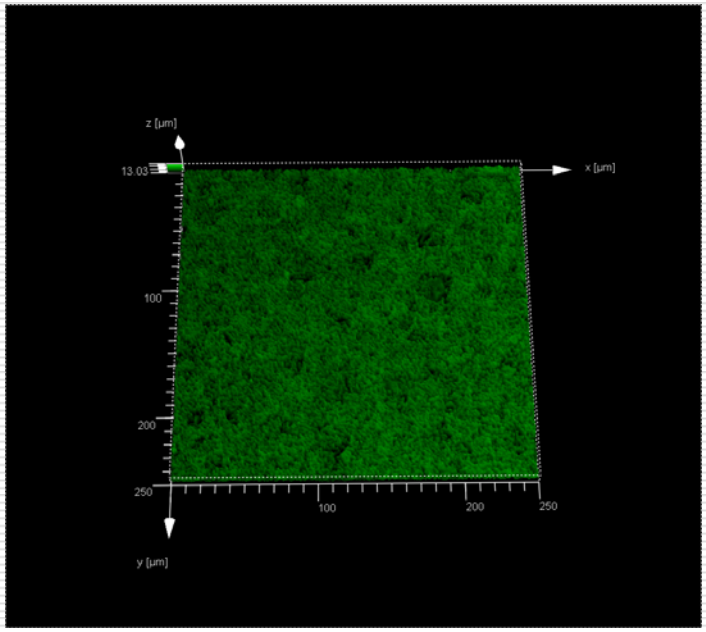


Mean	0.38 um
Rq	0.07 um
Ra	0.05 um
Peak/Valley	0.36 um

Microscop confocal cu baleiaj laser Leica TCS SP.

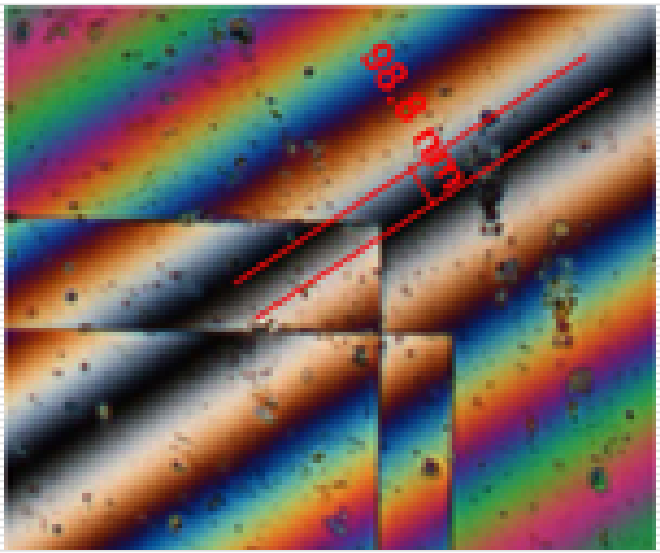
Caracteristici:

Lungime de unda acordabila: 700 nm- 850 nm;
Putere medie: 900 mW
Durata pulsului: 70 fs
Rata de repetitie: 80 MHz



Diferential Interference Contrast \ Total Interference Contrast

- Adachi M, Yasaka K. , **Roughness measurement using a shearing interference microscope.** Appl Opt. 1986 Mar 1;25(5):764-8.,

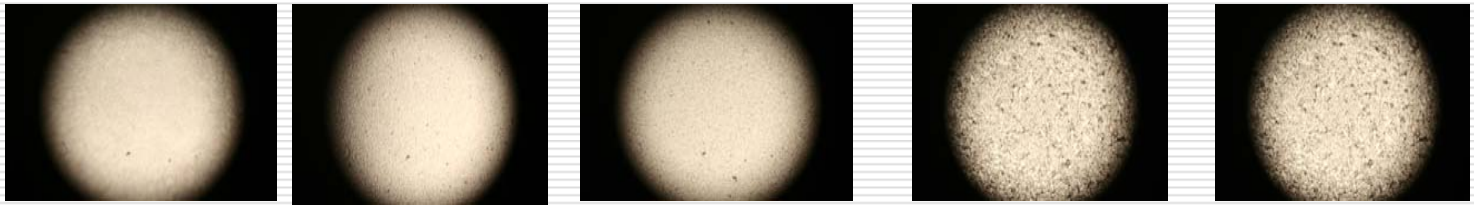


Round Robin

Instruments:

Stylus /White light interferometry (Zygo, Wyko,) / Lateral shear interferometry (Zeiss microscopy)/ AFM / Confocal / Scanning Near Field Optical Microscope / Digital holography / Light Scattering / Differential Interference Contrast (DIC sau Nomarski) microscopy/ Total Inteference Contrast (TIC) microscopy /

Microscope.pictures of the samples:



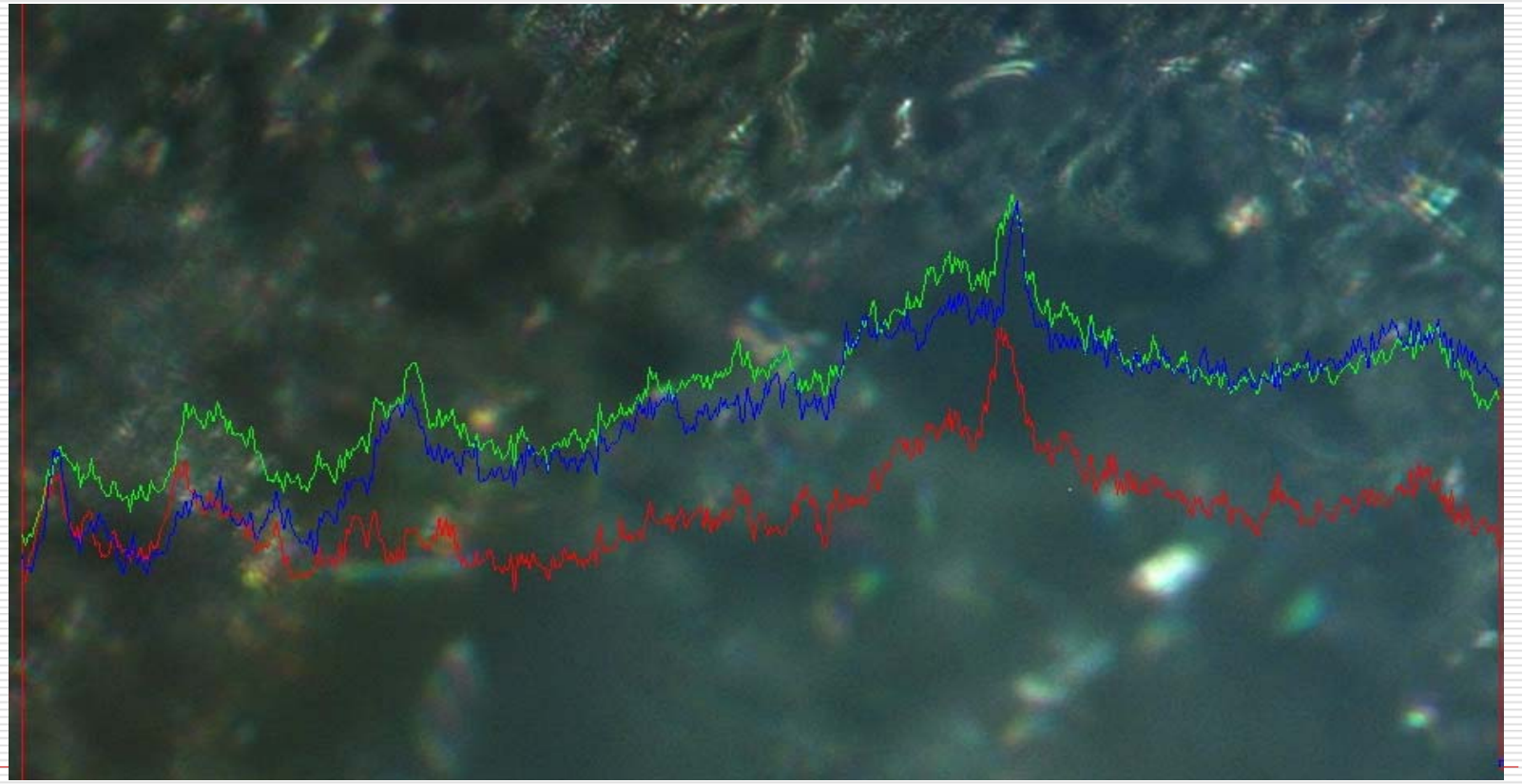
Nr.	Granulatia abrazivului	Profilometer StylusTokyo Seimitsu Surfcom	Xp-2(Stylus AMBIOS USA)	PERTHOMETER S2 Mahr.	WLI (ob. Michelson)	WLI (ob. Mirau)
1	1.6	0.268	0.285	0.690	2.06	1.46
2	3.5	1.084	0.997	2.723	4.25	3.29
3	3.2	0.702	0.754	1.708	3.15	3.04
4	1.6	0.291	0.308	0.487	2.35	1.48
5	1.5	0.210	0.231	0.417	1.55	1.55

Ra [µm]

Ordinea granulatiei: 2, 3, 4, 1, 5.

DIC for the basic color pixels

- Camera video AxioCam MRc5 de la Axio Imager Zeiss



CONCLUZII

- Softul aparatelor e necunoscut si ca atare nu sti exact ce face;
- Vezi la Veeco rugozitatea a dat cu zecimi de nm cand nu pot masura nici 10 nm
- Suprafata reala difera substantzial de cea observata
- Stylus are 2,5micrometri si sub 1 micrometru nu am gasit ! (normal!)
- Cred ca cel mai bun instrument pentru rugozitate este CONFOCAL (pata focala foart mica! Nu depinde de calitatea suprafetei ca la WLI, nu depinde de inclinarea suprafetei fat ade axa optica,)
- Neuniformitatea GEOMETRICA si de sensibilitate si de culoare a camerei video ma face sa ma indoiesc de orice valoare sub nano!

1.	**AFM (contact)**	**1,0325**	**IMT**
2.	**AFM (alternative contact)**	**1,0480;**	**IMT**
3.	**WLI**	**1,0324;**	**IMT**
4.	**AFM (Quesant)**	**0,980;**	**INFLPR (Toni)**
5.	**WLI (Veeko)**	**1,0142;**	**ICPE (George)**
6.	**LINNIK**	**1,0300**	**INFLPR (ila) (Damian)**
7.	**WLI (Ambios)**	**1,01633;**	**INFLPR (ila) (Bojan)**
	MEDIA:	1,0219±	0.087