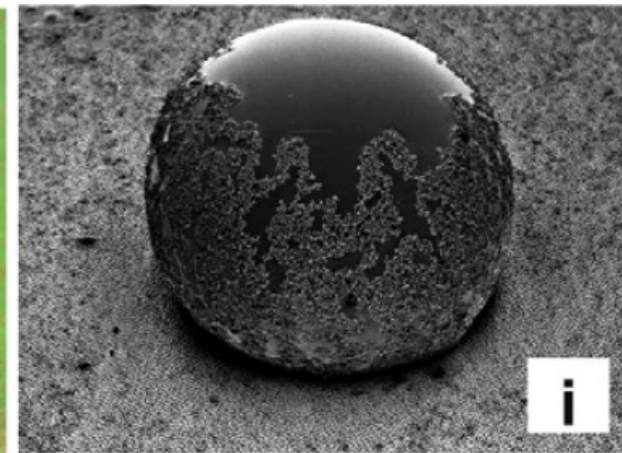
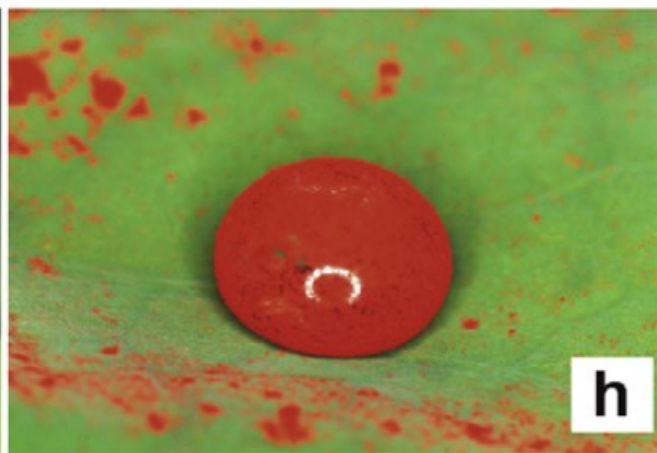
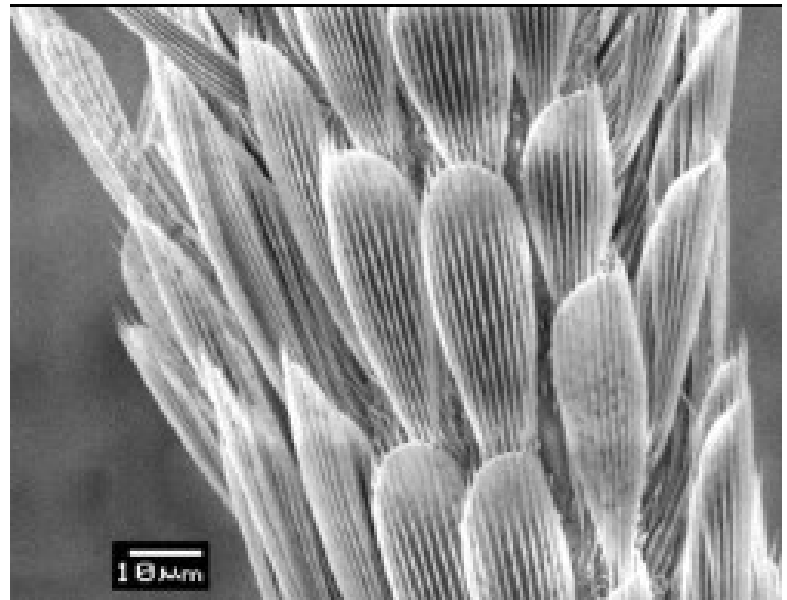


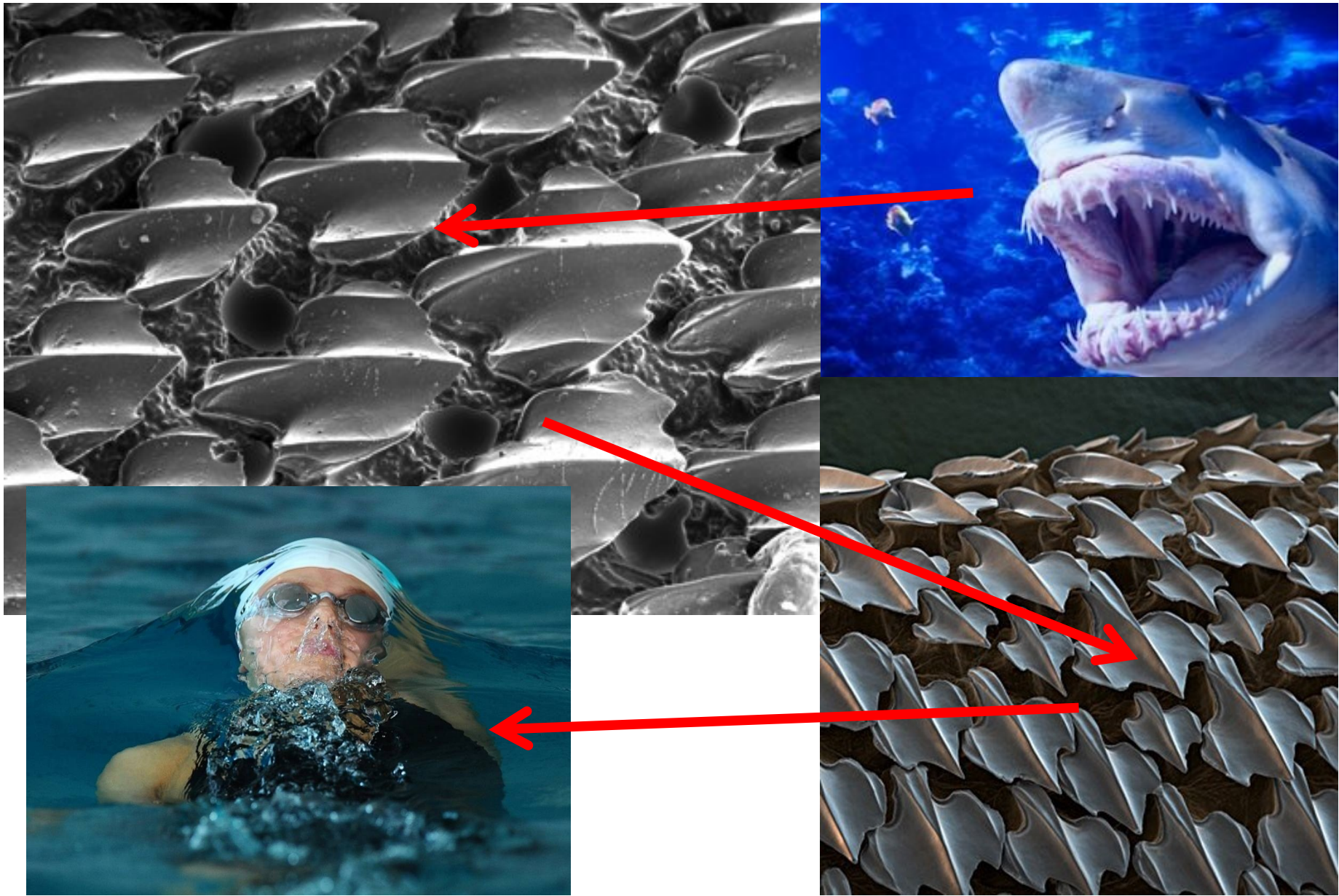
The background is a scanning electron micrograph (SEM) showing a highly textured surface. The surface is covered with numerous small, rounded, dome-like structures. Two larger, prominent spherical structures are visible, one in the foreground and one slightly behind it to the left. These spheres exhibit a distinct layered or concentric internal structure, suggesting a hierarchical or multi-layered material design. The overall appearance is that of a complex, porous, and textured material, likely a biomimetic surface.

Biomimetika, struktura povrchů materiálů

Aleš Mráček







SEM micrograph of the shark skin (*Squalus acanthias*) replica. See *Phil. Trans. R. Soc. A* (2010) 368, 4775–4806 (doi:10.1098/rsta.2010.0201)

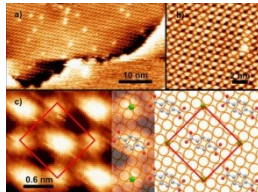
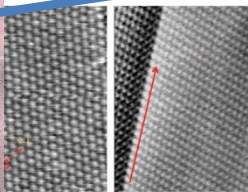
„God made solids, but surfaces were the work of the devil.“

Wolfgang Pauli

Definice povrchu

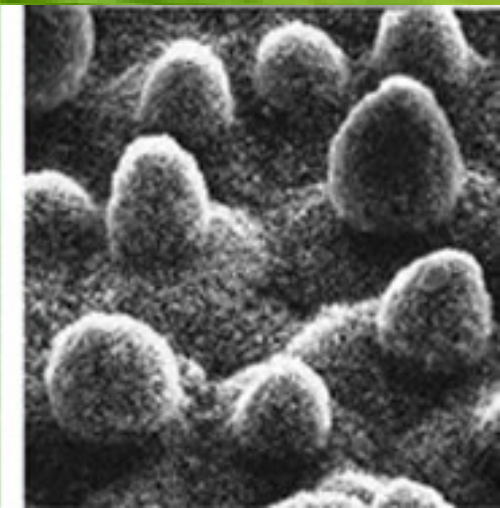
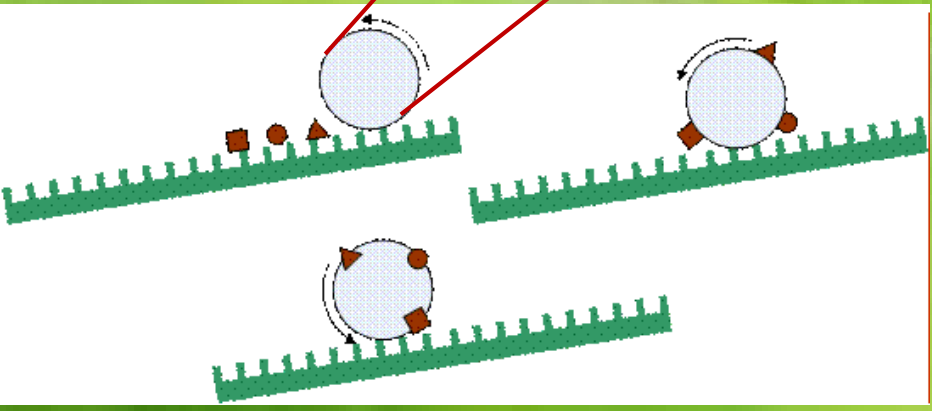
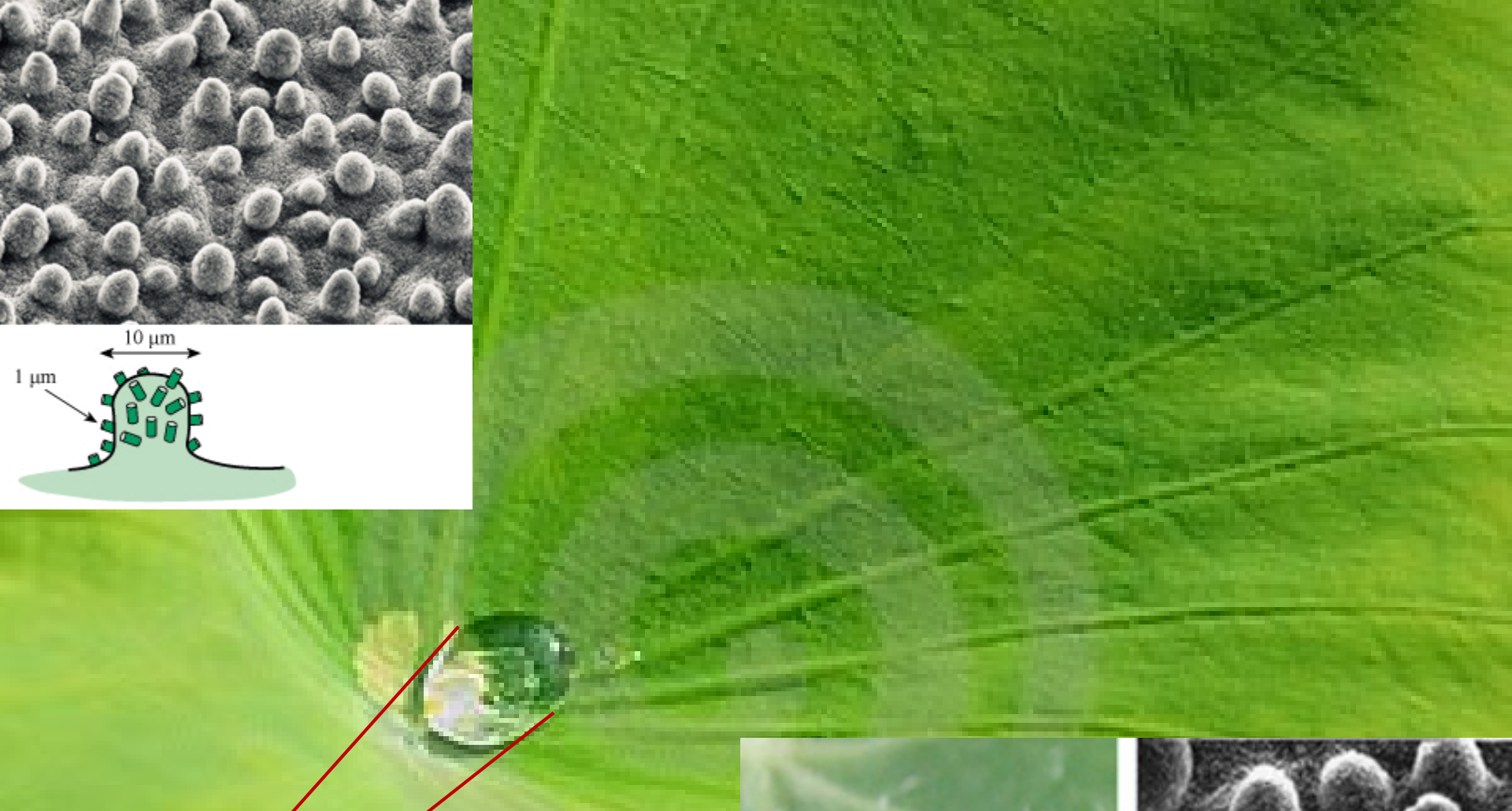
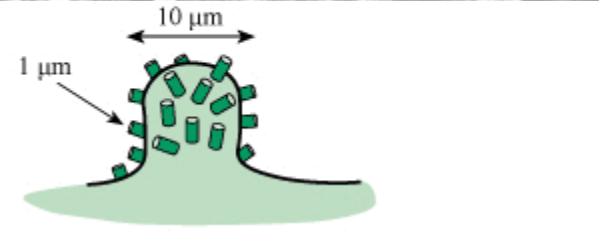
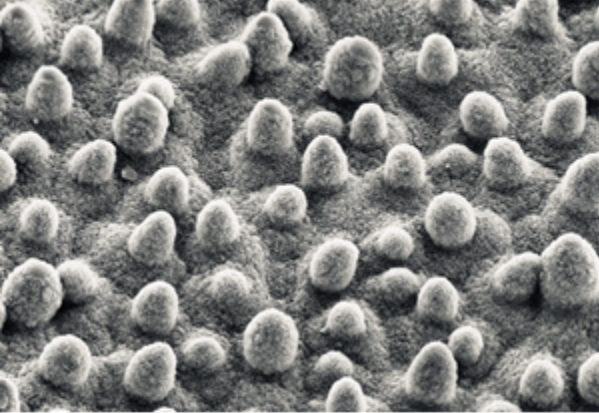
Povrch je část hmoty interagující s jejím okolím, přičemž síly působící mezi molekulami či atomy jsou zcela jiné ve srovnání s interakcemi molekul nebo atomů, které jsou v přímém kontaktu s jinou látkou.

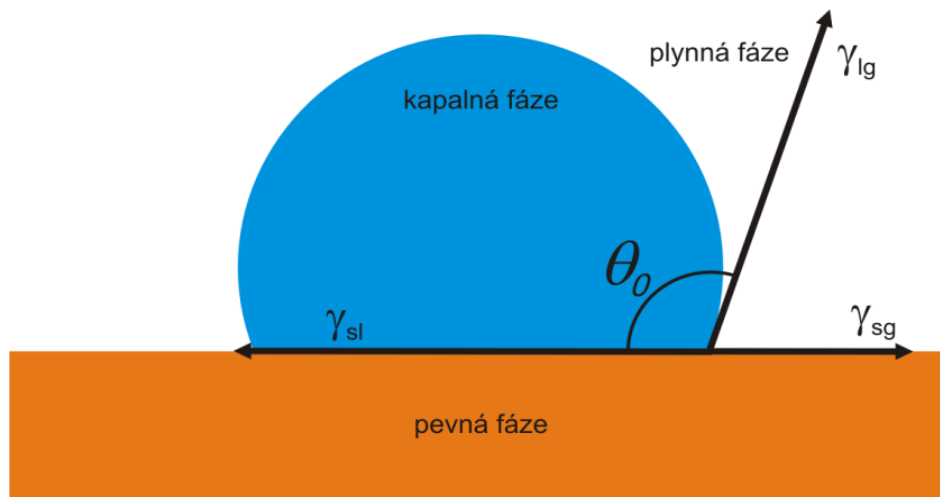
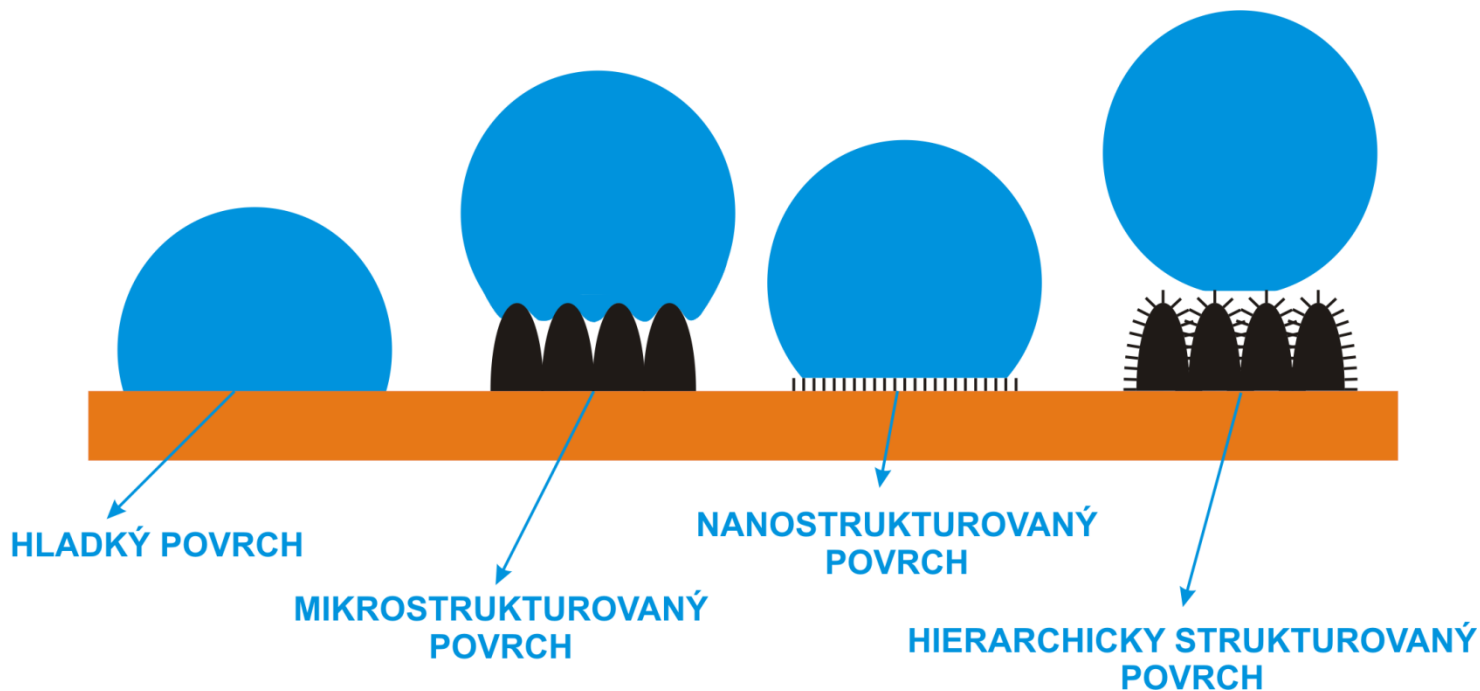
Na povrch se každý dívá ze svého „úhlu pohledu“



„Je povrchem jedna atomární vrstva nebo více, anebo dokonce povrch tvoří valenční elektrony atomů v první atomární vrstvě?“

Jinými slovy, záleží na hloubce nebo tloušťce





$$\cos\theta_0 = \frac{\gamma_{sg} - \gamma_{sl}}{\gamma_{lg}}$$

Bhushan B., Jung Y.C., *Progress in Materials Science*, **56** 1-108 (2011)

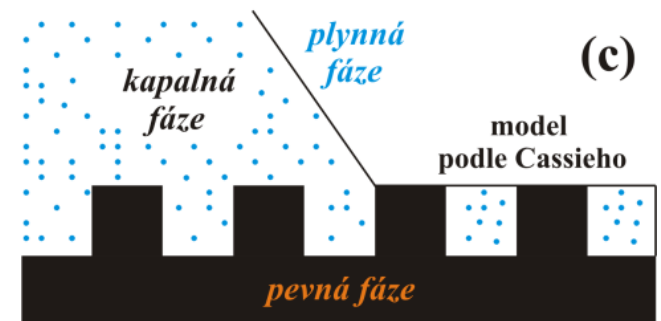
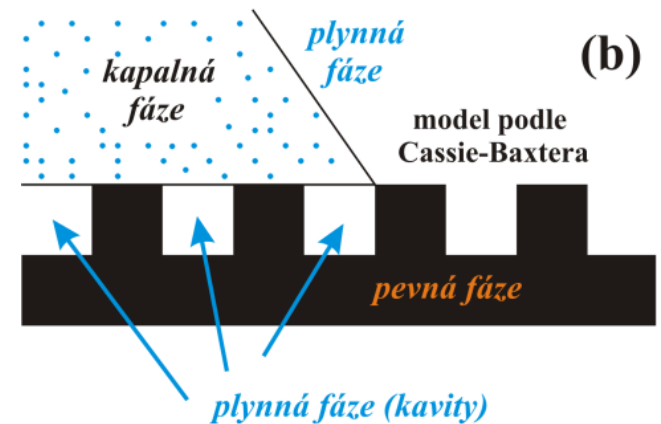
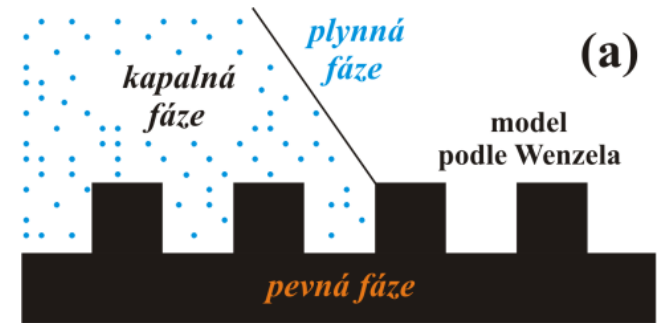
Young T.: An Essay on the Cohesion of Fluids. *Philosophical Transactions of the Royal Society of London*. (1805) 95, 65-87. DOI: 10.1098/rstl.1805.0005.

Heterogenní povrch

Wenzelova rovnice

$$\cos \theta = R_f \cos \theta_0$$

$$R_f = \frac{A_{SL}}{A_F}$$



Wenzel R.N., *Indust. Eng. Chem.*, **28** 988–94 (1936).

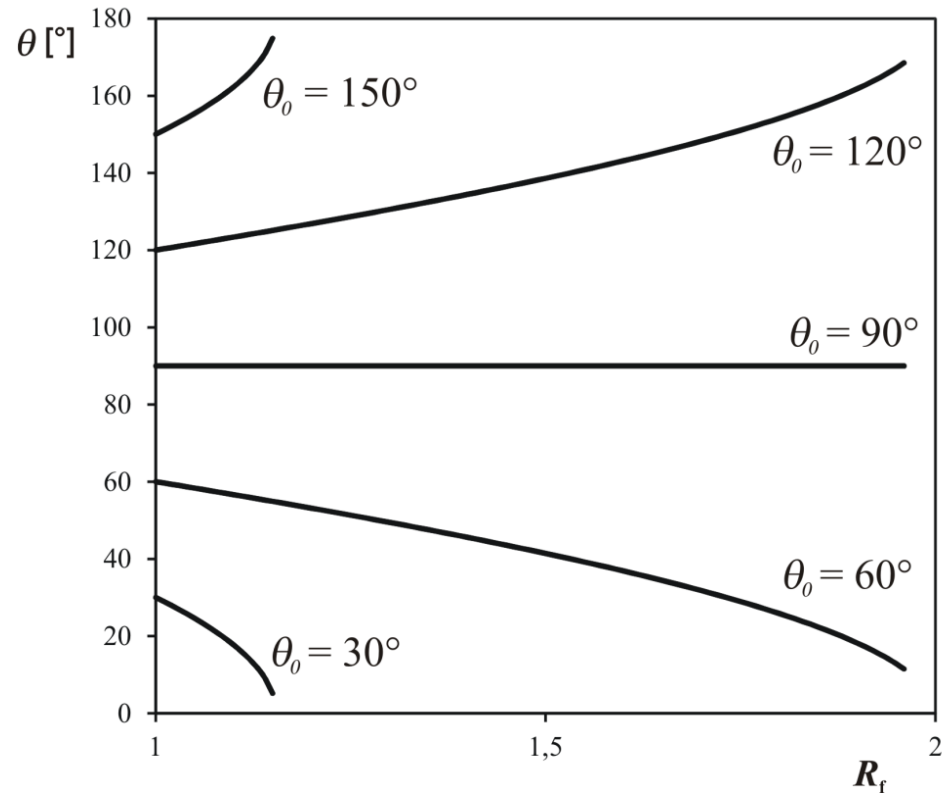
Heterogenní povrch

Wenzelova rovnice

$$\cos \theta = R_f \cos \theta_0$$

↓

$$R_f = \frac{A_{SL}}{A_F}$$

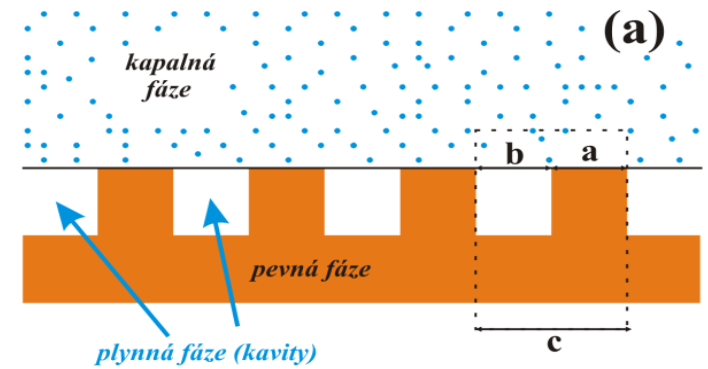


S rostoucím R_f roste hydrofilita, resp. hydrofobita.

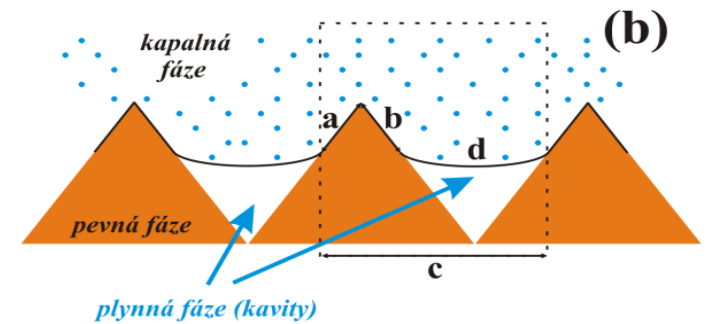
Heterogenní povrch

rovnice Cassie-Baxterova

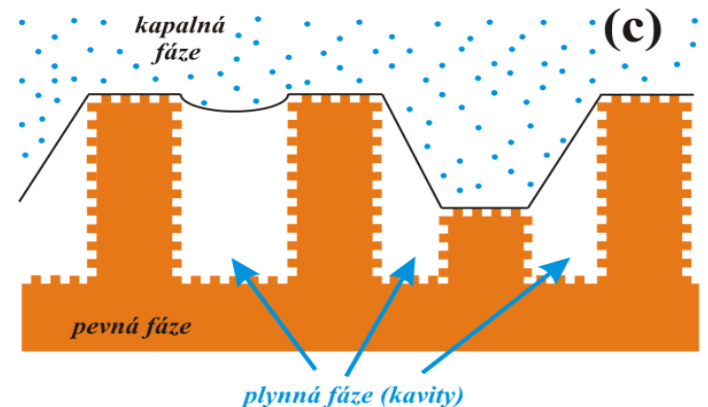
$$\cos\theta = f_1 \cos\theta_0 - f_2$$



$$f_1 = \frac{a}{c}, \quad f_2 = \frac{b}{c}$$



$$f_1 = \frac{a+b}{c}, \quad f_2 = \frac{d}{c}$$

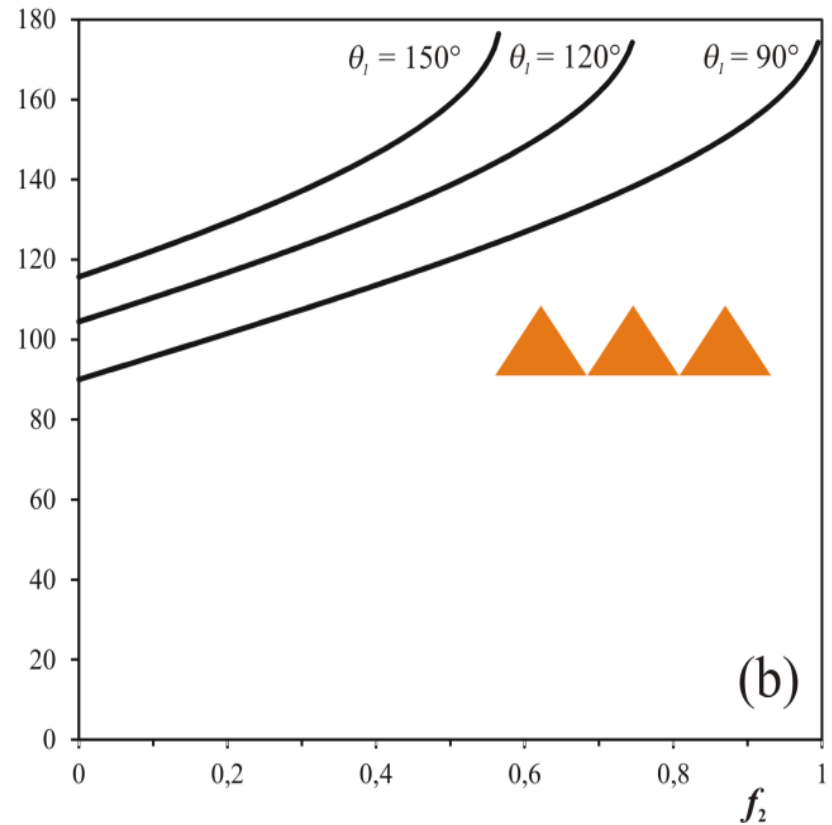
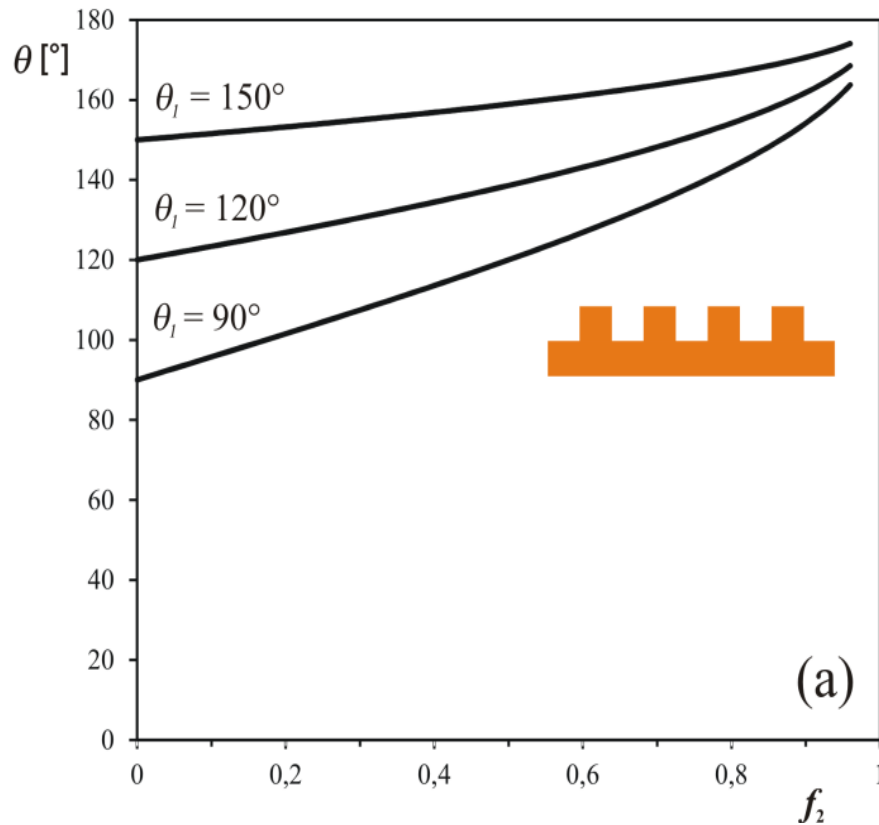


Cassie A., Baxter S., *Trans. Faraday Soc.*, **40** 546–51 (1944),
 Milne A.J.B., Amirfazli A.: The Cassie equation: How it is mean to be used.
Advances in Colloid and Interface Science. (2012) 170, 48-55,
 DOI:10.1016/j.cis.2011.12.001.

Heterogenní povrch

rovnice Cassie-Baxterova

$$\cos\theta = f_1 \cos\theta_0 - f_2$$

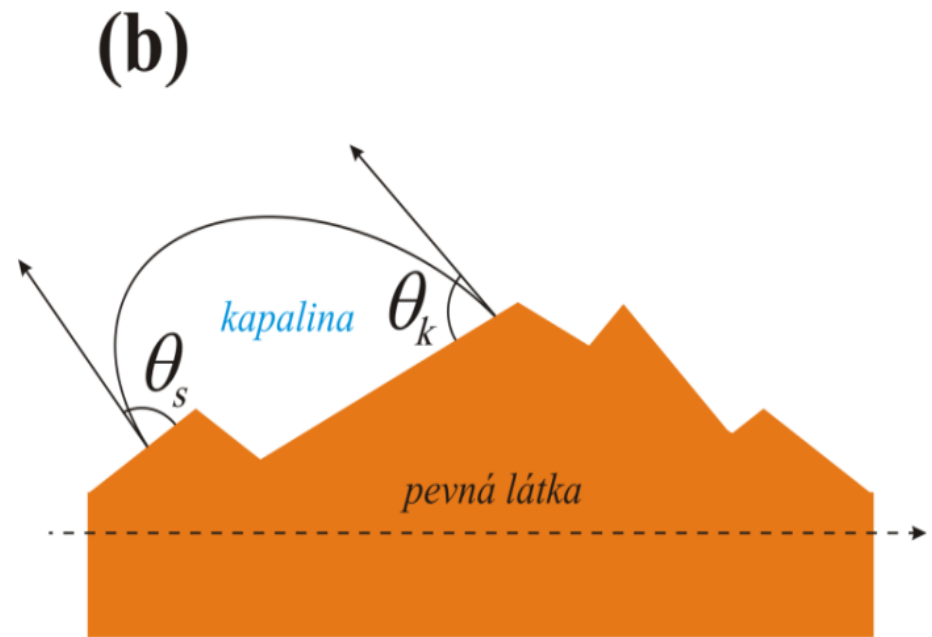
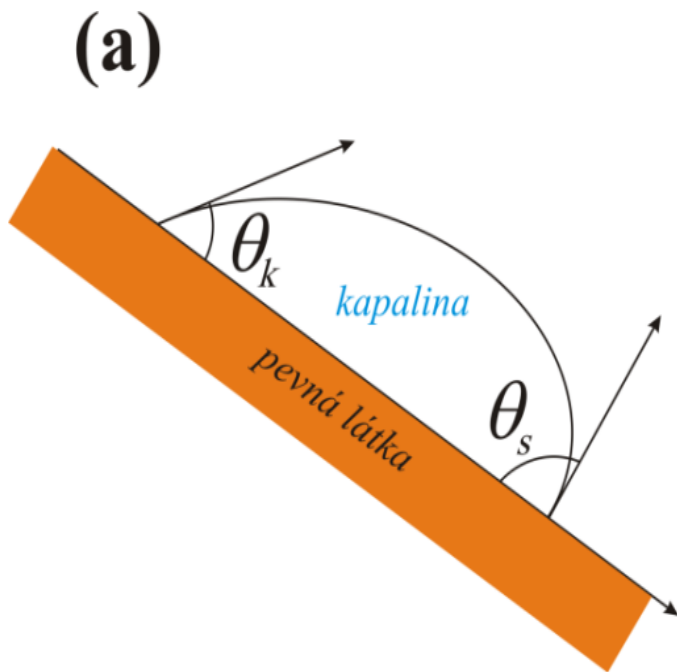


Heterogenní povrch a hystereze k. ú.

$$H = \theta_s - \theta_k$$

„stoupající“

„klesající“



Některé základní metody studia povrchů



Měření kontaktní úhlů

The diagram shows a blue sphere on an orange surface. A black probe tip is in contact with the sphere. The contact angle is indicated by a dashed line and an arc.

Mikroskopie skenující sondou



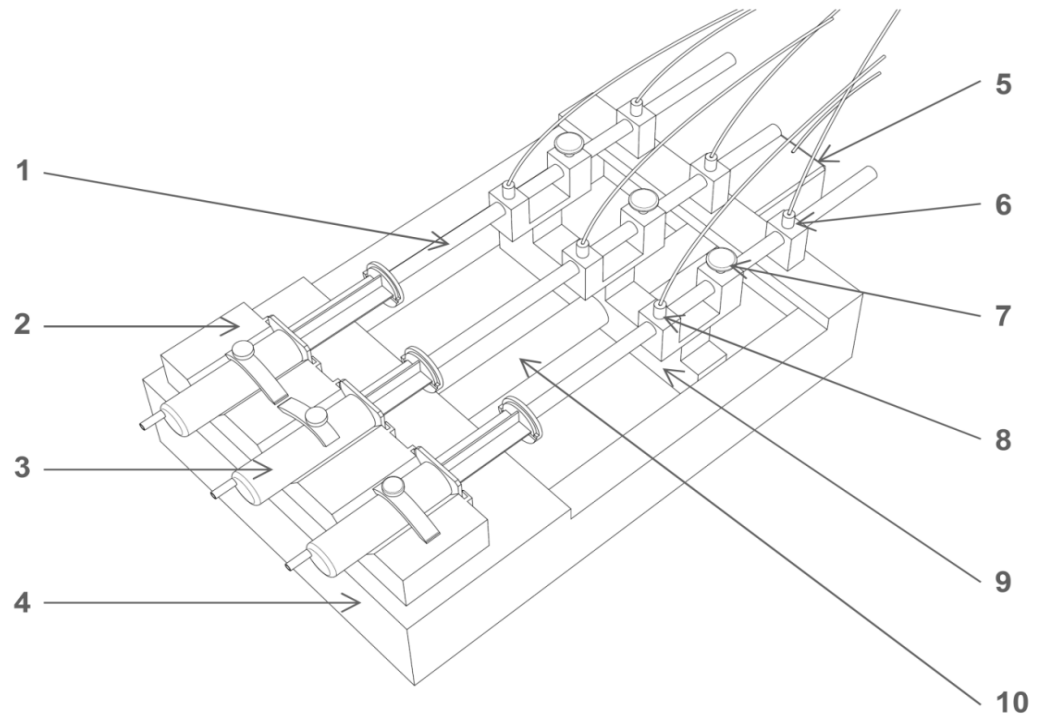
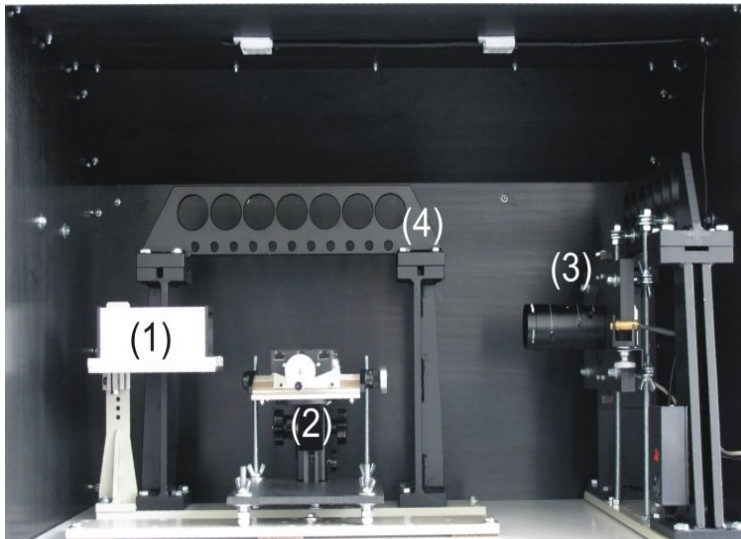
Elektronová mikroskopie

The diagram shows a blue sphere on an orange surface. A black probe tip is positioned above the sphere, emitting a beam of electrons (represented by small black lines) towards the surface.

Rentgenová fotoelektronová spektroskopie (XPS)

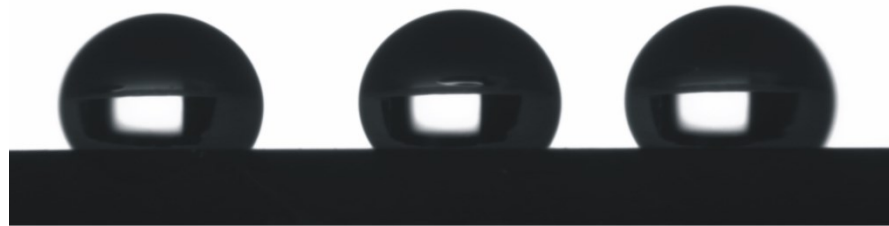


Měření kontaktní úhlů

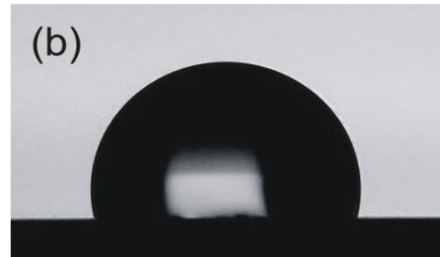


Měření kontaktní úhlů

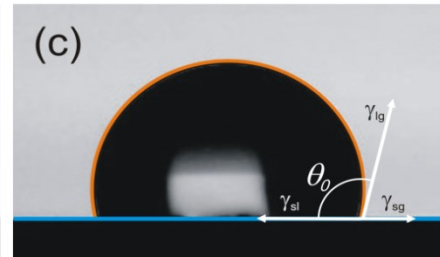
(a)



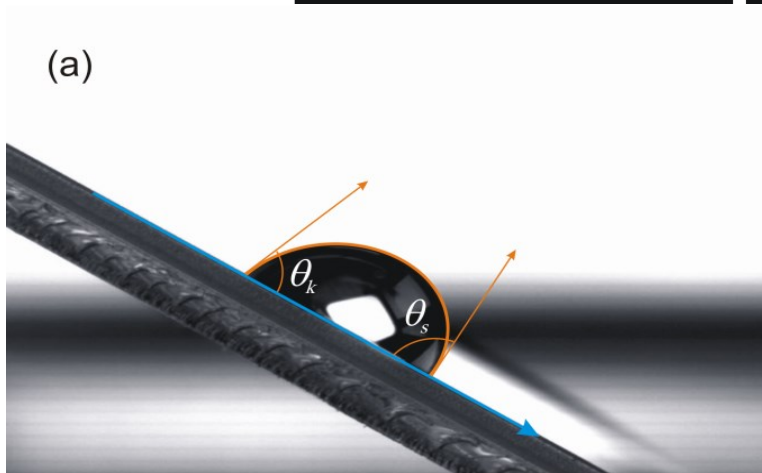
(b)



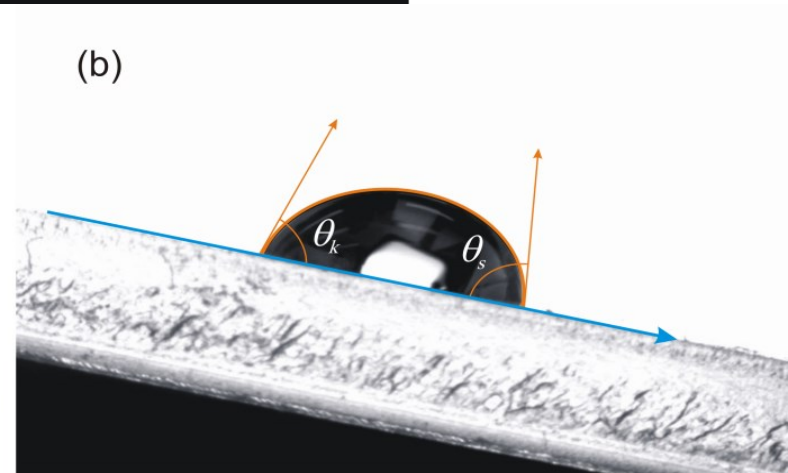
(c)



(a)

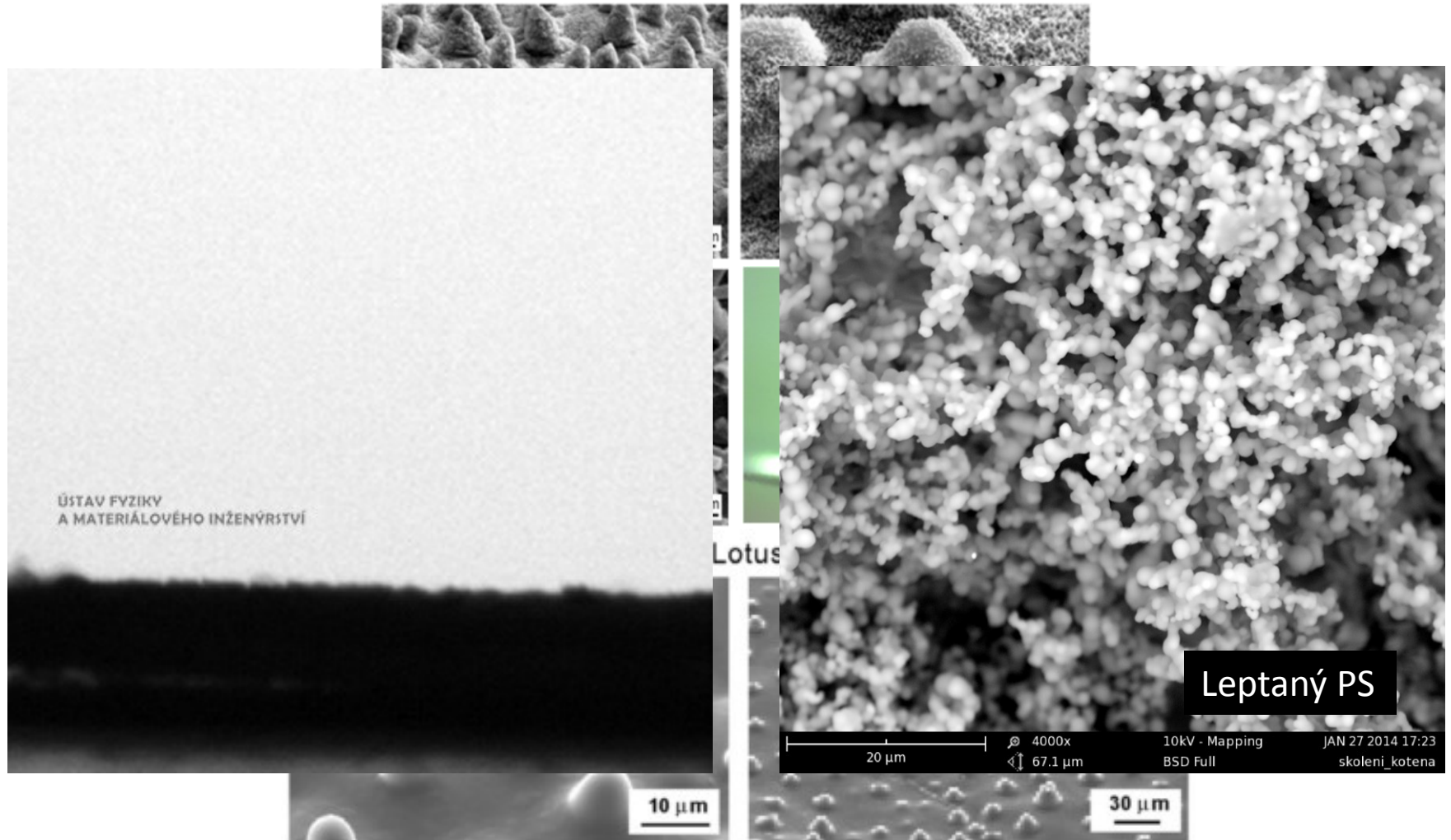


(b)



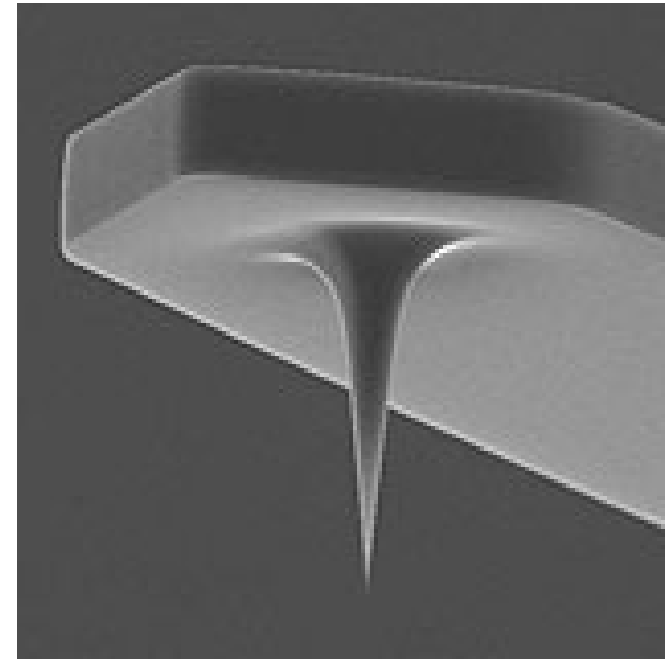
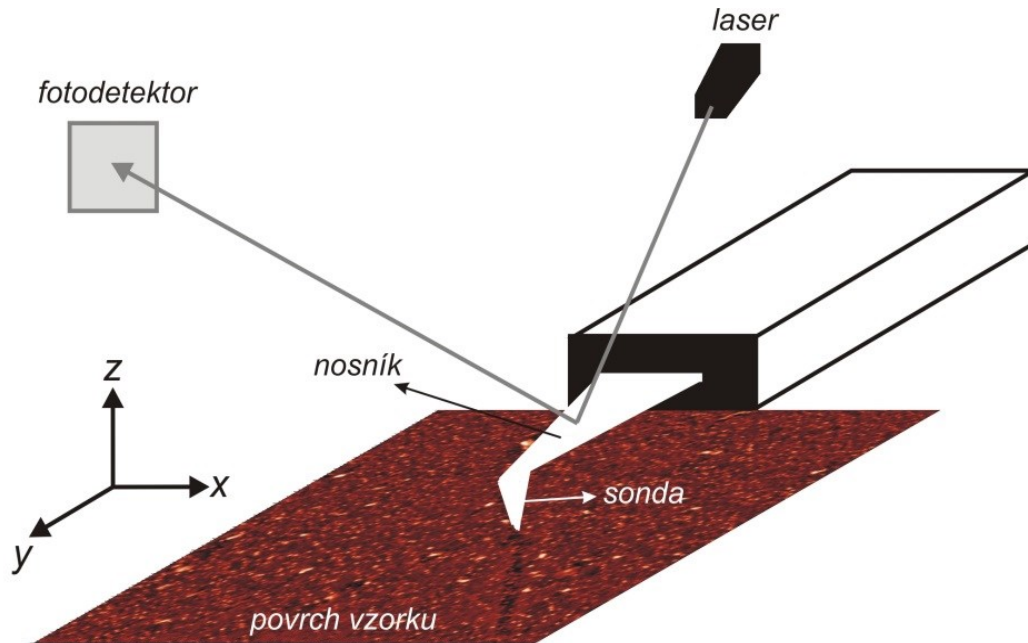
Smáčení a „samočistící povrchy“

Heterogenita povrchu



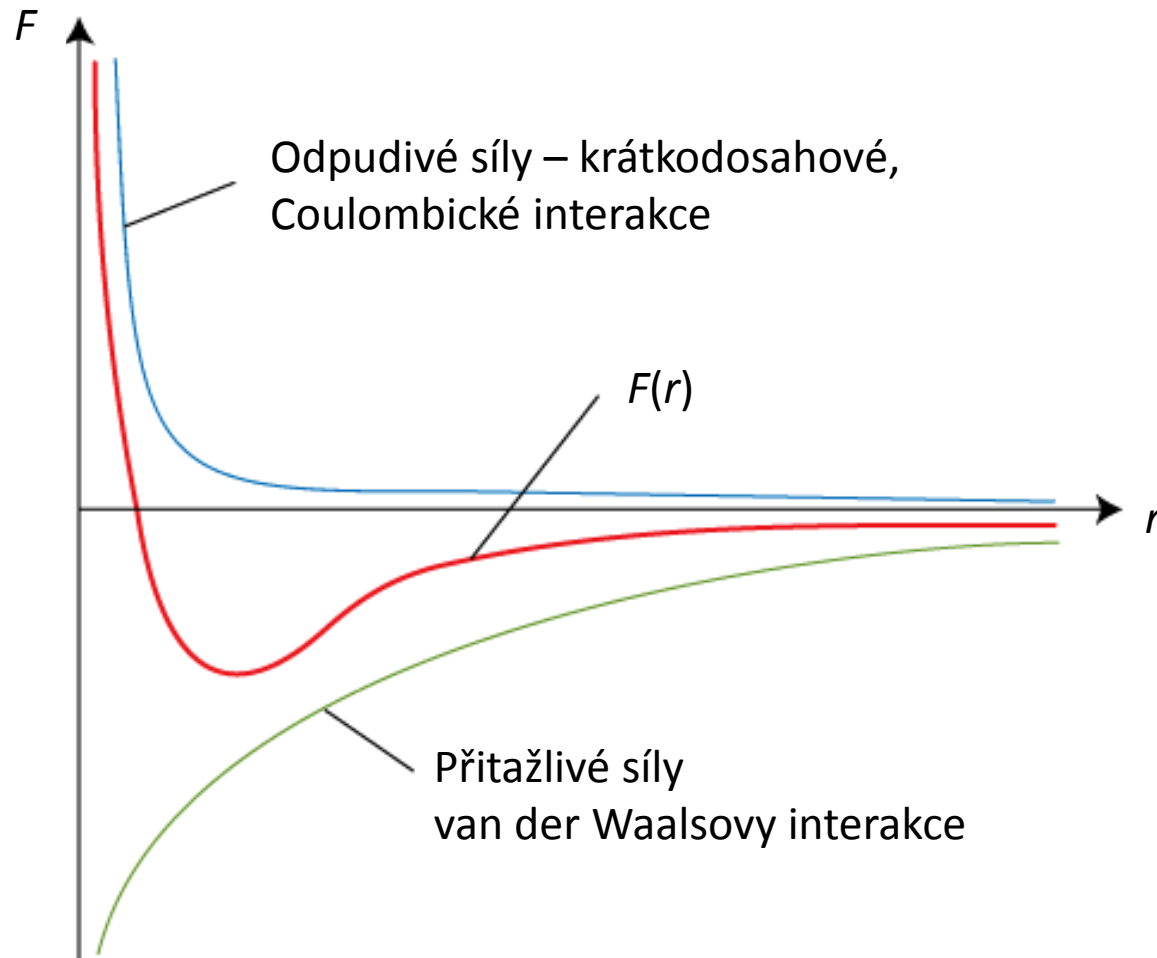
Burton Z., Bhushan B., *Nano Lett.*, 5 1607–13 (2005)

Mikroskopie atomárních sil

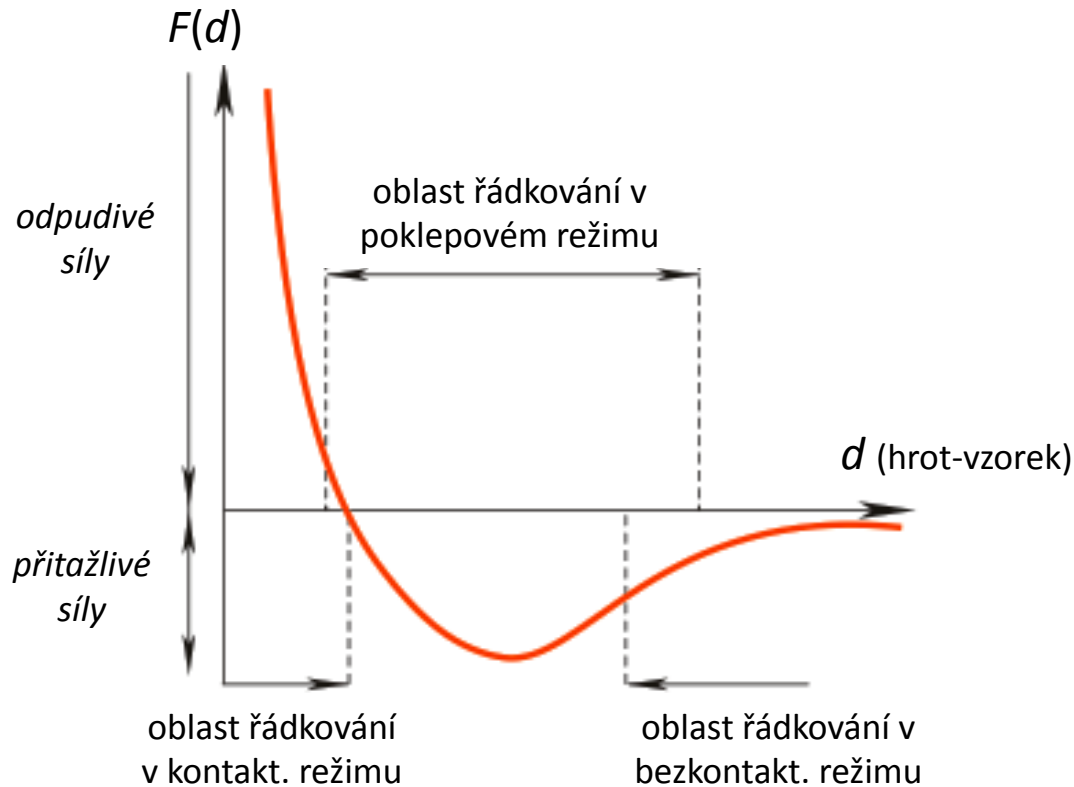


Detekce odraženého laserového paprsku na základě změny polohy sondy

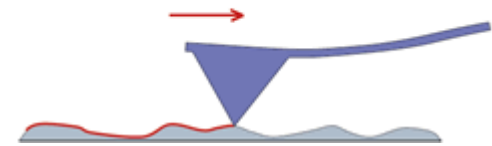
Mikroskopie atomárních sil



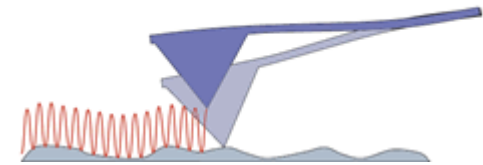
Mikroskopie atomárních sil



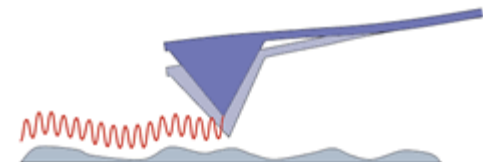
Kontaktní režim

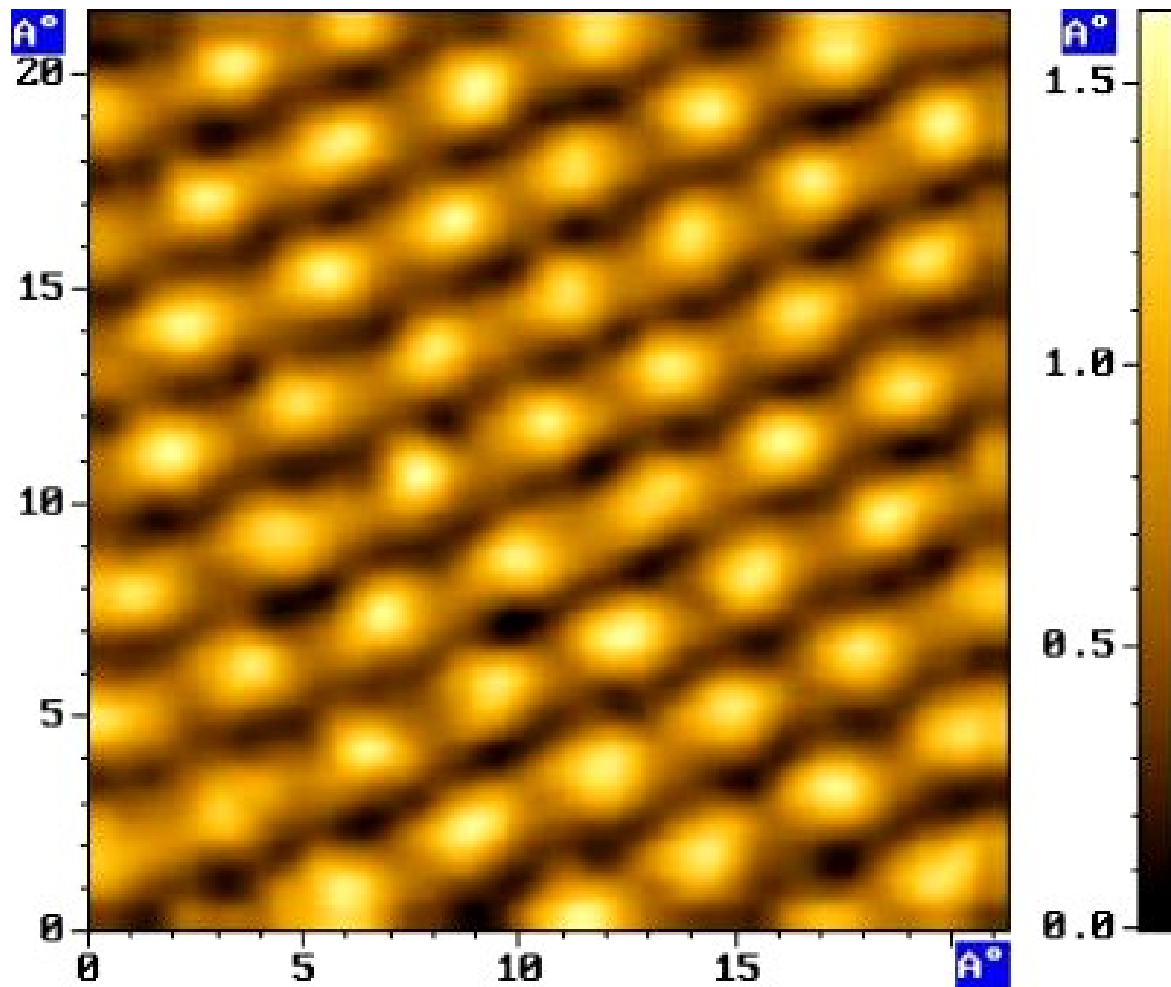


Pokleповý režim



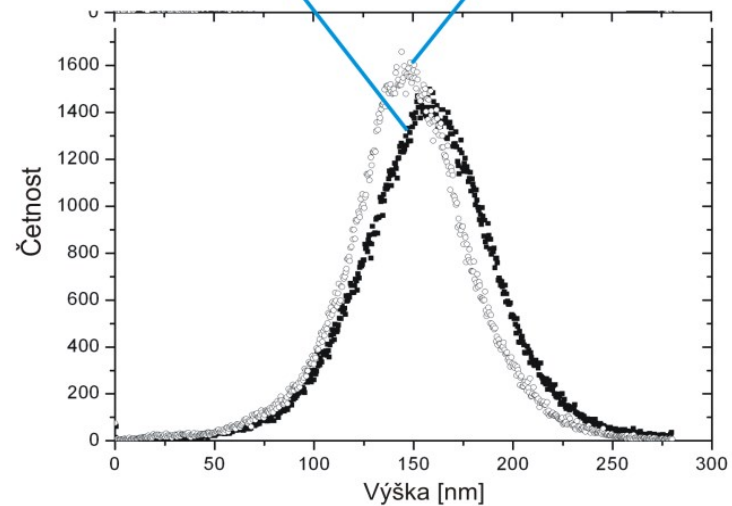
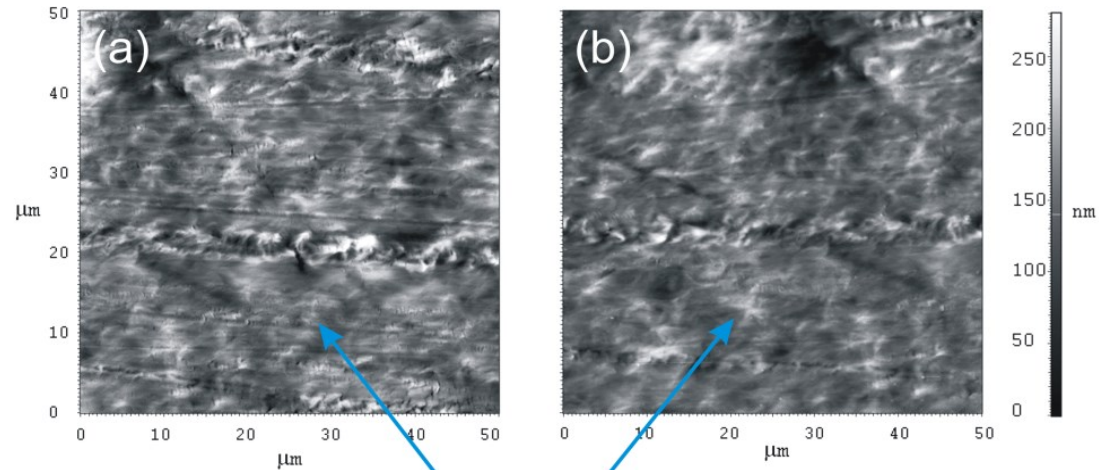
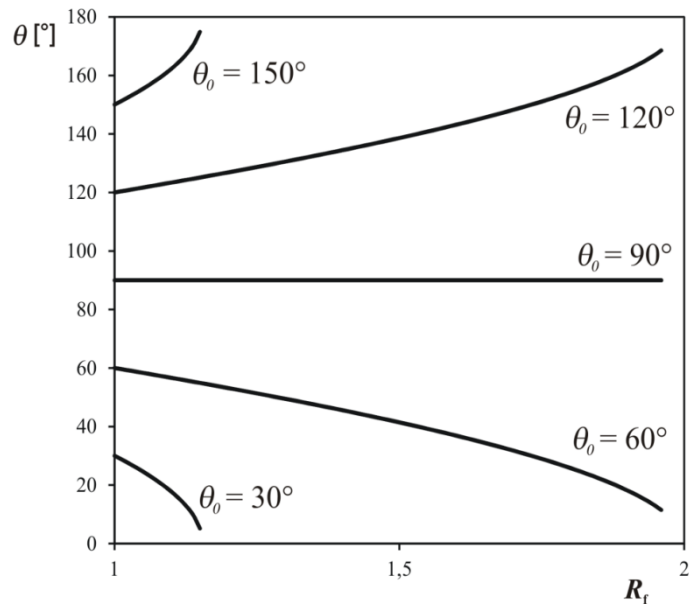
Bezkontakt. režim



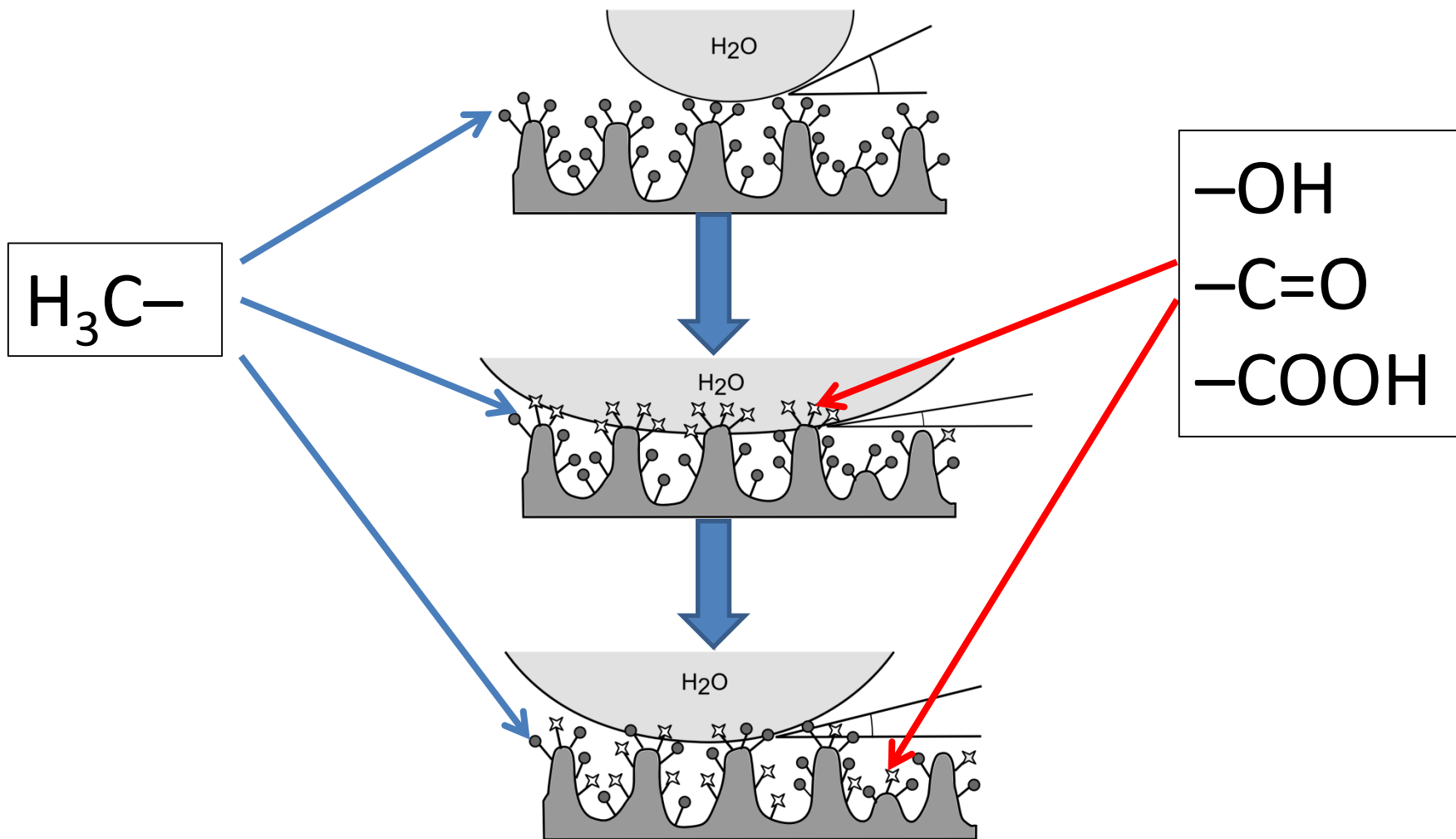


<http://www.ntmdt.com/scan-gallery/scan/stm-atomic-resolution-on-hopg>

Mikroskopie atomárních sil

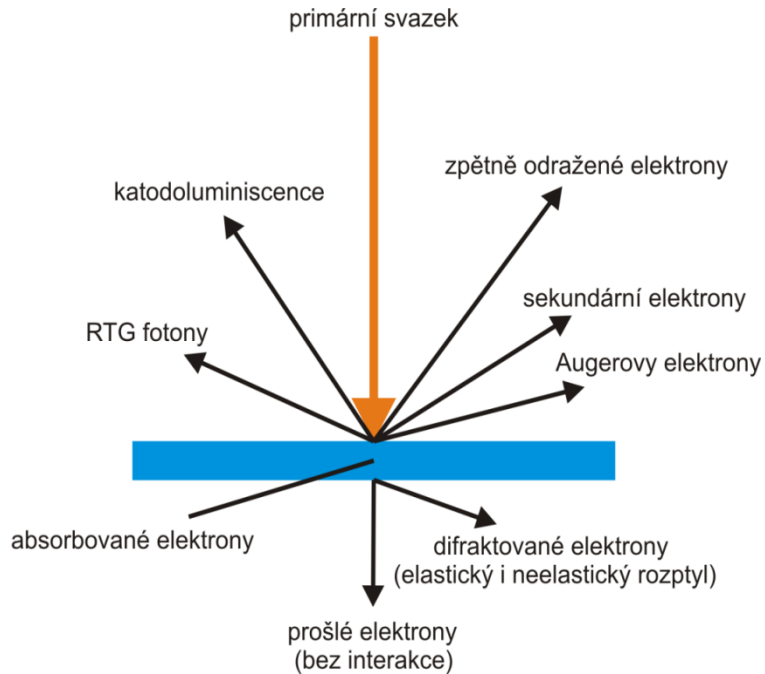


Chvátalová, L., Mráček, A. et al.: The effect of plasma treatment on structure and properties of poly(1-butene) surface. *European Polymer Journal*, 48 866-874 (2012)



Chvátalová, L., Mráček, A. et al.: The effect of plasma treatment on structure and properties of poly(1-butene) surface. *European Polymer Journal*, 48 866-874 (2012)

Skenovací elektronová mikroskopie



O rozlišení, stejně jako u světelné mikroskopie, rozhoduje vlnová délka.

U EM díky vysokým energiím el. svazku lze dosáhnout mnohem většího zvětšení.

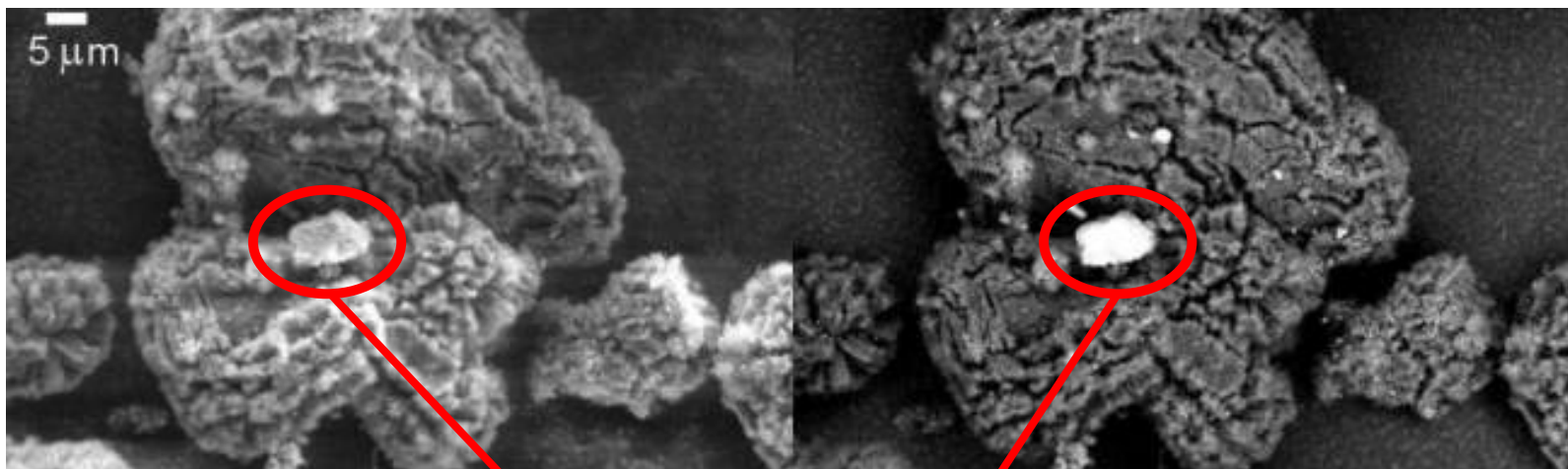
Sekundární elektrony podávají informaci o topografii povrchu

Zpětně odražené elektrony podávají informaci o atomárním rozložení

Skenovací elektronová mikroskopie

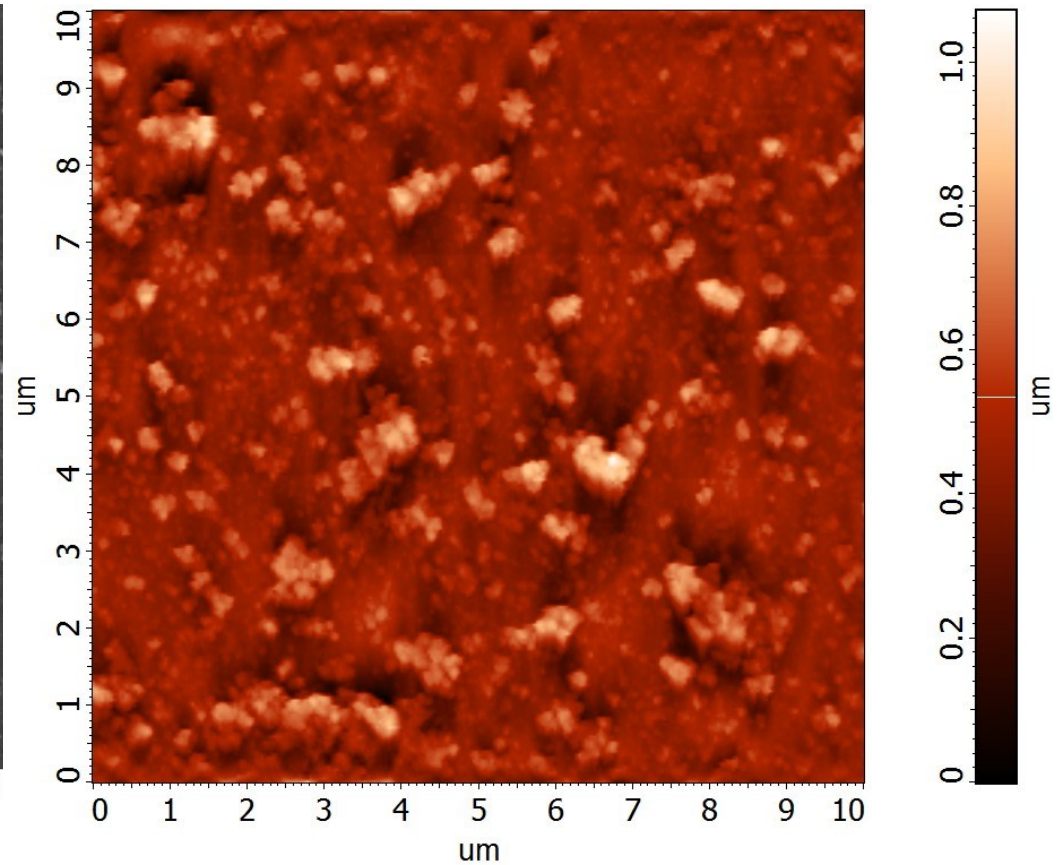
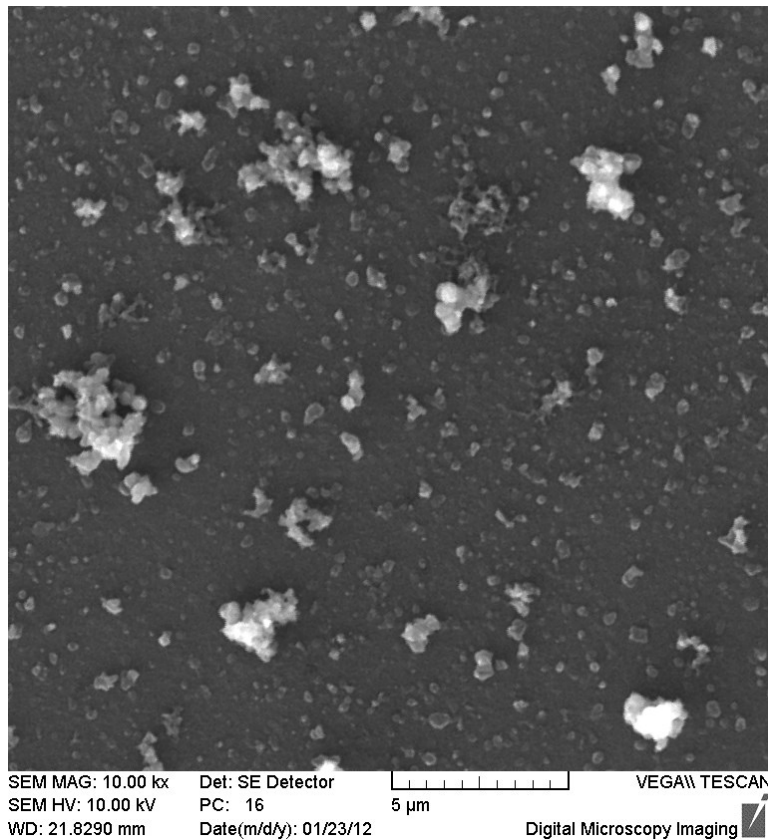
Režim sekundárních elektronů

Režim zpětně odražených elektronů

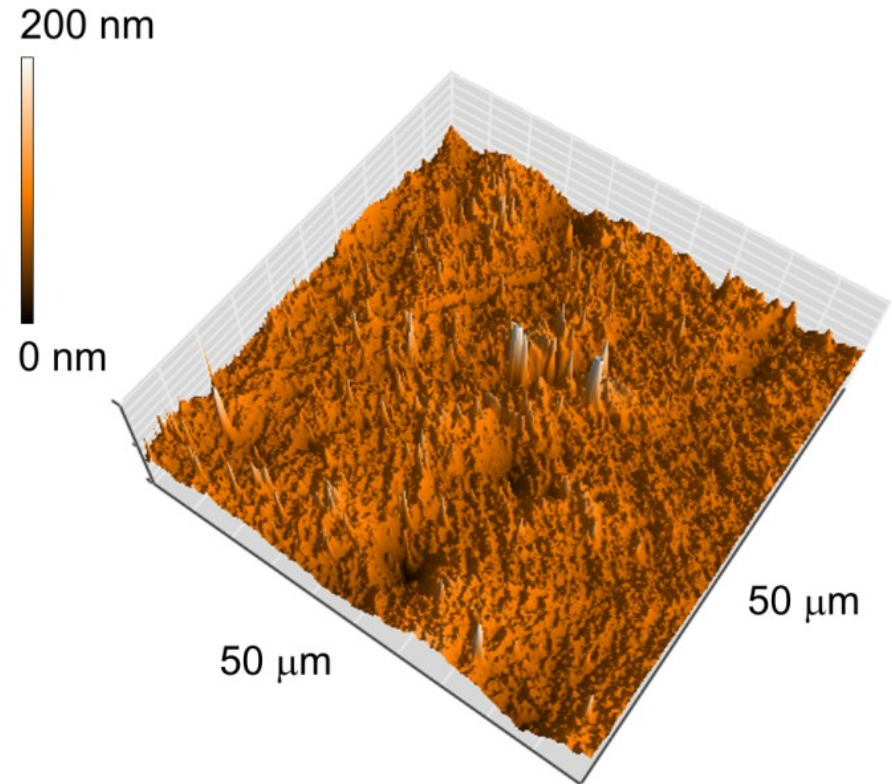
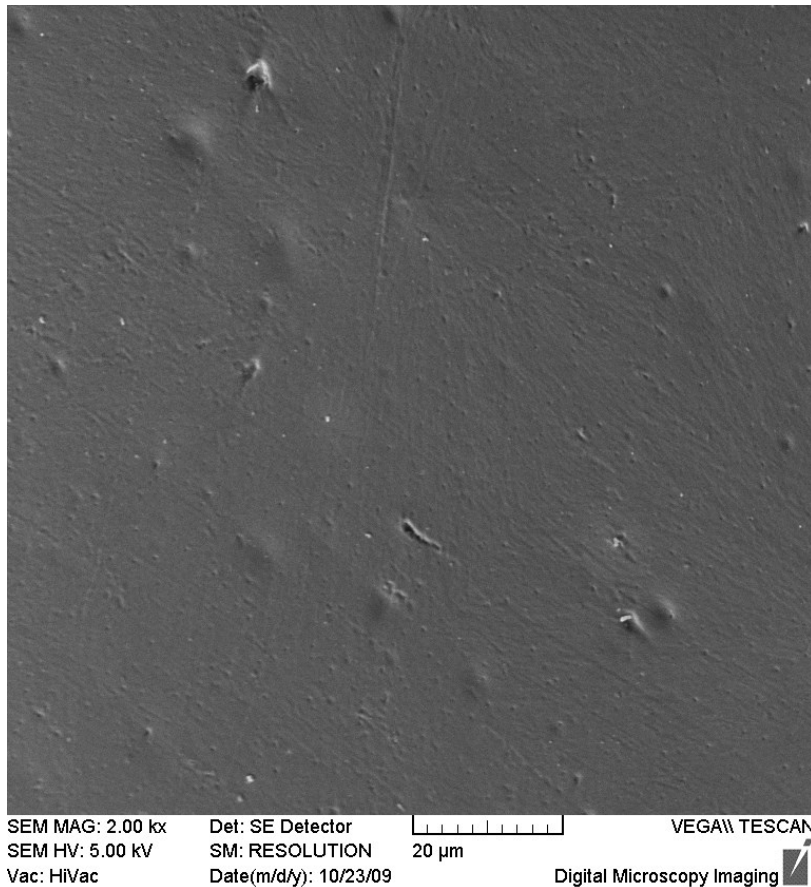


Částice železa na povrchu grafitu

SEM versus AFM



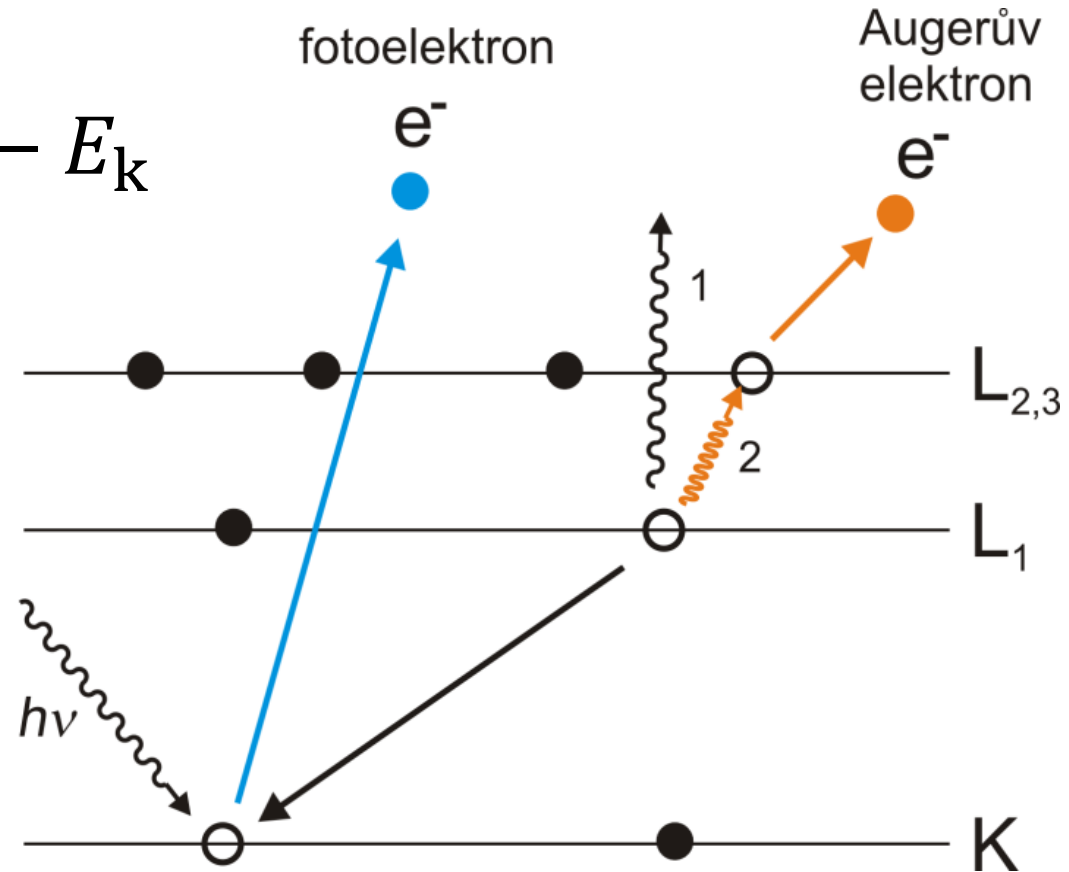
SEM versus AFM



Chvátalová, L., Mráček, A. et al.: The effect of plasma treatment on structure and properties of poly(1-butene) surface. *European Polymer Journal*, 48 866-874 (2012)

Rentgenová fotoelektronová spektroskopie (XPS)

$$E_b = h\nu - E_k$$



Hloubka analýzy – do 10 atomárních vrstev, avšak lze měřit pod úhlem – 2-3 atomy

Rentgenová fotoelektronová spektroskopie (XPS)

No4_110.spe: Sample 4

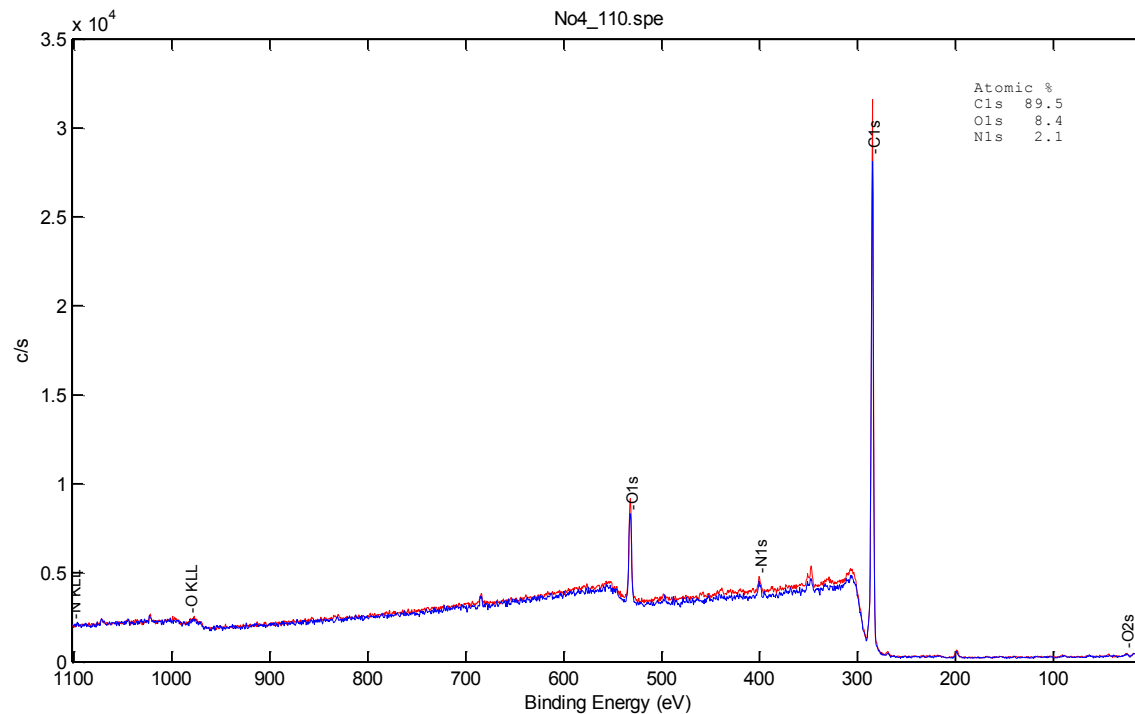
2010 Mar 15 Al mono 250.0 W 0.0 45.0° 187.85 eV

3.1588e+004 max

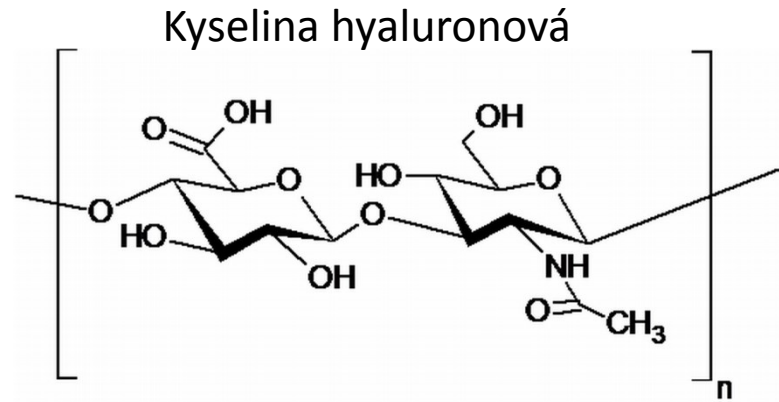
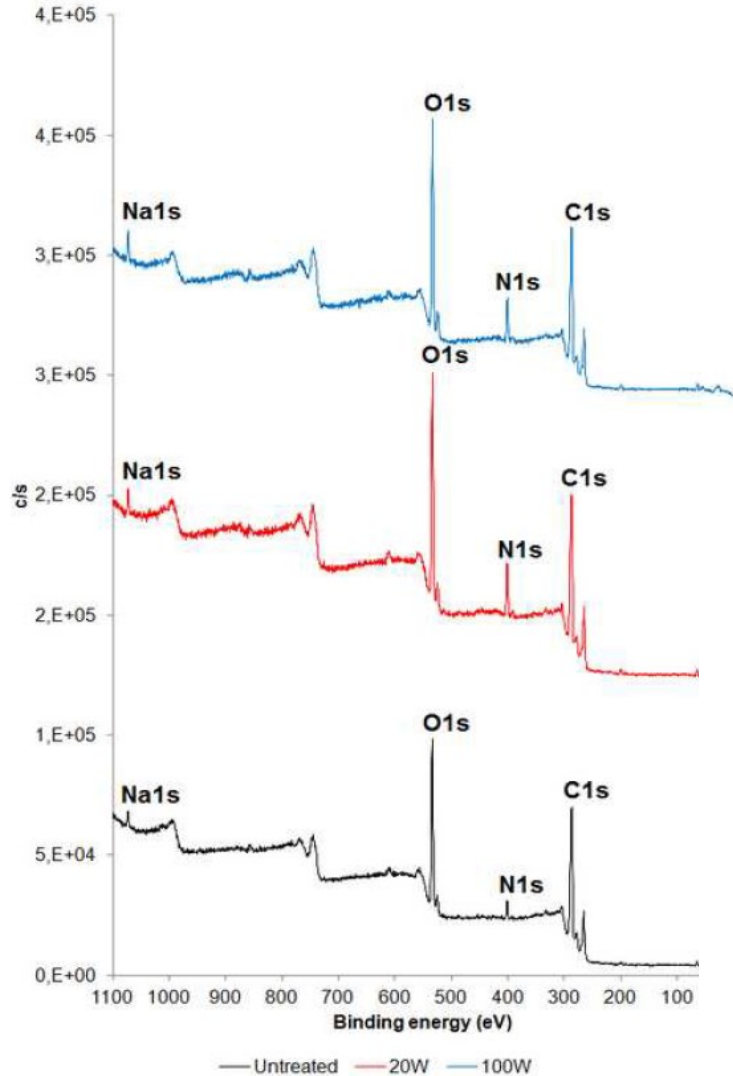
Company Name

13.75 min

Sur1/Full/1 (Shft SG5)



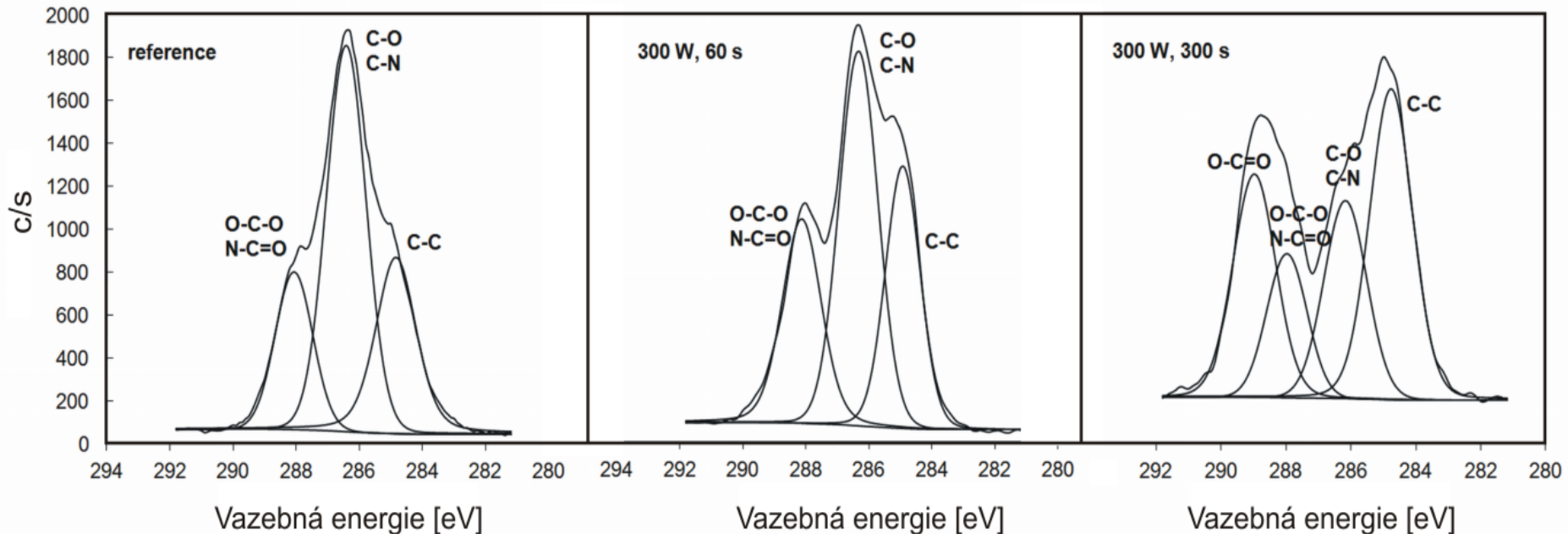
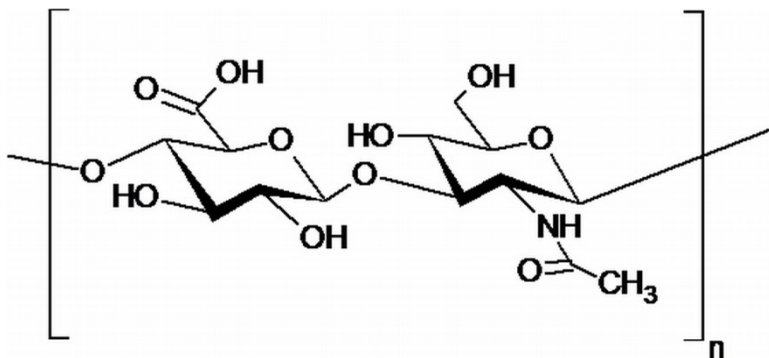
Rentgenová fotoelektronová spektroskopie (XPS)

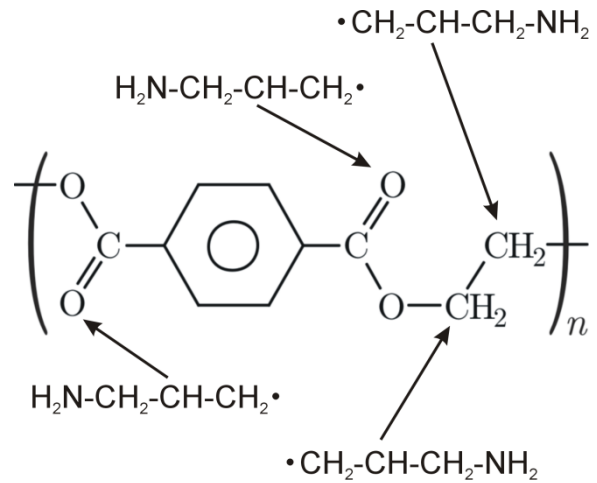
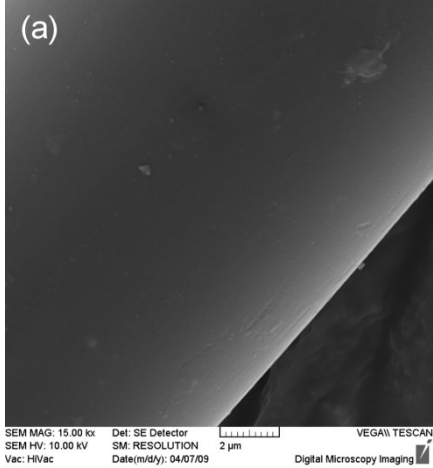


	C	N	O	Na	Si	Ca	N/C
Výpočet složení	51.9	3.7	40.7	3.7			0.07
reference	55.1	4.1	37.4	3.5			0.07
100 W, 60 s	52.3	6.4	35.6	5.6			0.12
200 W, 60 s	53.8	6.9	34.4	4.6	0.3		0.13
300 W, 60 s	53.7	7.8	33.4	4.7	0.4		0.14
300 W, 300 s	27.0	1.9	46.9	17.9	5.7	0.5	0.07

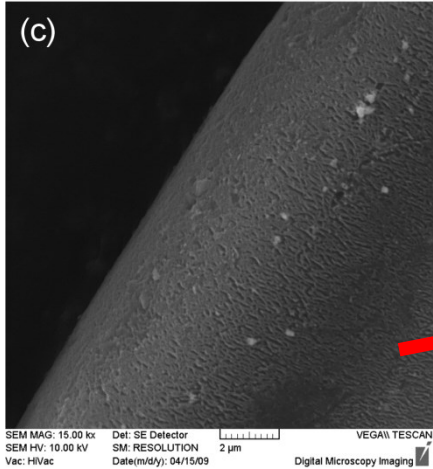
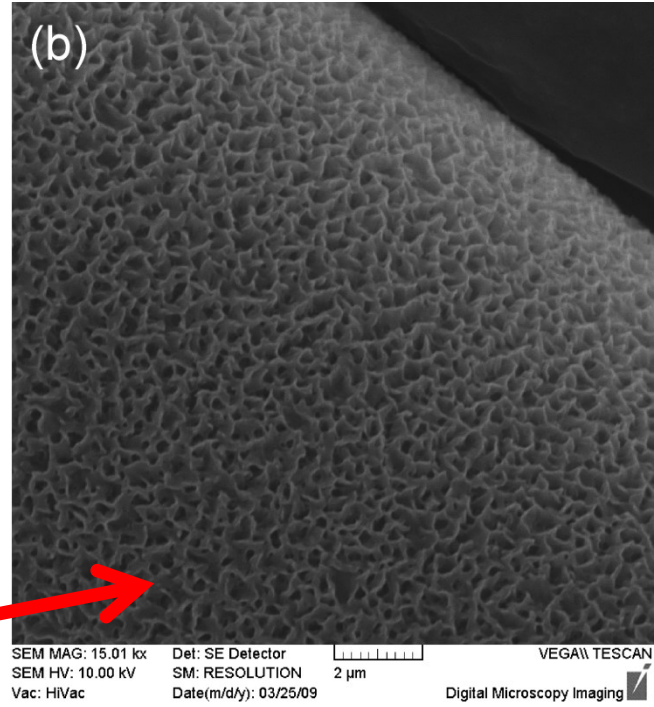
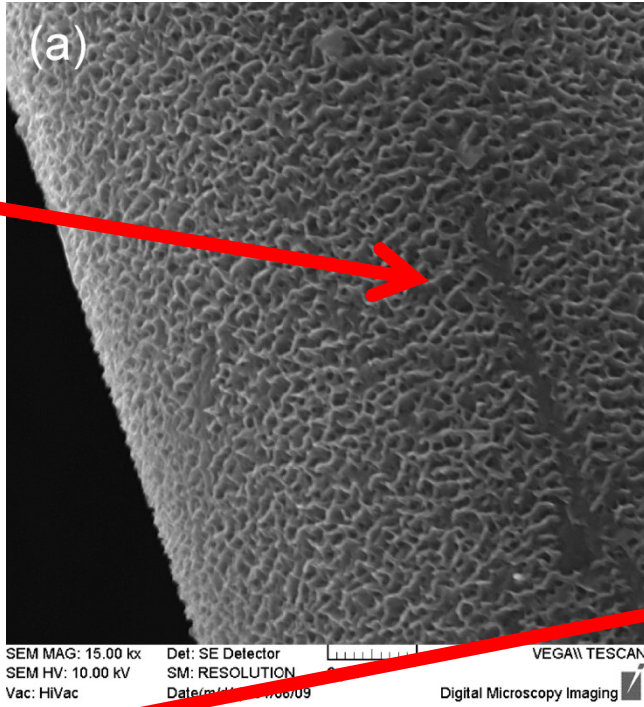
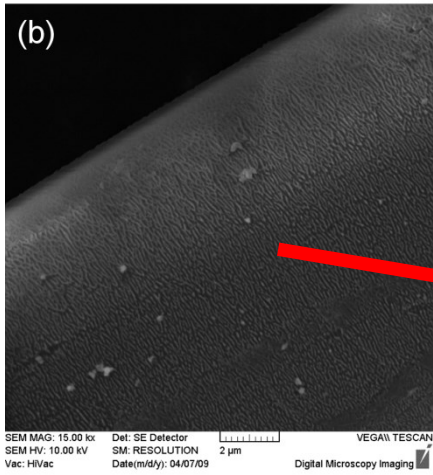
Rentgenová fotoelektronová spektroskopie (XPS)

Kyselina hyaluronová

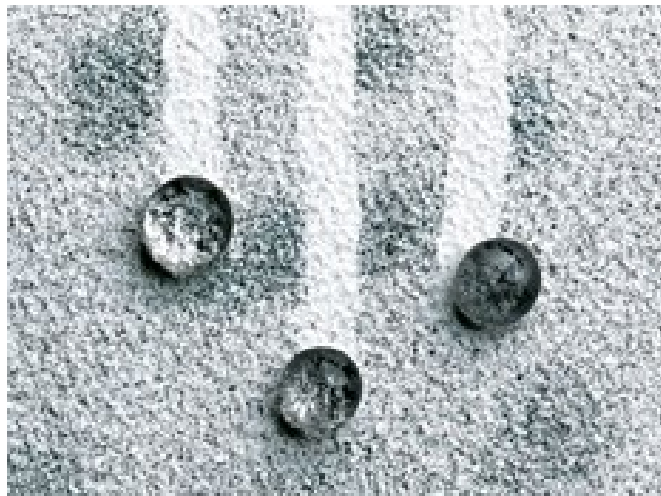




Sample	C1s	O1s	N1s
Pure PES	84,6 ± 2,5	15,4 ± 0,3	0
PES-Ar-Allylamine	78,1 ± 1,8	16,5 ± 0,6	5,4 ± 0,09
PES-N ₂ -Allylamine	84,3 ± 2,1	10,8 ± 0,4	5 ± 0,1



Mráček, A. et al.: The Allylamine grafting on the plasma pre-treated polyester nonwoven fabric. *Fibers and Polymers*, 11(8), 1106 (2010)



Děkuji za pozornost