

Plazma polymerace a depozice

Velmi tenké vrstvy II

Velmi tenké vrstvy

Efekty od „nano“ tloušťky

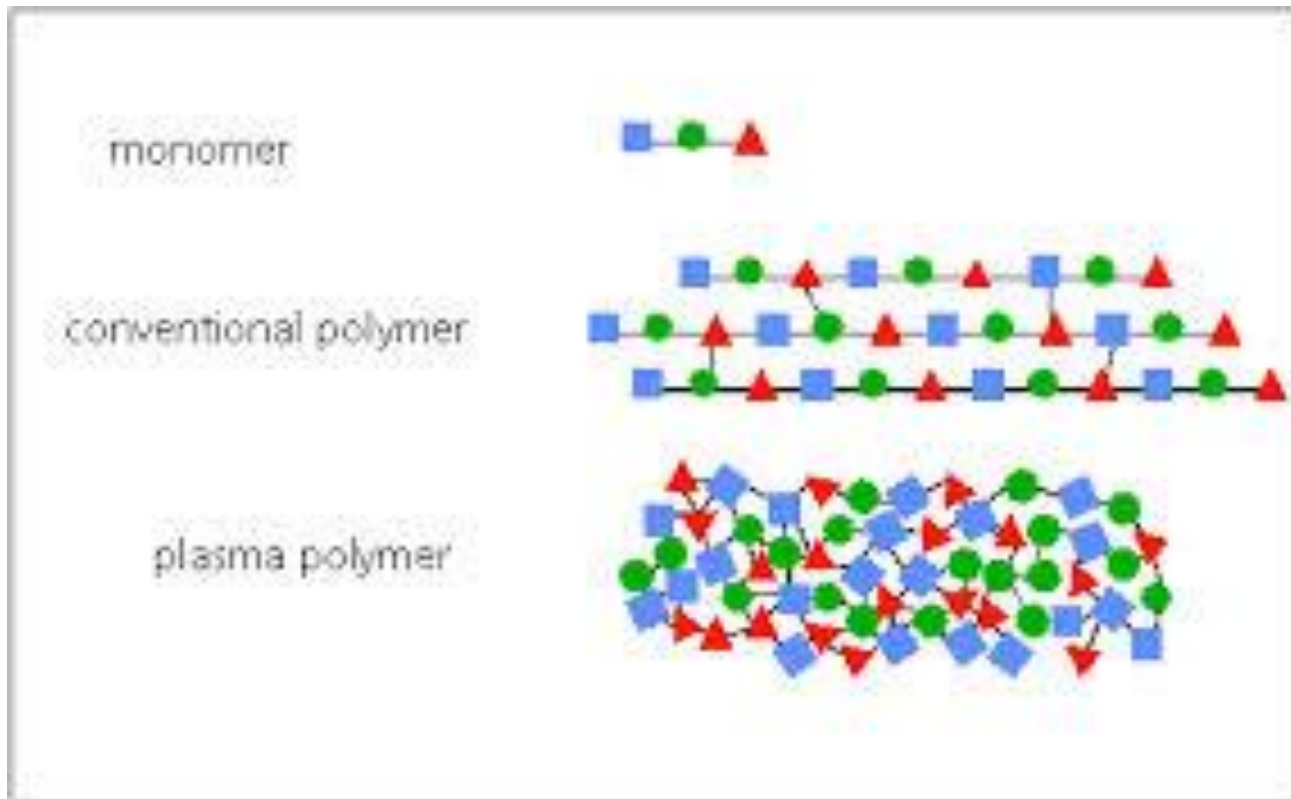
Polymerizace

- je základní reakce pro výrobu plastů, syntetických kaučuků a umělých vláken, v nanotechnologiích se uplatňuje zejména při vytváření tenkých polymerových vrstev.
- Je to chemická reakce, při které z malých molekul (monomerů) vznikají vysokomolekulární látky (polymery).

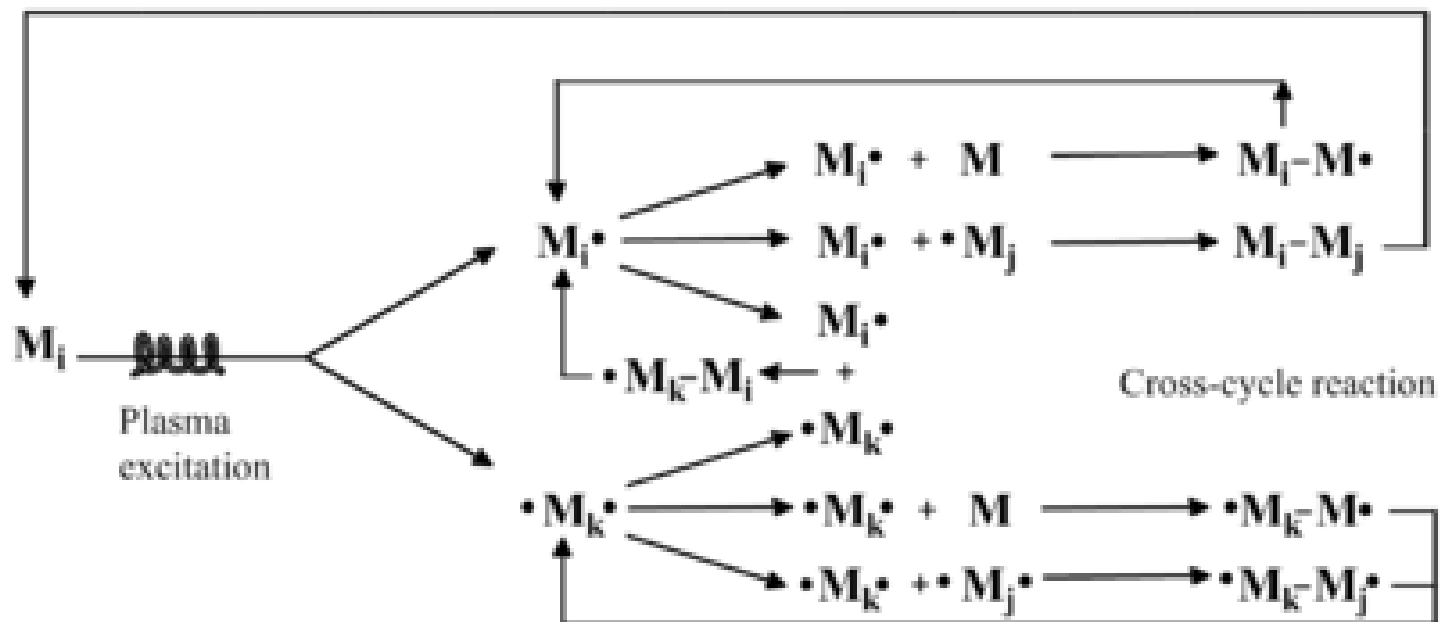
Polymerizace

- Existuje celá řada typů těchto reakcí, plazmová polymerizace je zvláštním případem radikálové polymerizace.
- Při aktivaci plazmou dochází k interakci iontů a elektronů plazmy s molekulami monomerů ke tvorbě radikálů - molekul s volnými vazbami.
- Na povrchu substrátu se vytváří polymer z různě prosítovanými vazbami.

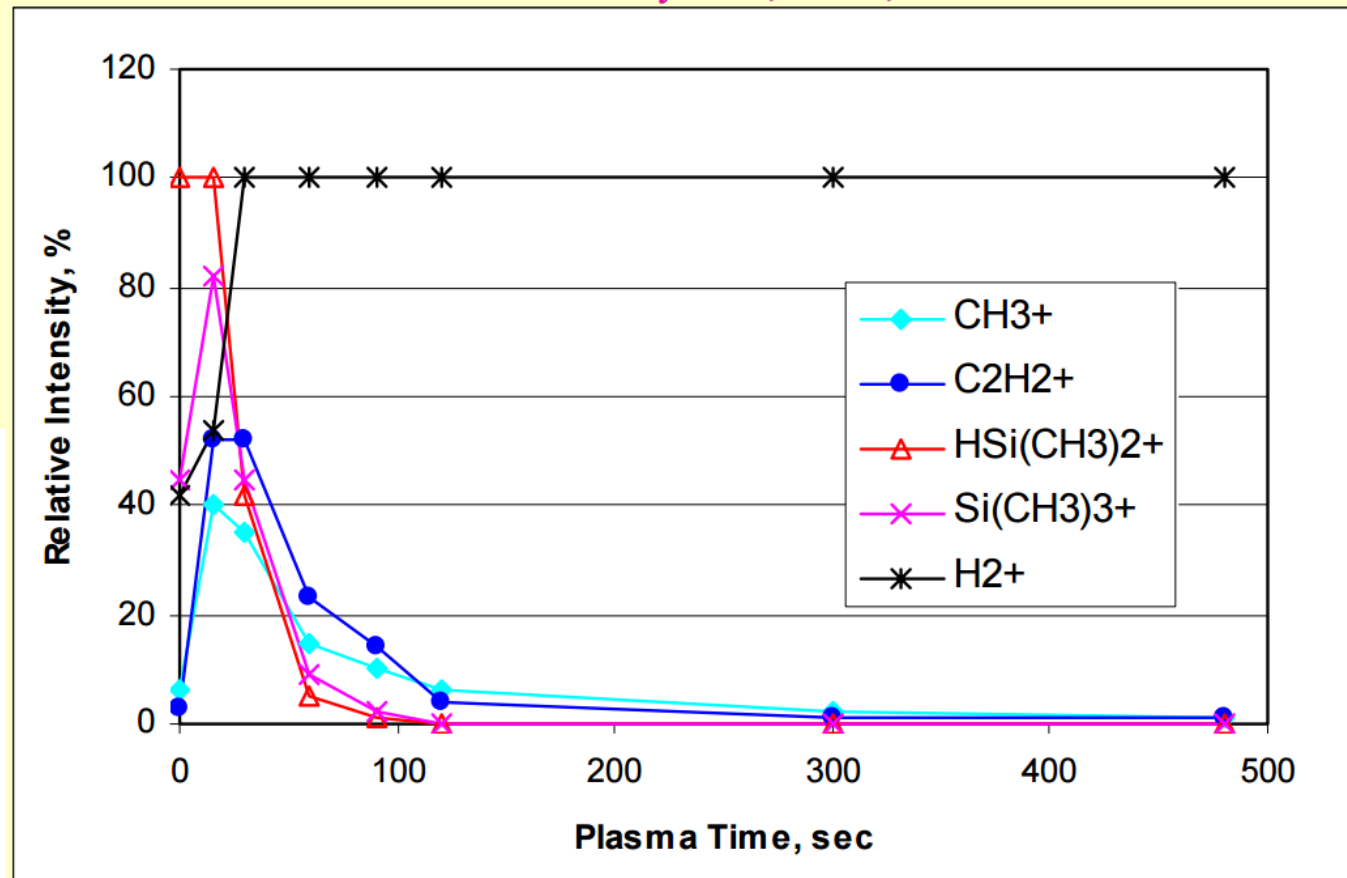
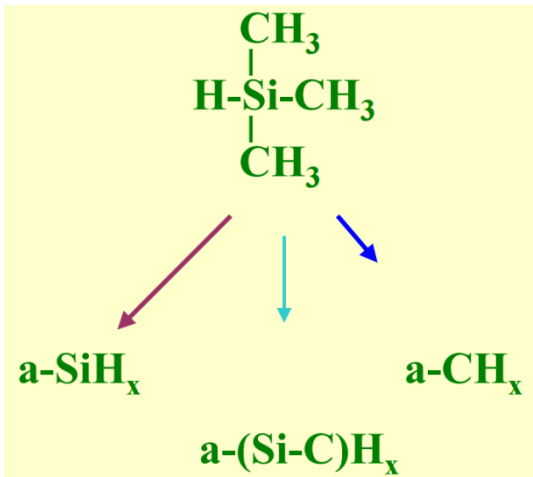
Polymerace a plazma polymerace



Možnosti reakcí



Uzavřená komora



Je nutné přidávat nový monomer a odvádět produkty reakcí

Možnosti

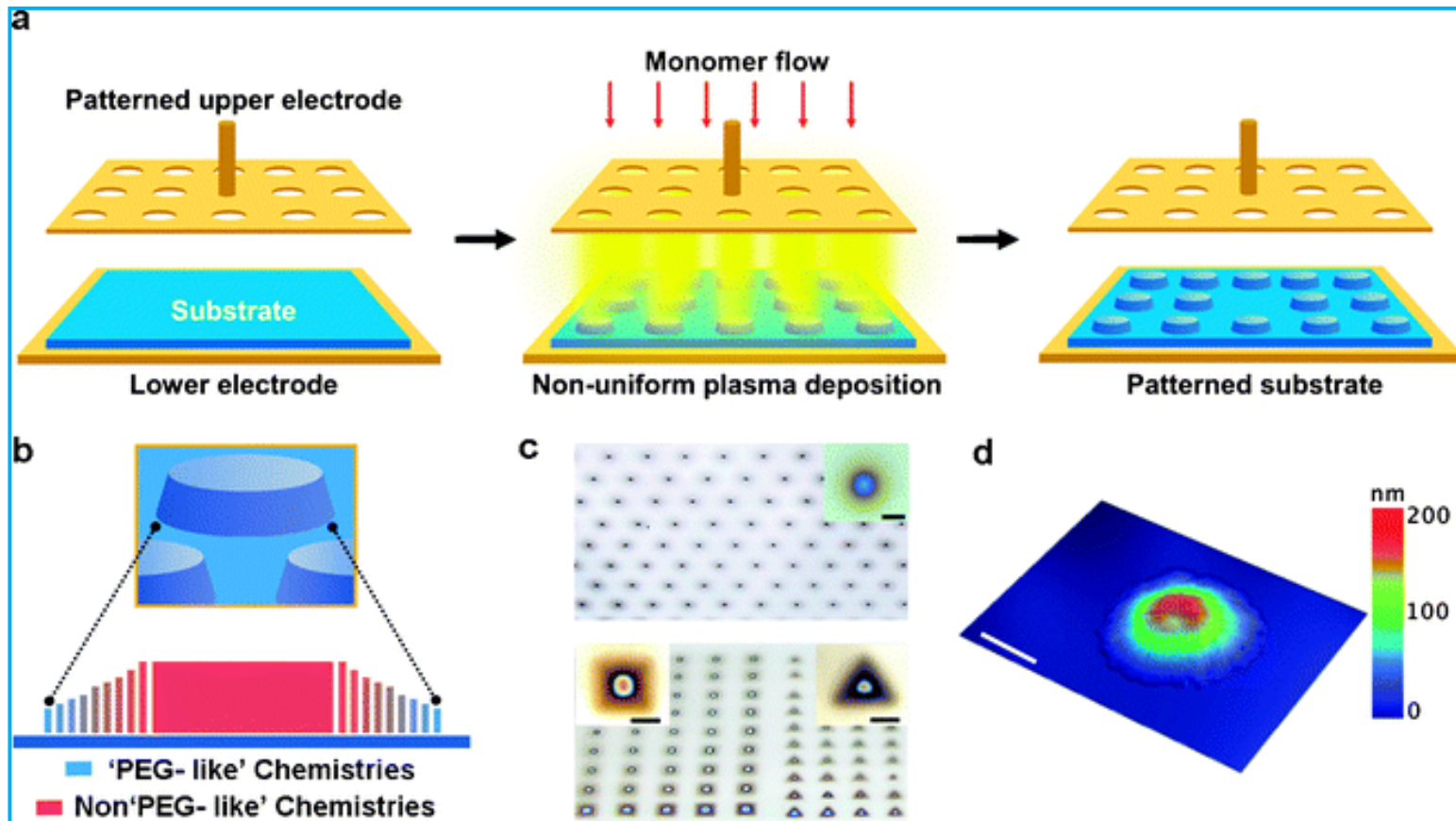
- Lze deponovat vrstvy organické, anorganické nebo hybridní, a především lze fyzikální a chemické vlastnosti těchto vrstev řídit depozičními podmínkami. Výsledkem jsou vrstvy s definovanými elektrickými, mechanickými a optickými vlastnostmi. Morfologii povrchu vrstev lze rovněž měnit v širokém rozsahu.

Měnitelné parametry

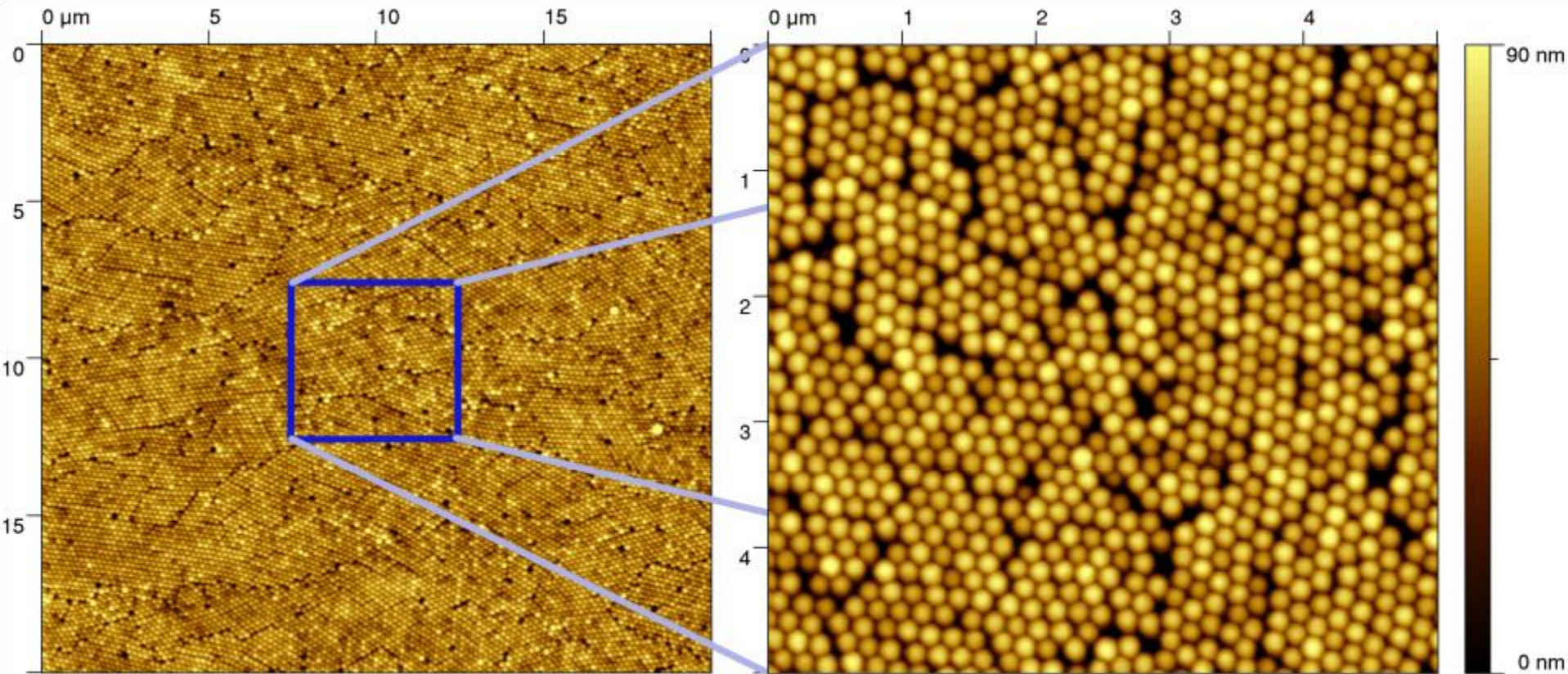
- tlak: 0,1 - 1000 Pa, výběr vhodného plynu nebo monomeru, dávkování plynů, případně par monomerů, výkon, frekvence, tlak, proud plynu/par, geometrický faktor
- Depoziční rychlost, s jakou je vrstva nanášena, závisí na depozičních podmínkách a pohybuje se v rozmezí 0,1 - 10 $\mu\text{m}/\text{hod}$.

Lze kombinovat i s litografií

Možnost 1



Is nanosférickou

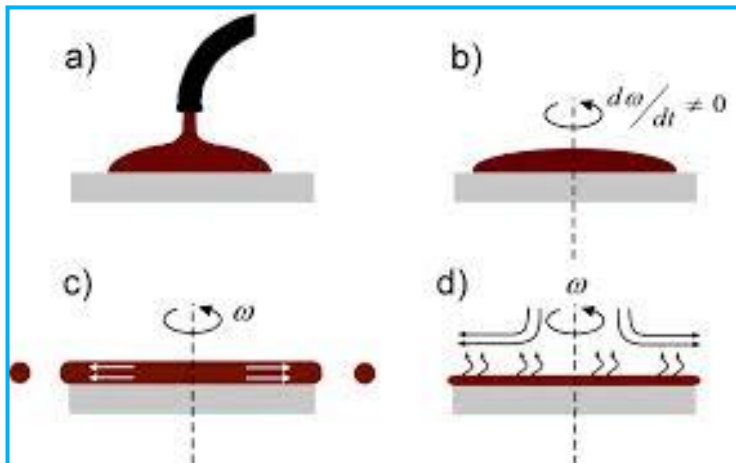


Monolayer of PS spheres 200 nm prepared by dip-coating method,
AFM image of area 20×20 a 5×5 μm.

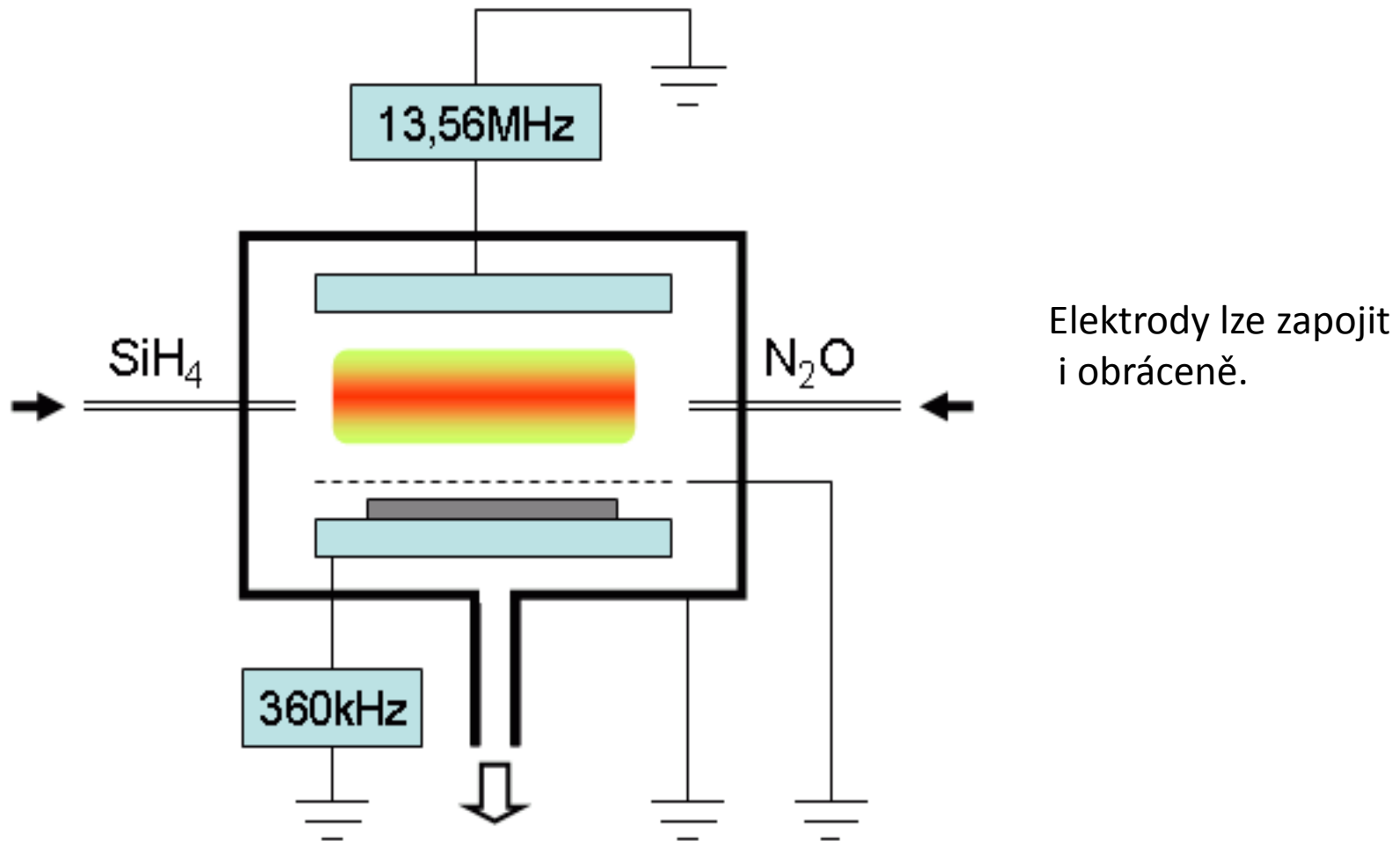
Spin coatings

Depoziční proces vytvářející homogenní vrstvy na plochých substrátech.

Deponovaný materiál se nanáší na střed rotujícího substrátu a odstředivá síla způsobuje pokrývání substrátu od středu ke hranám, přebytečný materiál je odstříknutý mimo substrát. Současně se odpařuje použité rozpouštědlo. Tloušťka vrstvy závisí na otáčkách, viskozitě a koncentraci materiálu v rozpouštědle

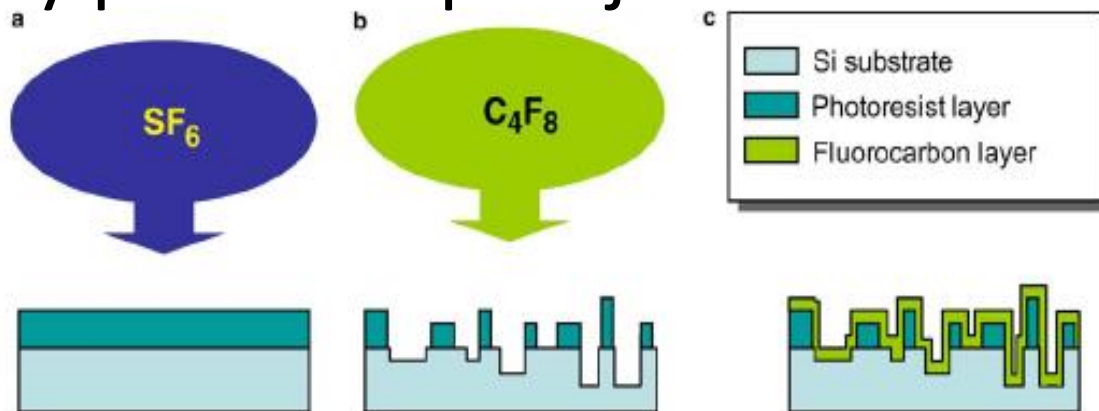


Vytváření - Triodový PECVD systém



Superhydrofobní povrch

- PACVD z C_4F_8
- Vzorek na napájené elektrodě Si pokryt fotorezistem
- Vzorek byl před depozicí zdrsňen pomocí iontového bombardu
- Výsledný povrch odpuzuje vodu



Výsledek

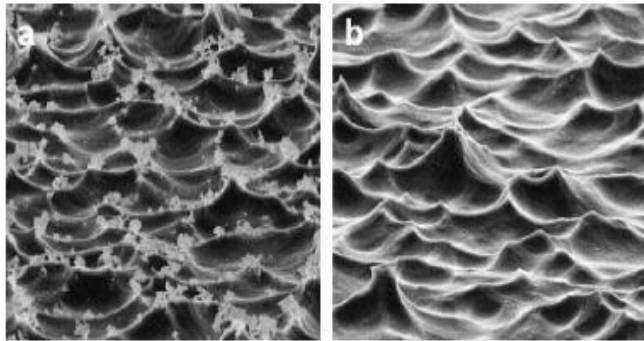


Fig. 4. SEM picture of sample (a) after 2.5 min of etching and (b) after cleaning in ultrasonic acetone bath.

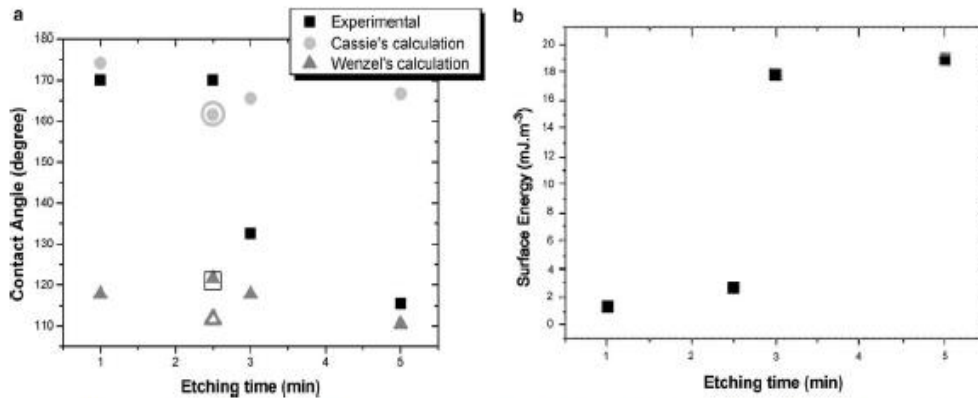
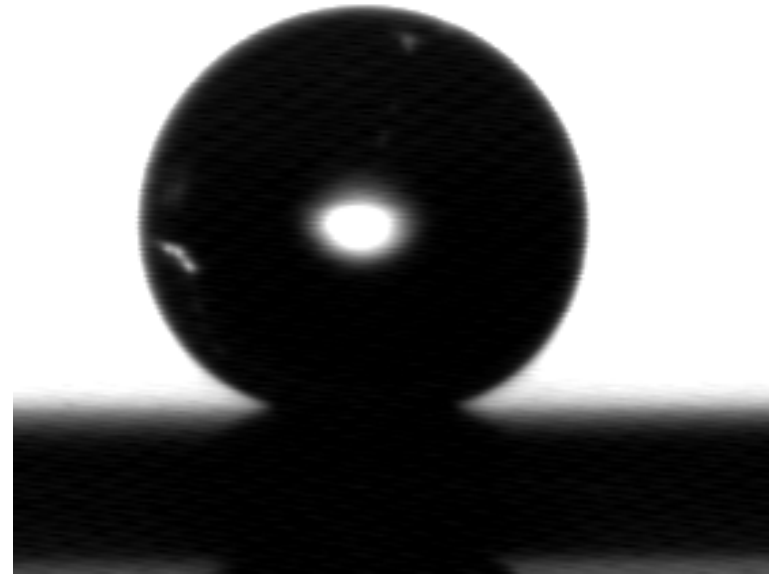
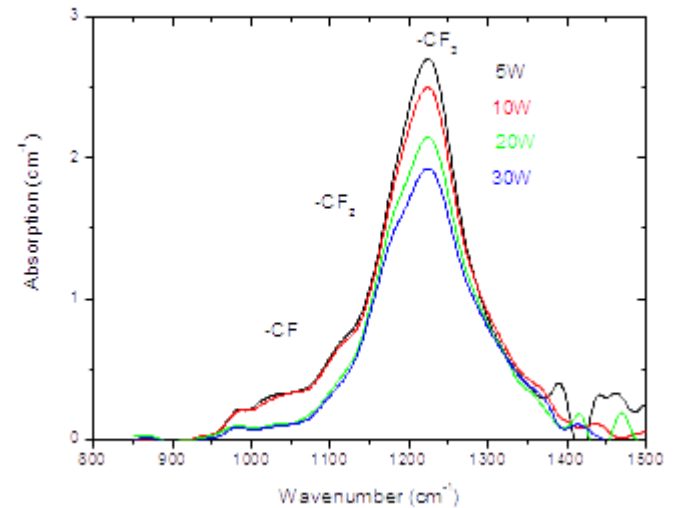
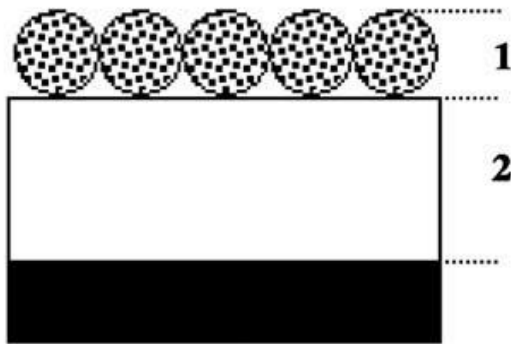


Fig. 5. (a) Water contact angle values of CF_2 surfaces for different etching time. The black squares, the light grey circles and the dark grey triangles are respectively the experimental measurements, contact angles calculated from Cassie equation, and contact angles calculated from Wenzel equation. Open symbols are measurements done on clean rough substrate. (b) Surface energy of CF_2 layers for different etching time.

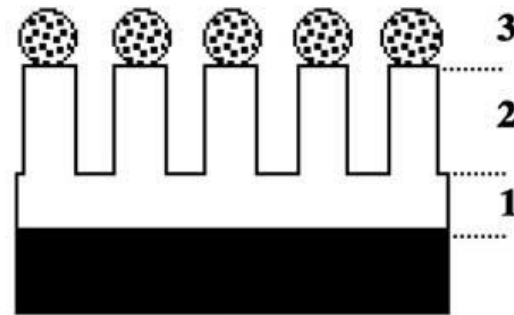


S použitím nanosférické masky

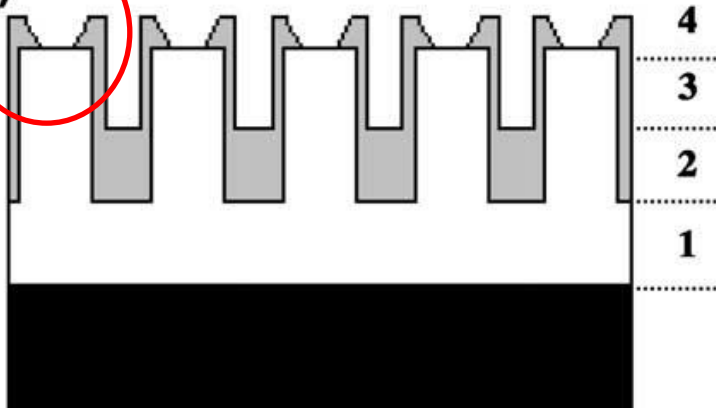
(a)



(b)



(c)



PS



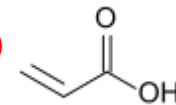
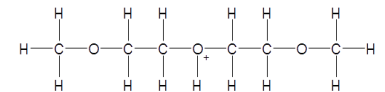
PEG



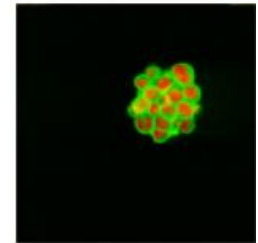
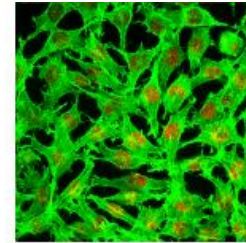
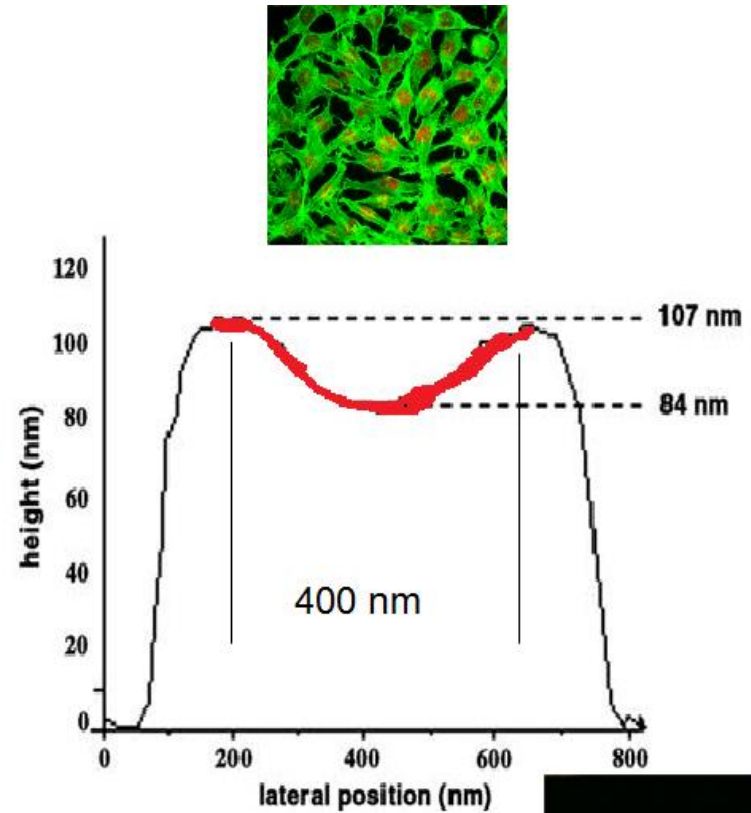
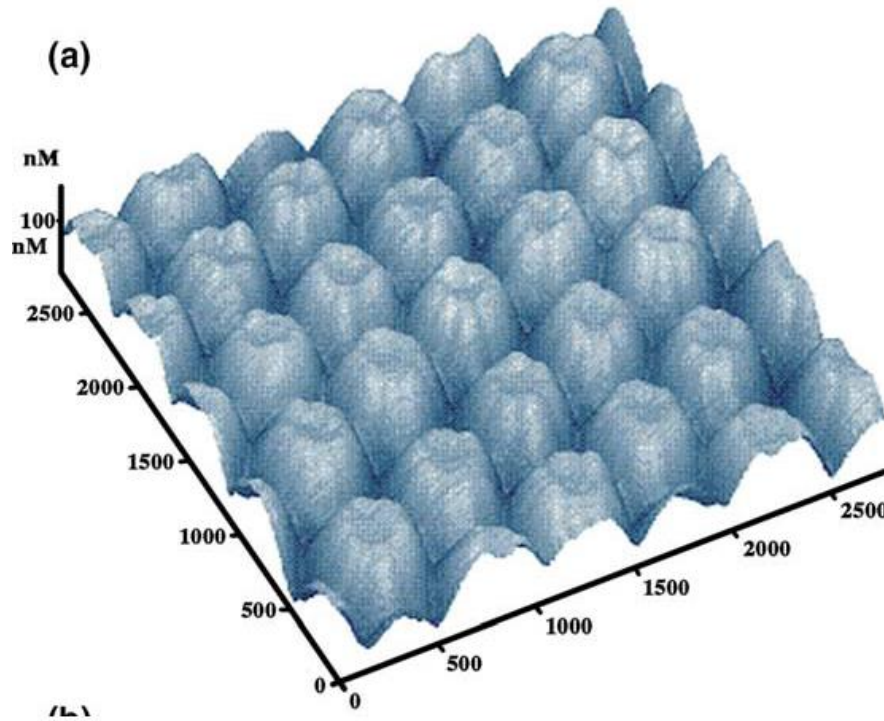
PPAA



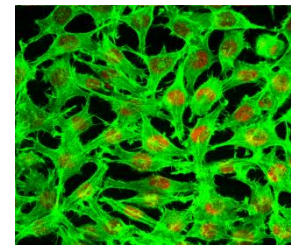
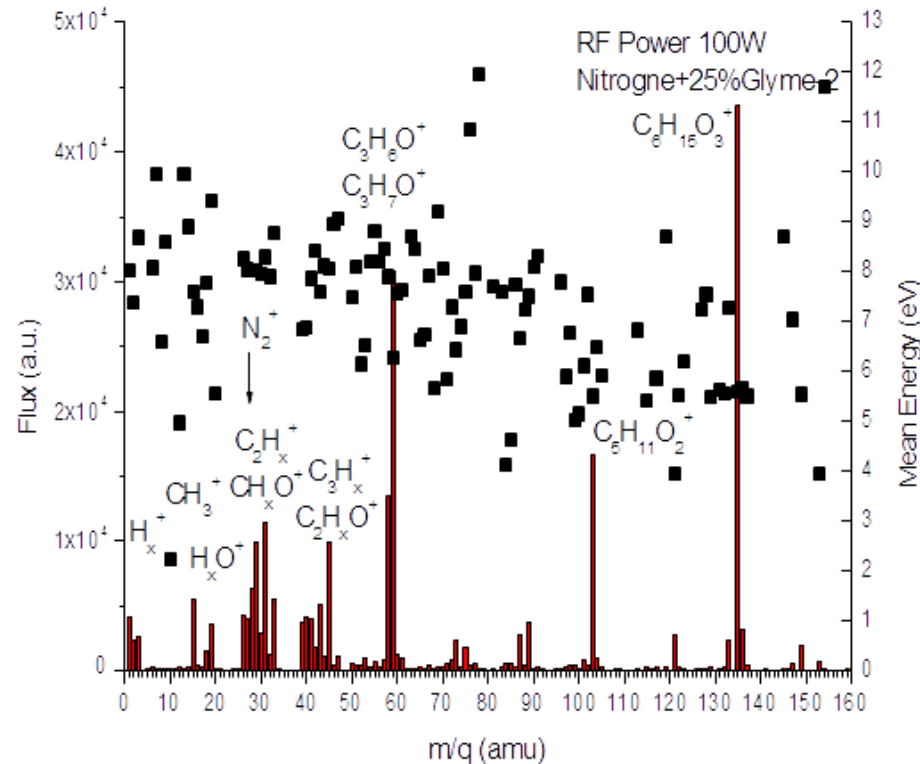
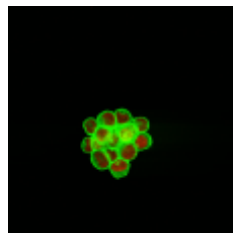
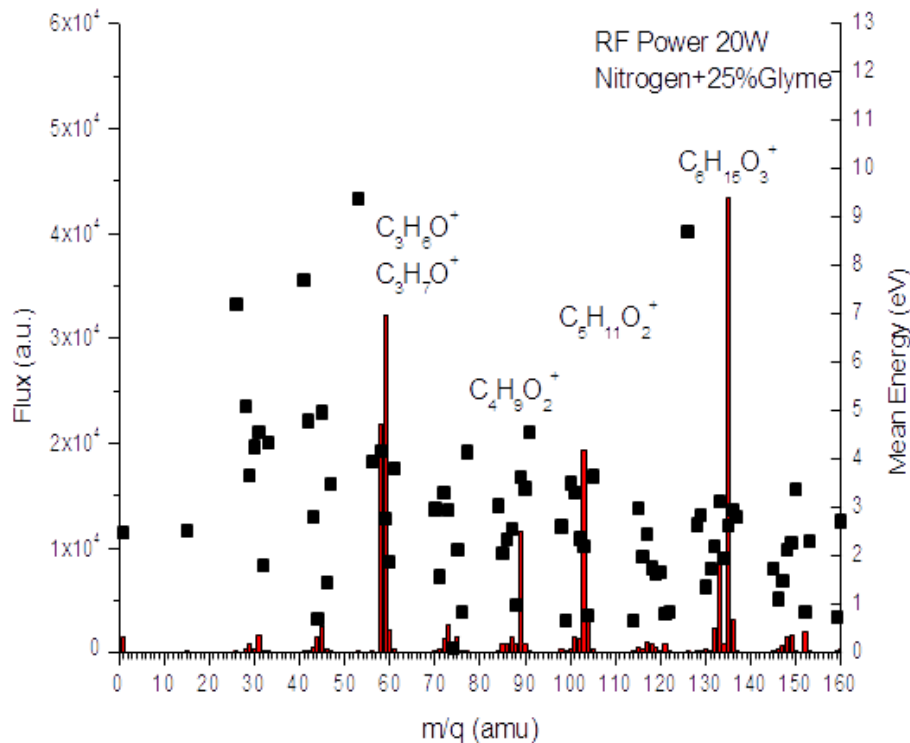
Si



S použitím nanosférické masky



Šlo by to i z jedného druhu monomeru?



Napařování

- Kovy (oxidy prakticky pouze reaktivně)
 - To už znáte
- Organické látky

Vhodné organické látky pro napařování

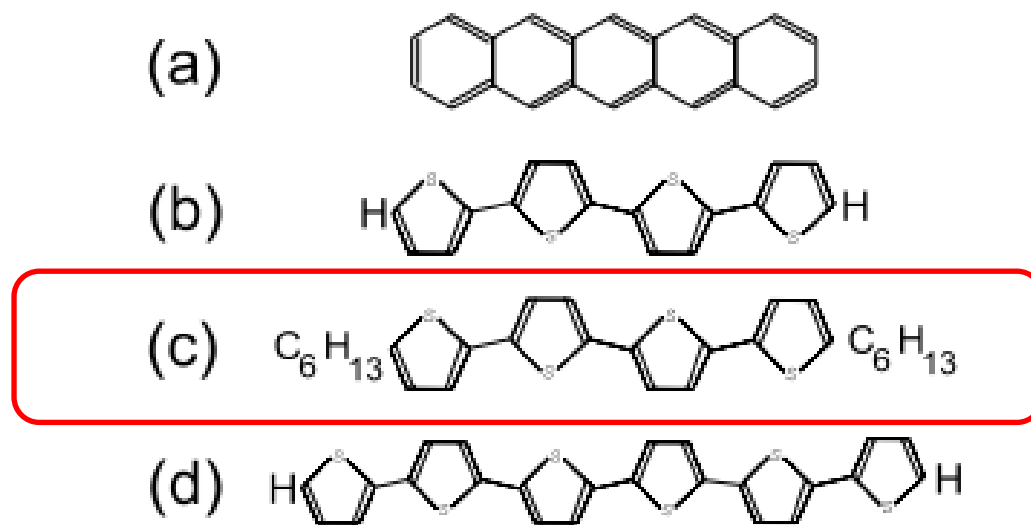


FIGURE 2.1. Chemical structure of (a) pentacene, (b) quaterthiophene, (c) α, α' -dihexylquaterthiophene and (d) sexithiophene.

Realizace

- Ohřev na cca 180 až 240 oC

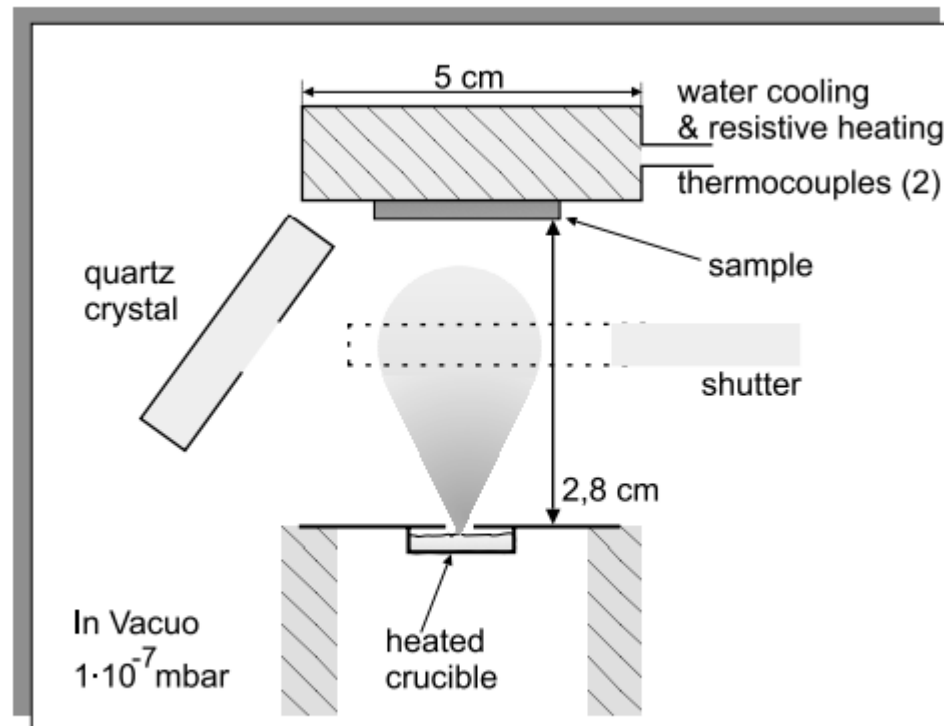


FIGURE 2.2. Experimental High-Vacuum evaporation setup.

Pracovní postup

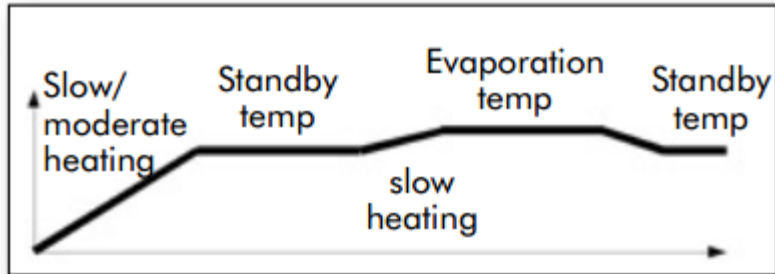
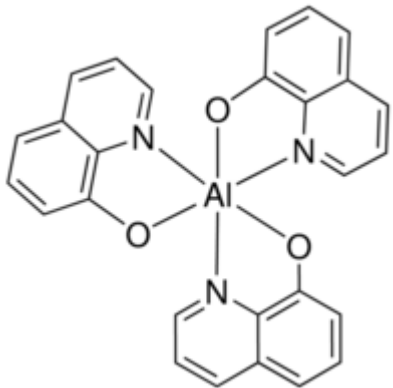


Figure 5:

Typical process steps and temperature variation during an evaporation sequence.



Aluminum oxinate
Používaný v OLED

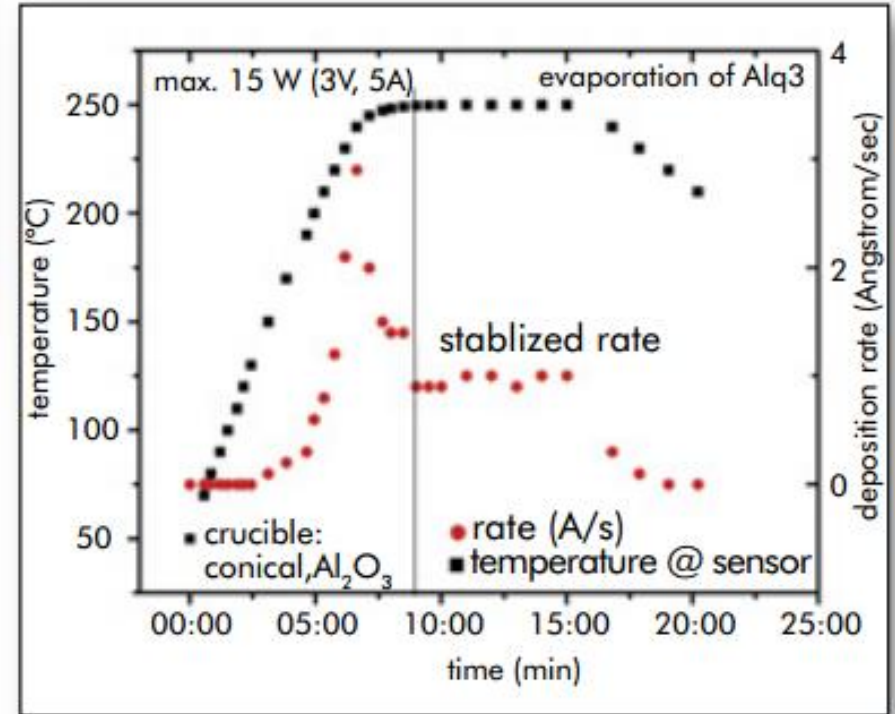


Figure 6:

Temperature-rate-time characteristic of a simple crucible-type point source during evaporation of an organic material (Alq3).

OLED a laser

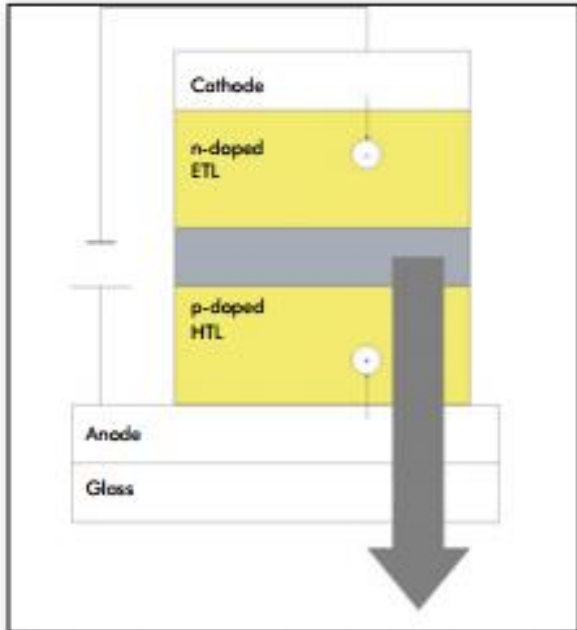


Figure 7: Organic light-emitting diodes (OLEDs) used for displays and as a light source.
Reference: Novald AG [3]

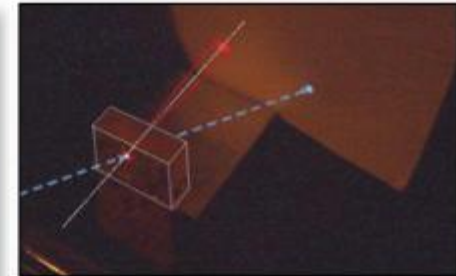
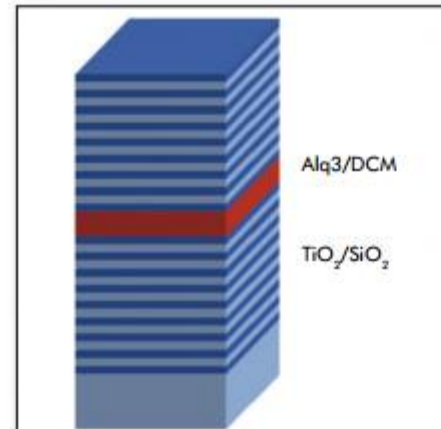


Figure 9: Optically pumped laser with active organic layers (Alq3/DCM) embedded in multilayers of transparent oxides. Reference: Institut für Angewandte Photophysik, TU Dresden.

Thiophene

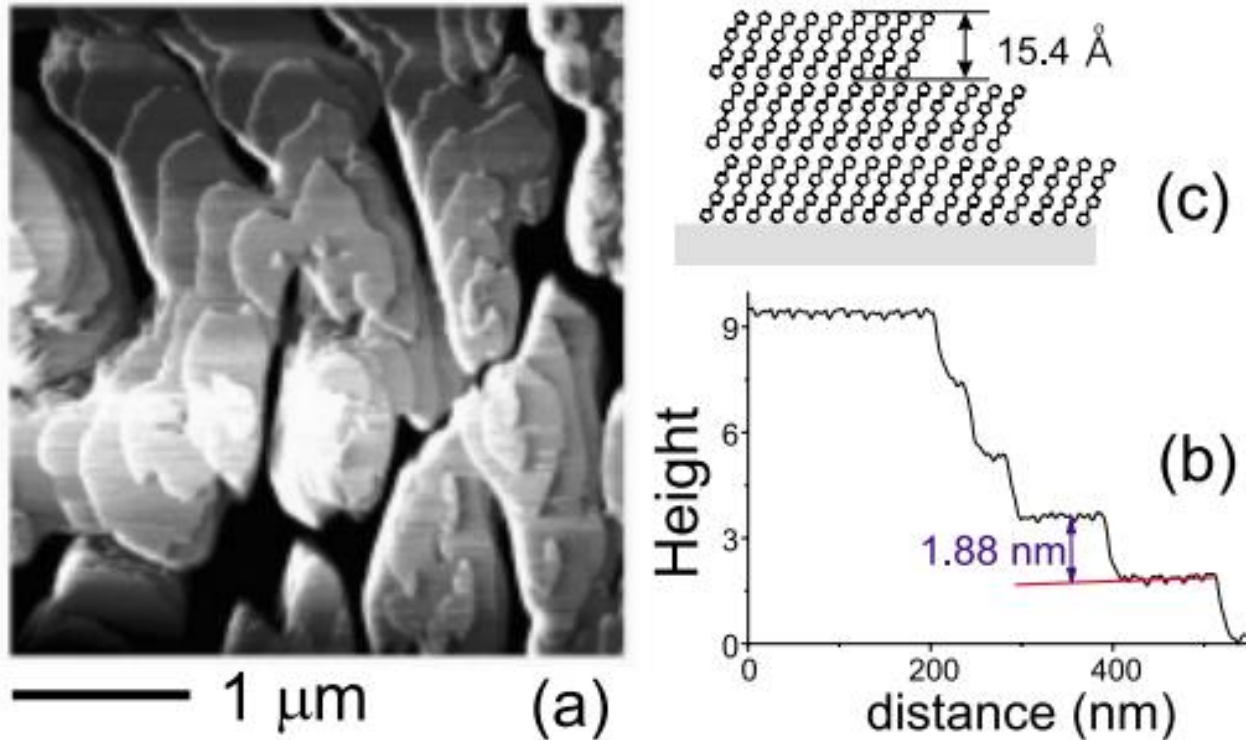


FIGURE 2.3. (a) AFM image of 10 monolayers of α -4T on mica, (b) linescan of an AFM image showing the individual mono-molecular steps and (c) schematic overview of three molecular layers.

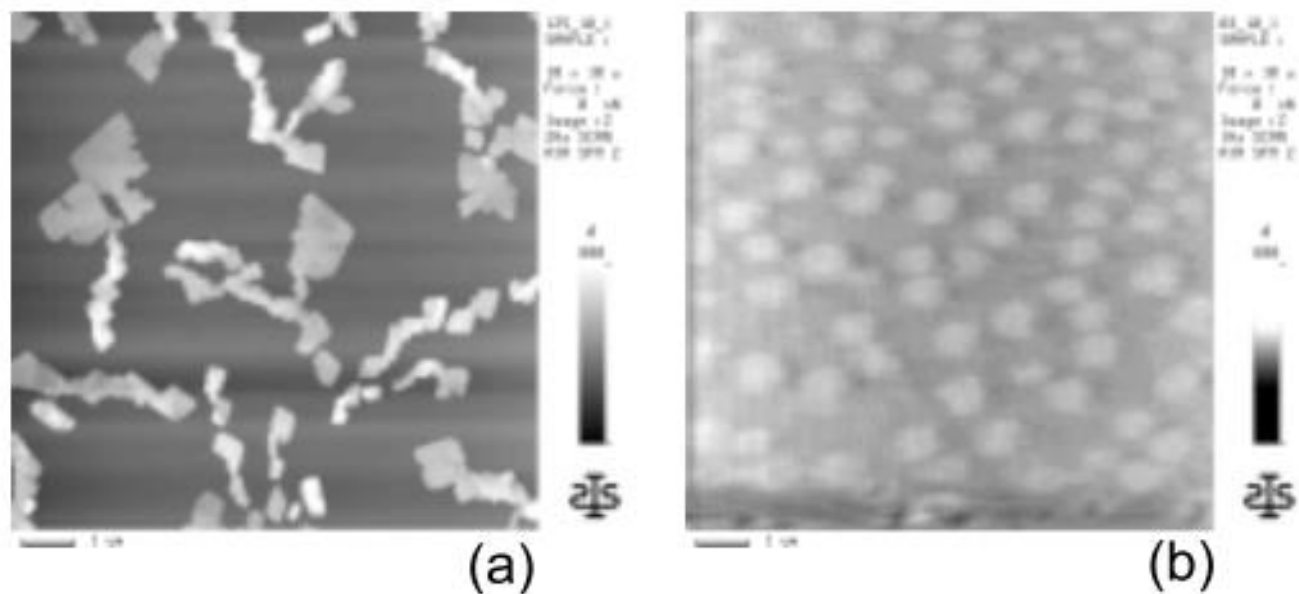


FIGURE 2.5. AFM images showing (a) strongly faceted islands with several monolayers of deposited material, and (b) monolayer islands in the (sub)monolayer coverage regime.

2D ostrůvky a 3D struktury

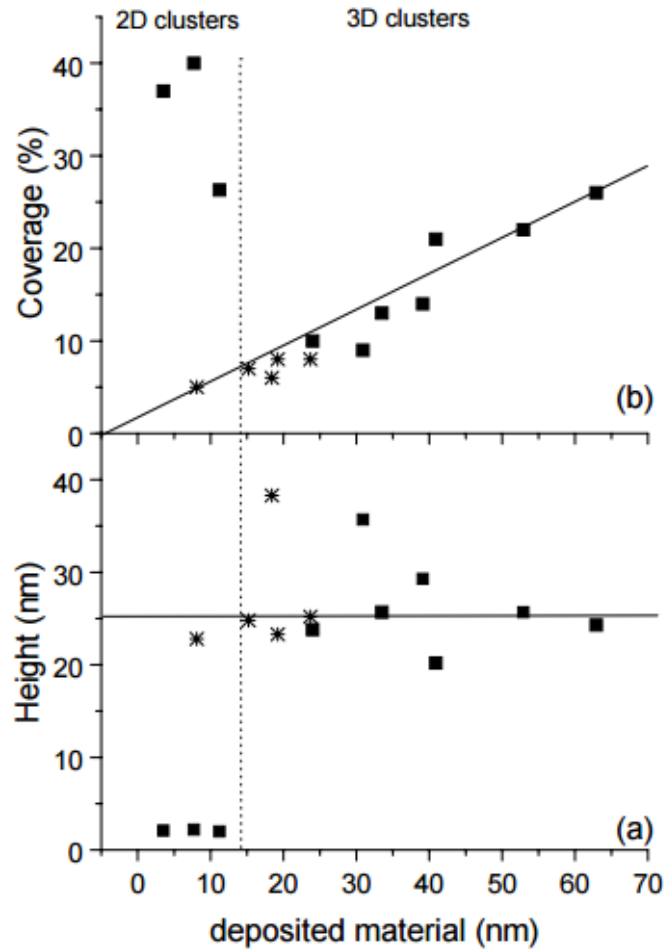


FIGURE 2.6. (a) The average height of the islands and (b) the coverage (in percentage of the substrate), as a function of the amount of deposited material. The data points marked with a asterisk (*) are obtained on additionally purified material.

Teplota substrátu

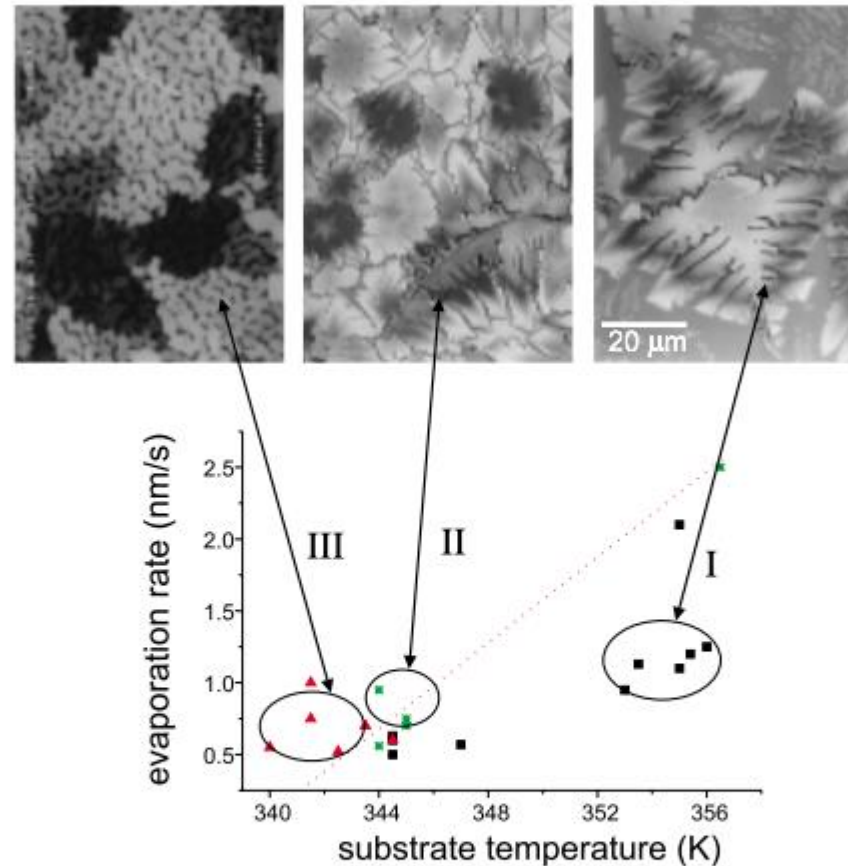


FIGURE 2.7. Three different types of α -4T thin-film morphology for several combinations of the substrate temperature and the evaporation rate from the source. The straight line is a guide to the eye and marks the optimal settings (morphology type II) in order to obtain large individual crystallites within a poly-crystalline thin film.

Výroba OLED



ROLL-TO-ROLL PROCESS TECHNOLOGY

TECHNOLOGY

- Vacuum thermal evaporation (VTE)
- Organic electronic devices on metal and plastic web
- OLED small-molecule evaporation
- Sputtering process of metal and metal oxide layers
- Plasma pre-treatments
- Gravure printing and slot die coating
- Web cleaning
- Lamination of barrier films

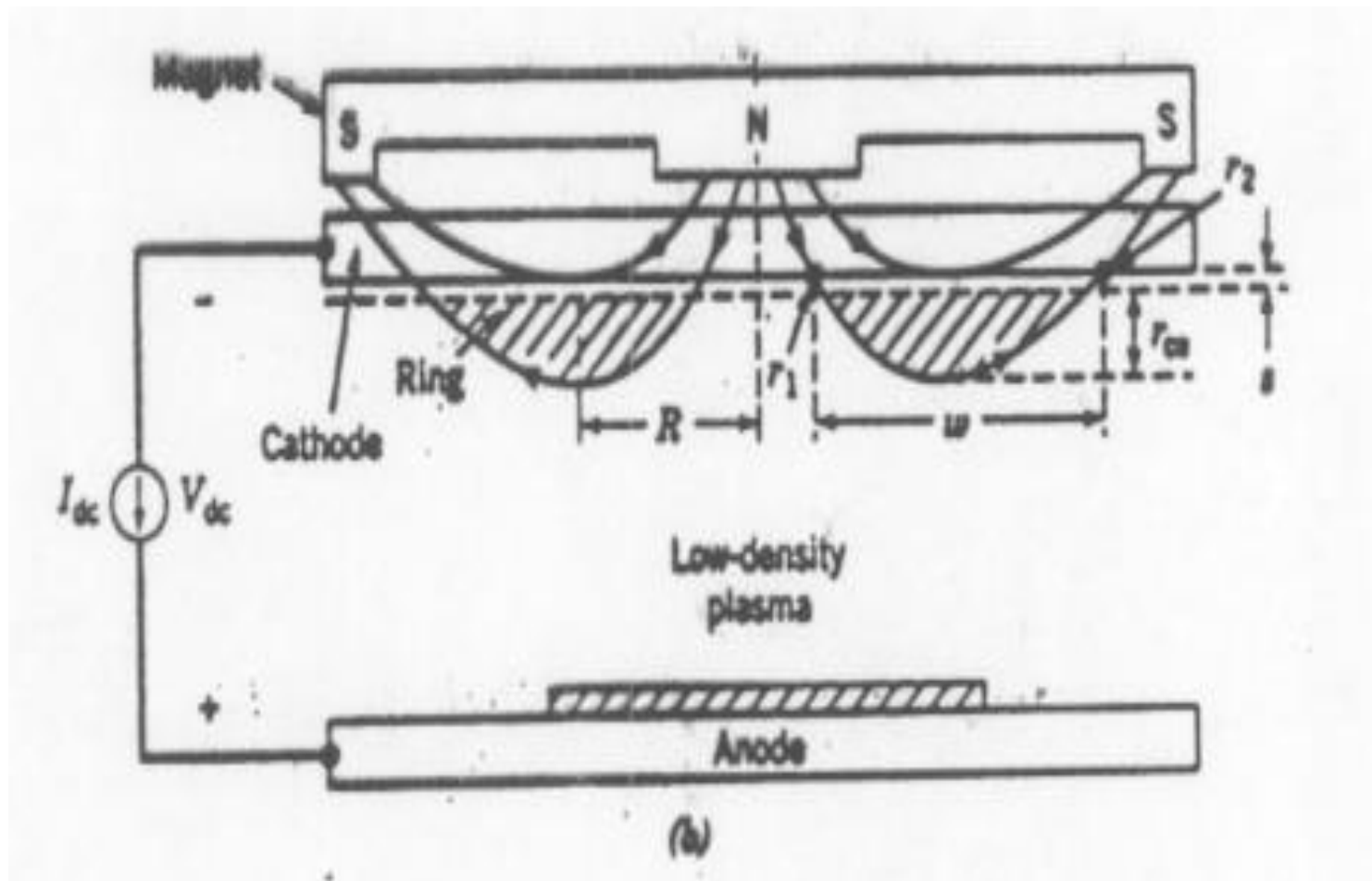
http://www.fep.fraunhofer.de/content/dam/fep/en/documents/Produktflyer/L12_Organic%20Electronics_net_EN.pdf

Magnetronové naprašování

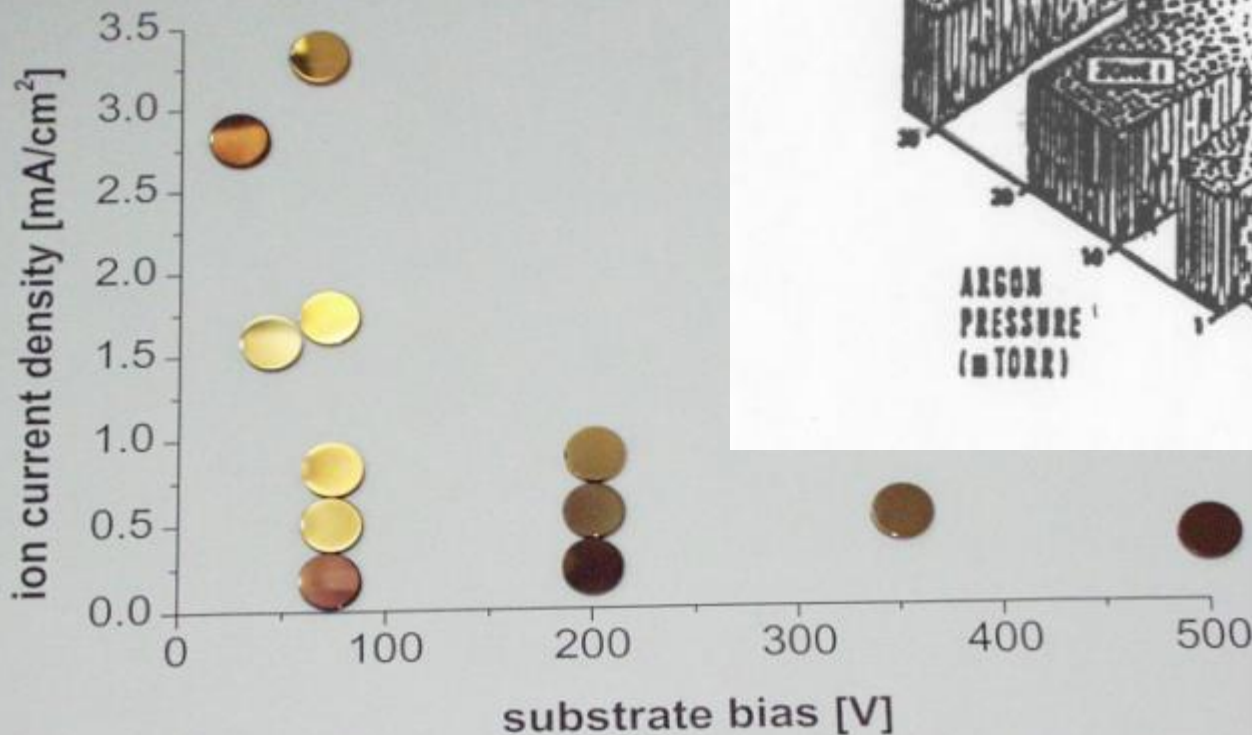
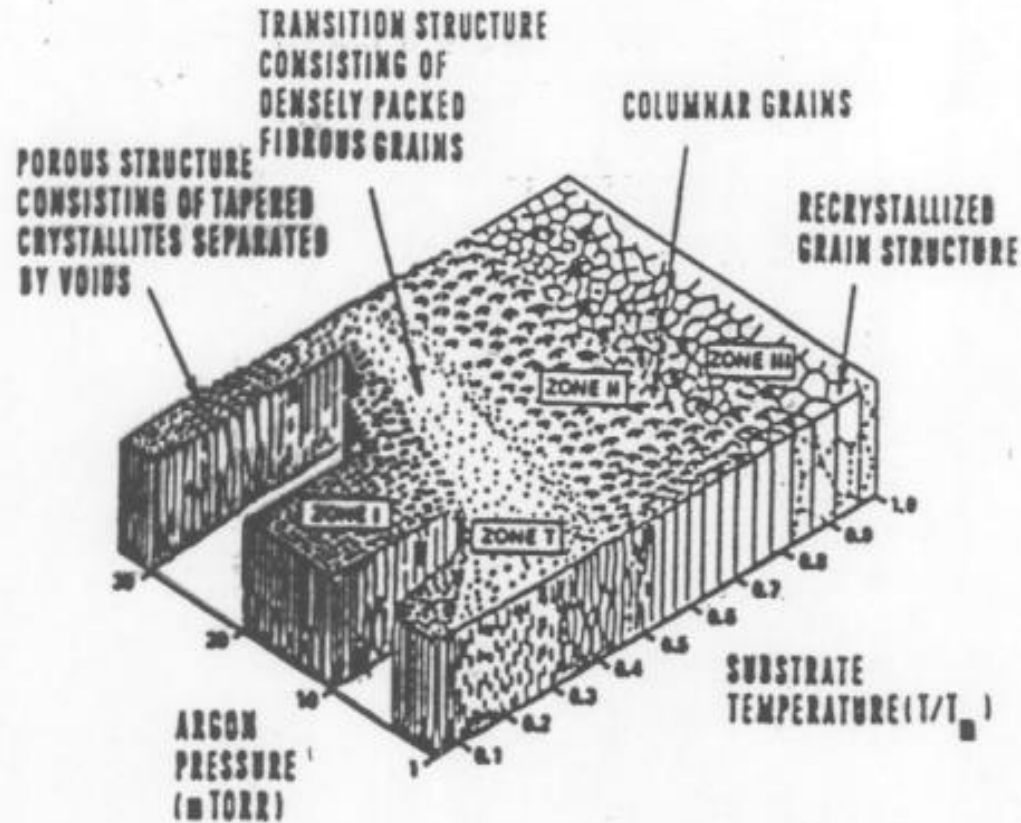
- Kovy, oxidy kovů (můžou být terč)
- Polymery (pozor na natavení)
- Lze řídit růst

Planární magnetron

DC, RF, pulzní, HIPiMS

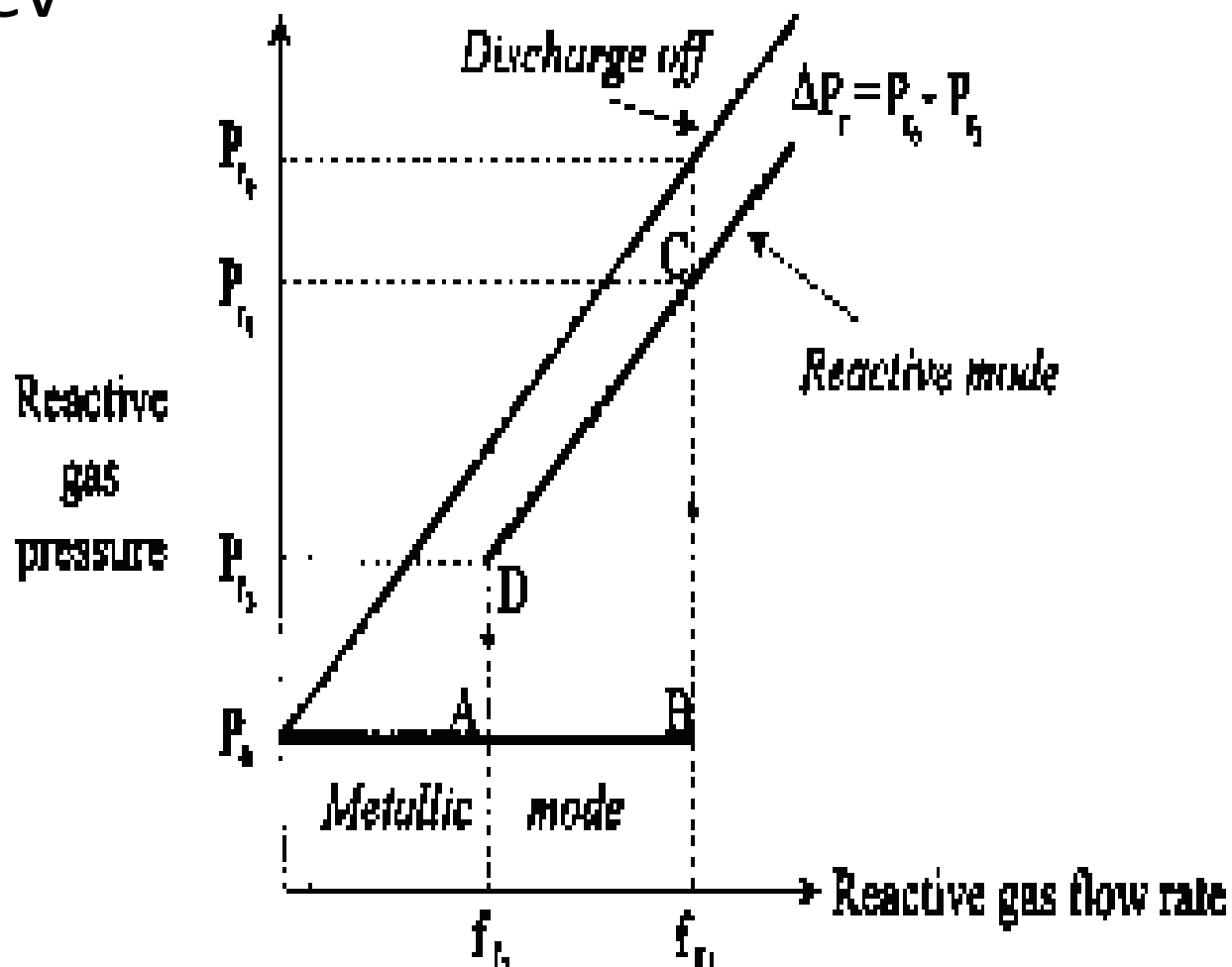


Ovlivnění růstu vrstvy



Reaktivní naprašování

- Hysterezní jev



Superhydrofobní vrstva

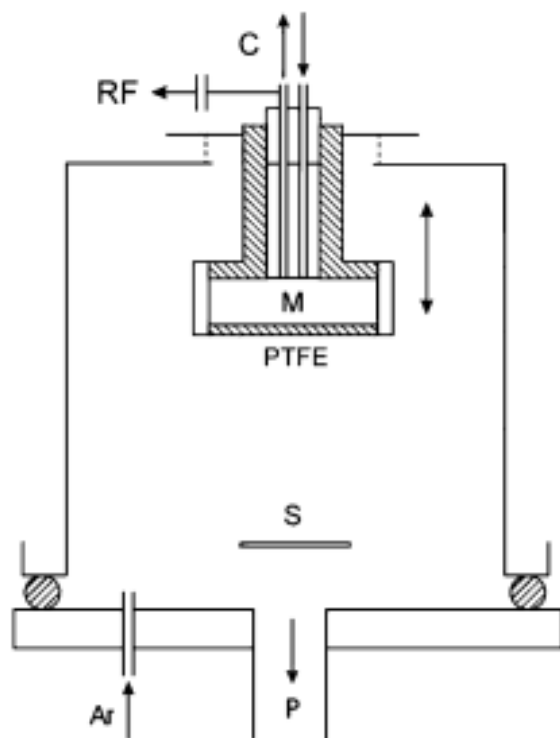


Figure 1. Schematic drawing of the vacuum deposition chamber. Ar – inlet of working gas (argon), C – magnetron water cooling, M – magnetron, P – to rotary and diffusion pumps, PTFE – polytetrafluoroethylene target, RF – to RF power source, S – substrate holder.

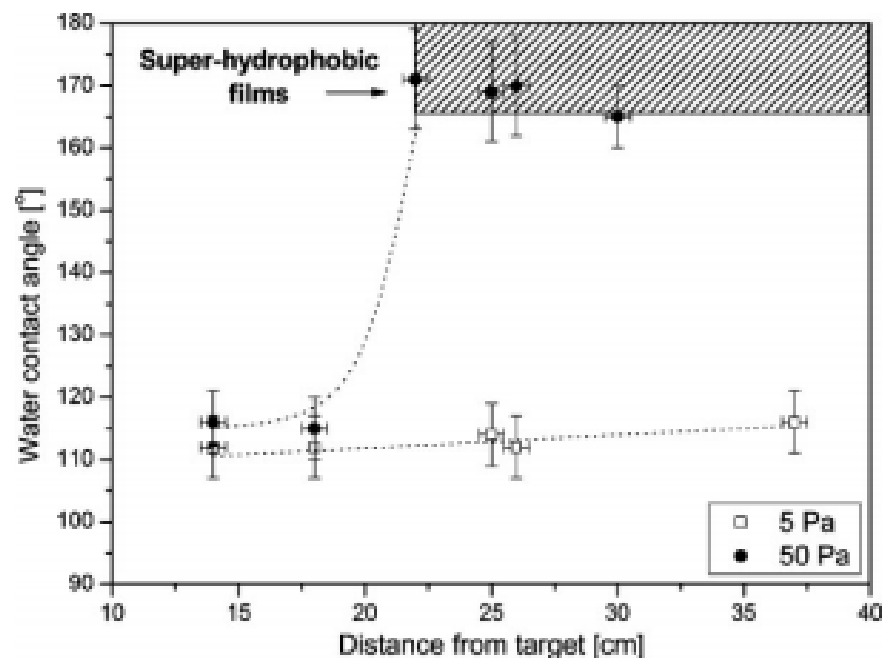


Figure 4. Variation in the static water contact angle of fluoro-carbon plasma polymer films with the substrate-target distance. Film thicknesses are about 70 nm.

Superhydrofobní vrstva

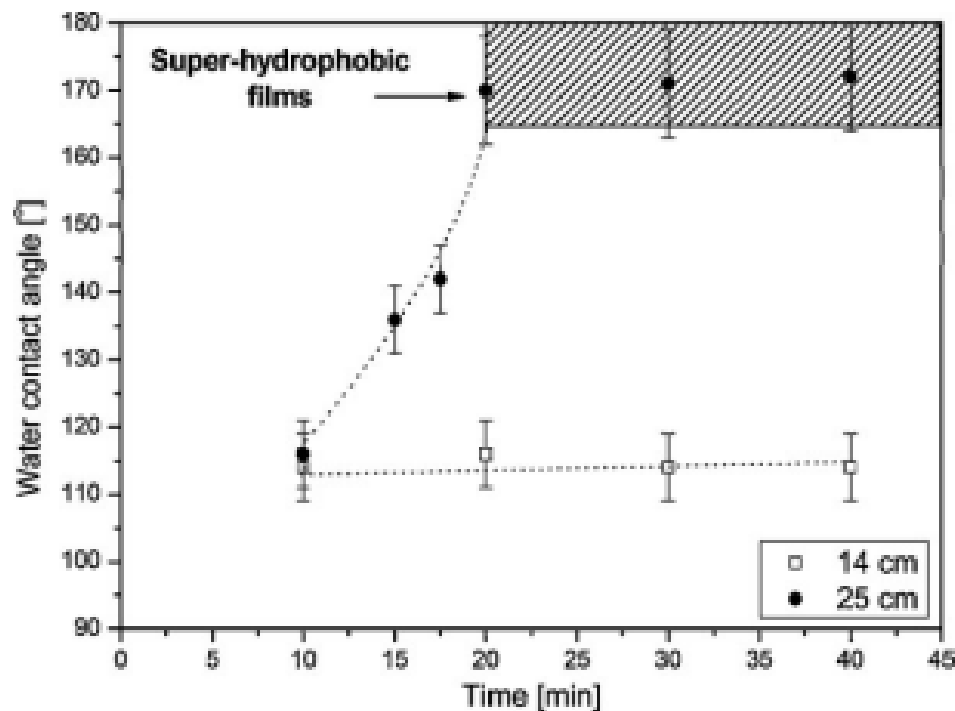


Figure 5. Water contact angle of fluorocarbon plasma polymer films as a function of the deposition time. Films were prepared at a working gas pressure of 50 Pa.

Superhydrofobní vrstva

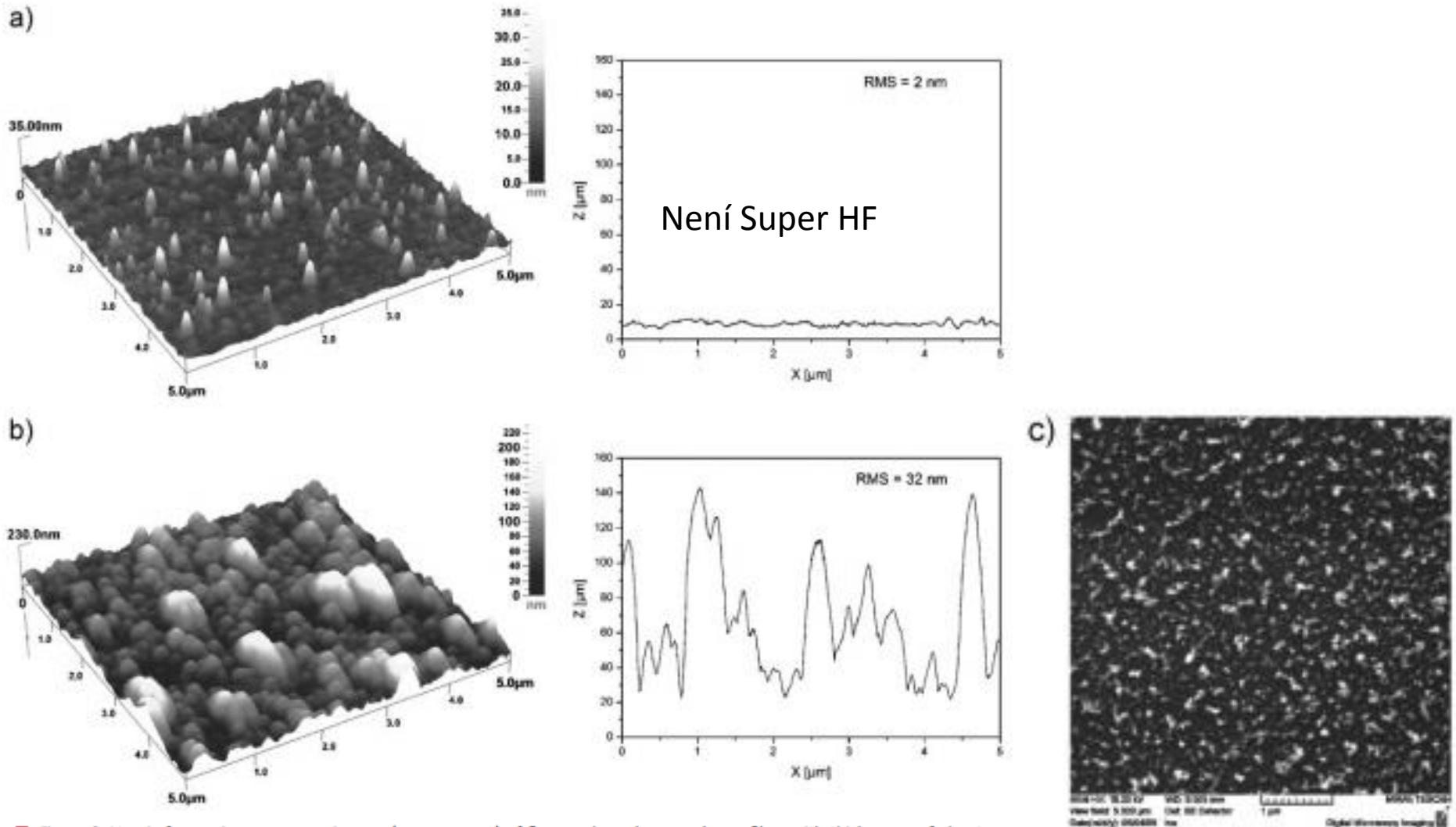
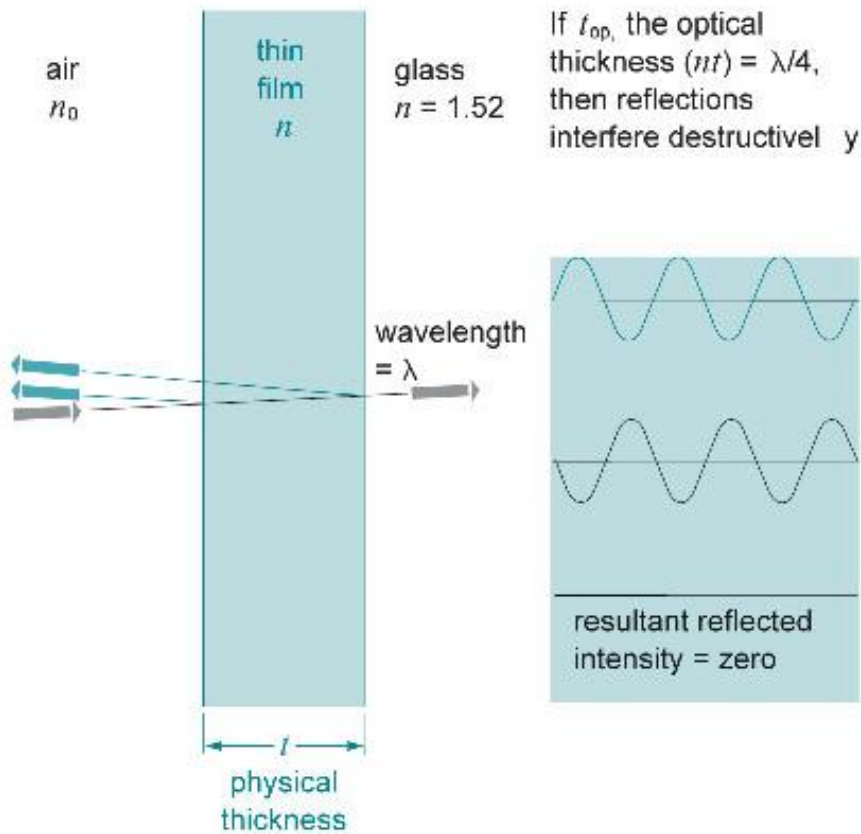


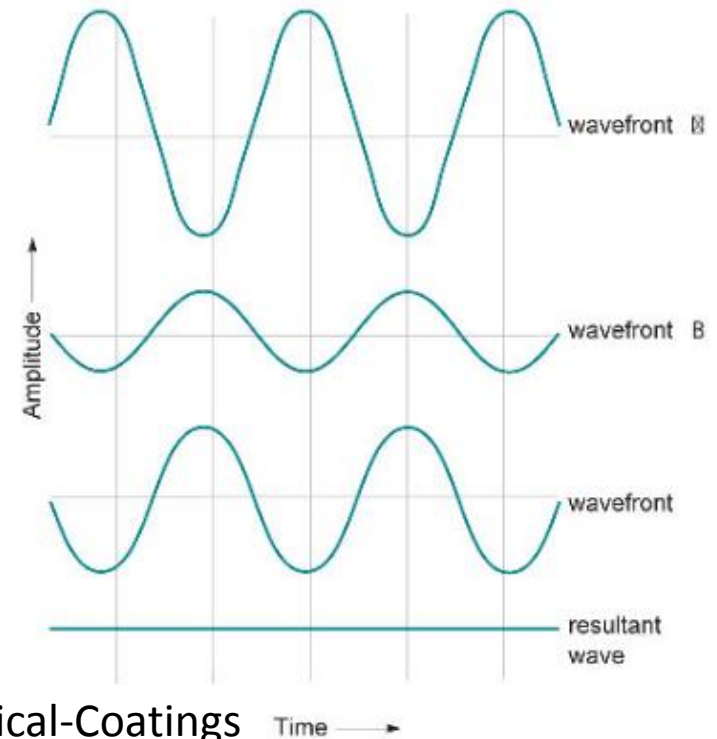
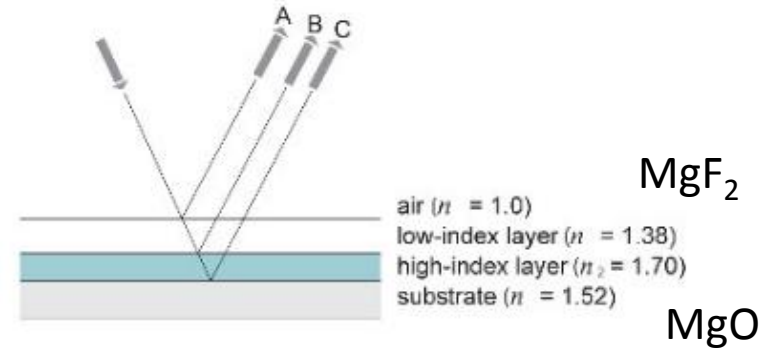
Figure 6. Atomic force microscope scan images ($5 \times 5 \mu\text{m}$ area) of fluorocarbon plasma polymer films with thicknesses of about 70 nm deposited at a working gas pressure of 50 Pa and at a different distance from target: a) 14 cm, b) 25 cm; together with c) SEM micrograph of sample from (b).

Antireflexní vrstva

Single-layer antireflection coatings are generally deposited with a thickness of $\lambda/4$, where λ is the desired wavelength for peak performance. The phase shift is 180 degrees (π radians), and the reflections are in a condition of exact destructive interference.

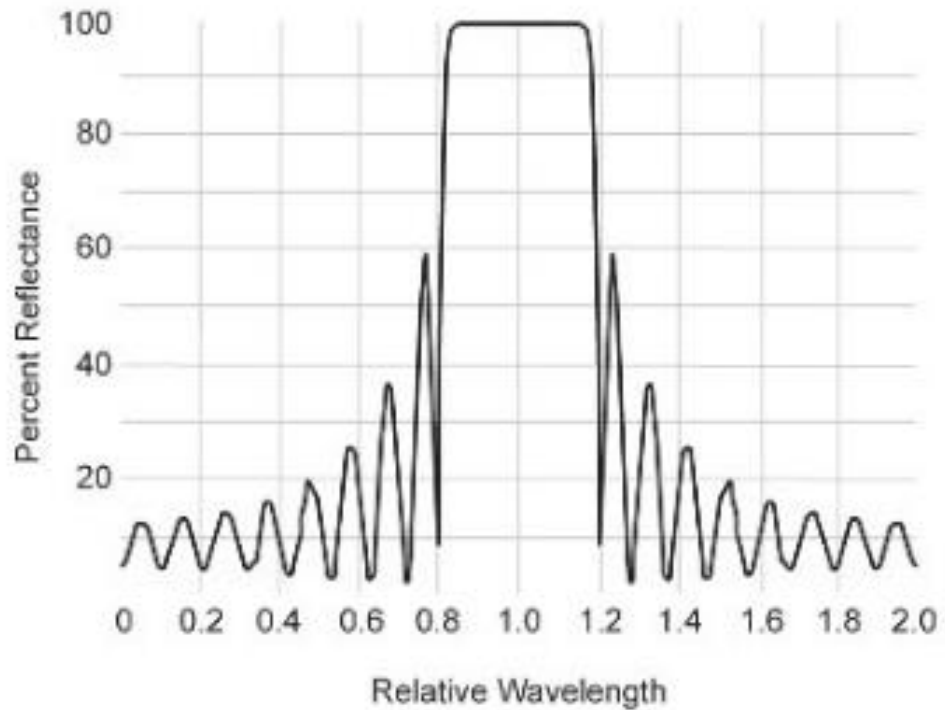


quarter/quarter antireflection coating



Vlnové délky

Jedno vrstvá jen na násobky jedné vlnové délky
Složitější systémy pak v nějakém „okně“



<http://cvilaseroptics.com/support/Technical-Library/Optical-Coatings>

Figure 5.17 Typical reflectance curve of an unmodified quarter-wave stack