evropský sociální fond v ČR
EVROPSKÁ UNIE
MINISTERSTVO ŠKOLSTVÍ, MLÁDEŽE A TĚLOVÝCHOVY
OP Vzdělávání pro konkurenceschopnost
INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ

Nanotechnologie v praxi

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FACULTY OF MECHANICAL ENGINEERING
BRNO UNIVERSITY OF TECHNOLOGY

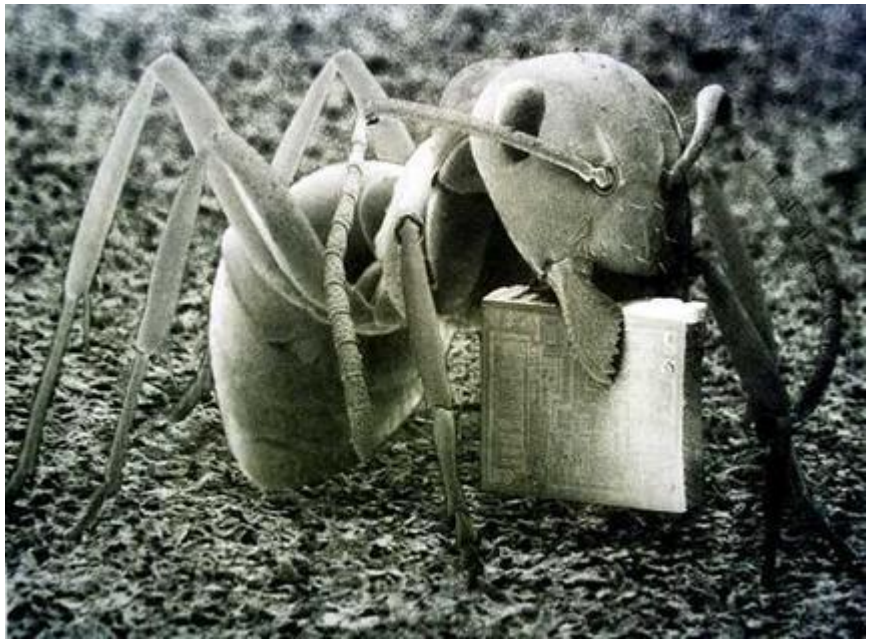
CEITEC
Central European Institute of Technology
BRNO | CZECH REPUBLIC

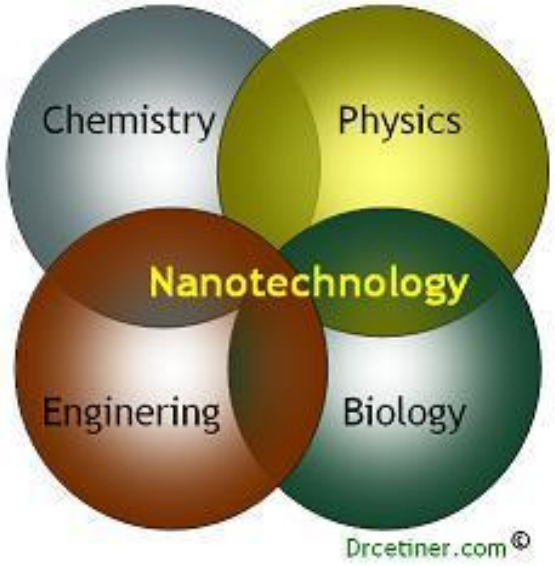
Obsah

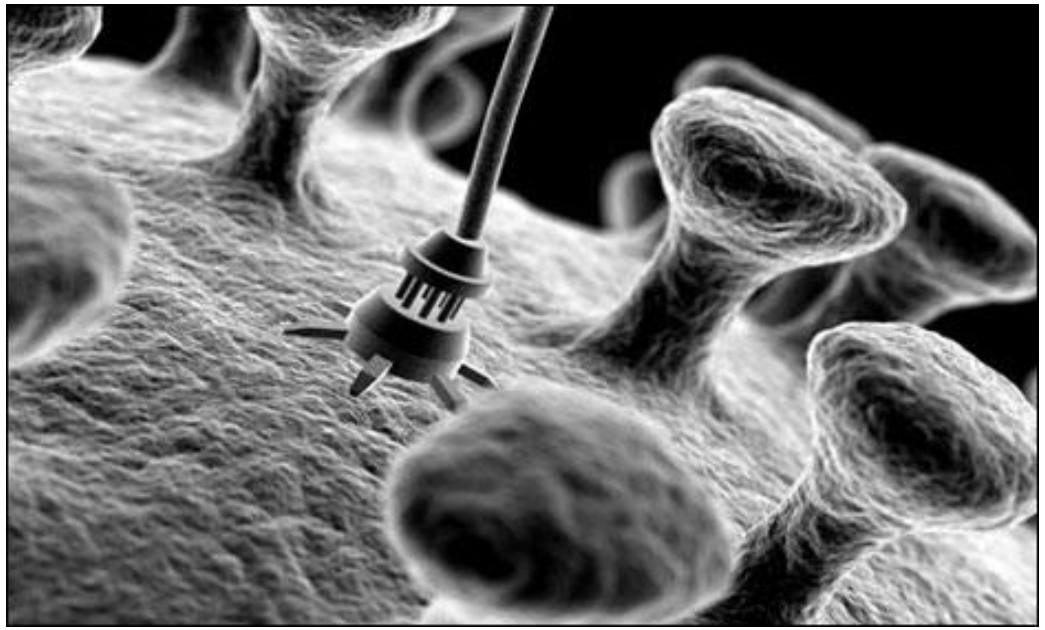
- Úvod a historie nanotechnologií
- Nanotechnologie v praxi a jejich aplikace
- Nanomateriály
- Nanoskopy a mikroskopy
- Výroba nanostruktur a jejich vlastnosti
- Budoucnost nanotechnologií

Nanotechnologie

- Nano - předpona 0,000 000 001 (10^{-9})
- Technologie – tvorba a zdokonalovaní výrobních procesů



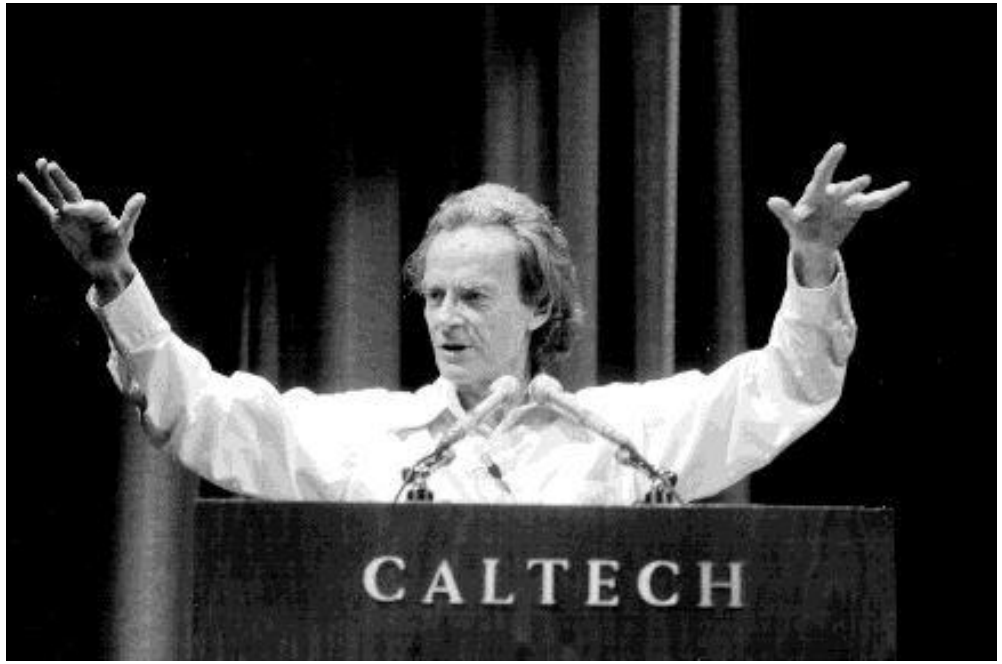


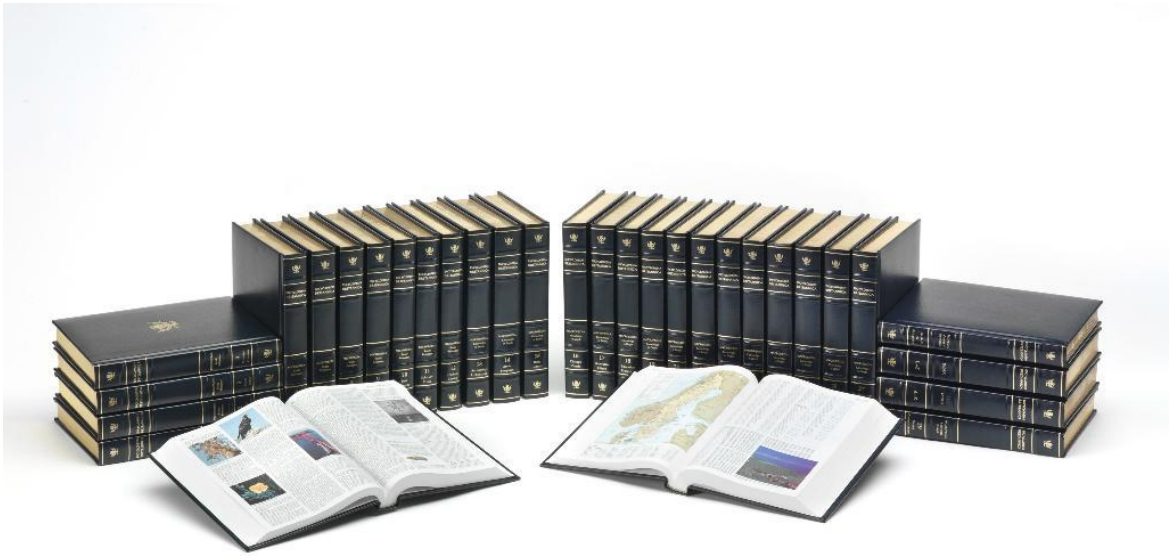


Zdroj: *www.fei.com*

Tam dole je spousta místa

- Richard Feynman (29. 12. 1959) "*There's Plenty of Room at the Bottom*"



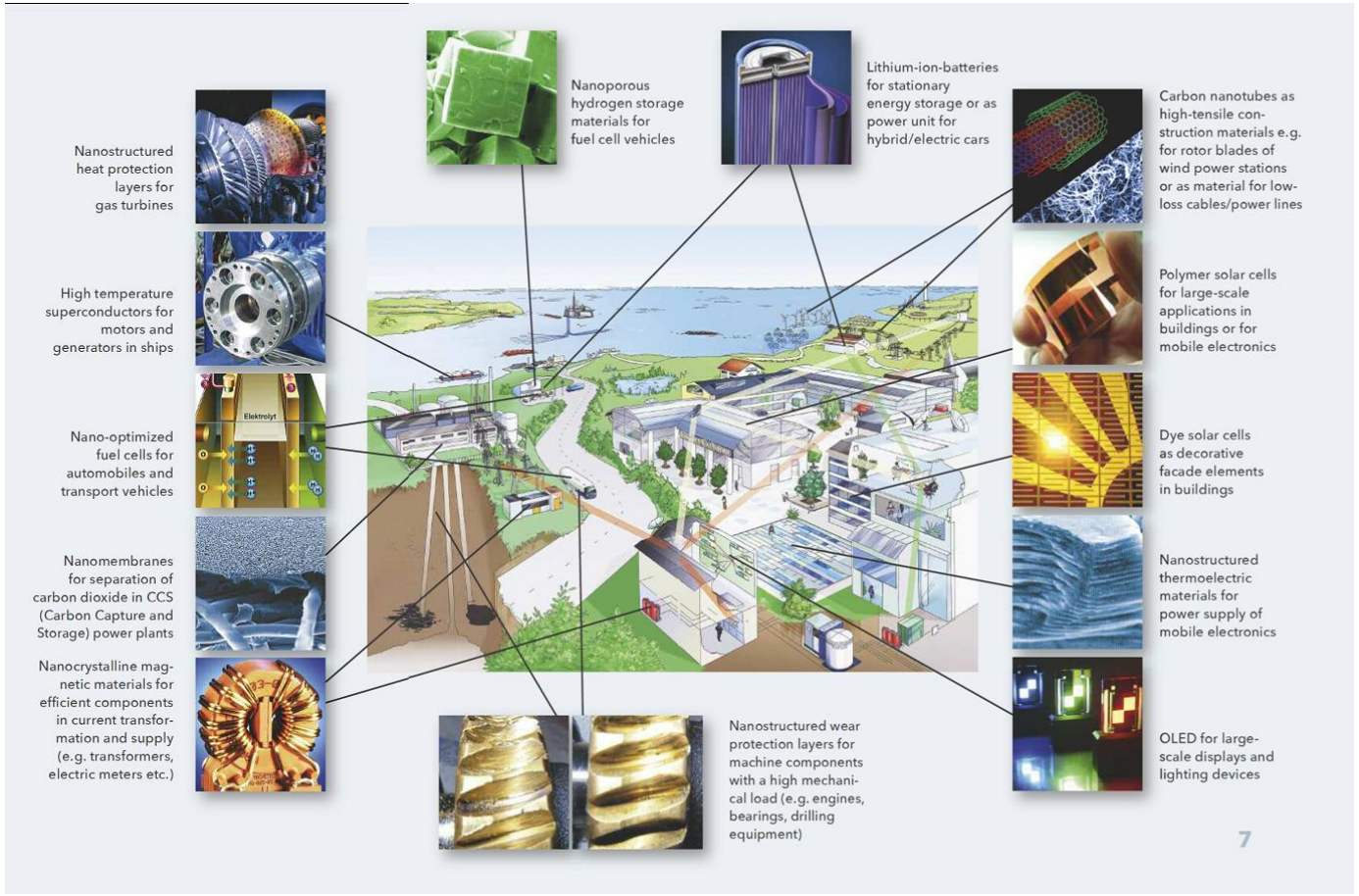


„Proč bychom nemohli zapsat na špendlíkovou hlavičku všech 24 dílů Encyklopedie Britanniky?".

Obsah

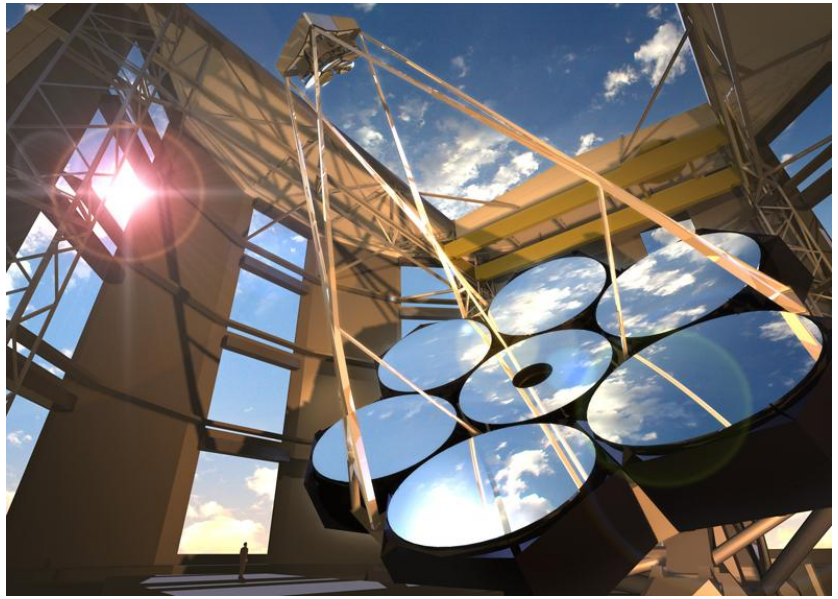
Využití nanotechnologií

- Elektronika
- Zdravotnictví
- Strojírenství
- Stavebnictví
- Chemický průmysl
- Textilní průmysl
- Optický průmysl
- Automobilový průmysl
- Energetika
- Ochrana prostředí
- **Astronomie**



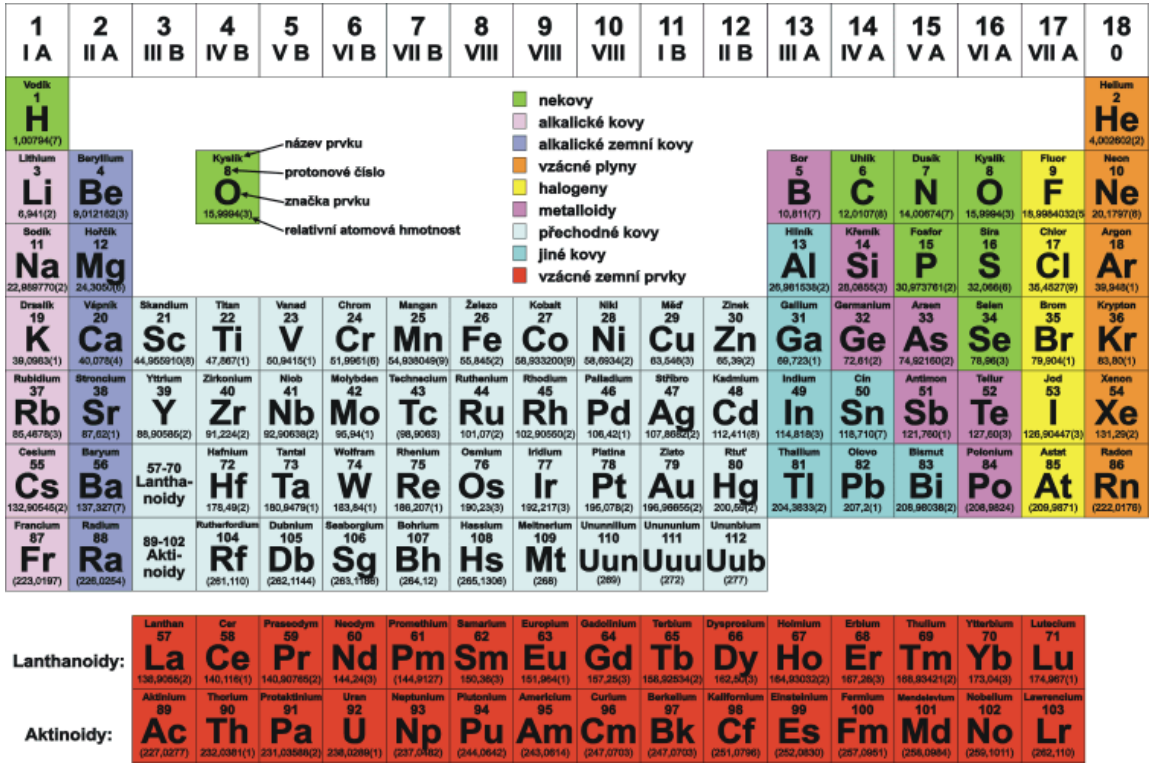
Nanotechnologie v astronomii

- Iontové leštění a pokovování zrcadel, adaptivní optika
- Kosmonautika - materiálový výzkum, vakuová a raketová technika
- IT technika a numerické simulace
- Mikroskopické a spektroskopické metody, CCD detektory



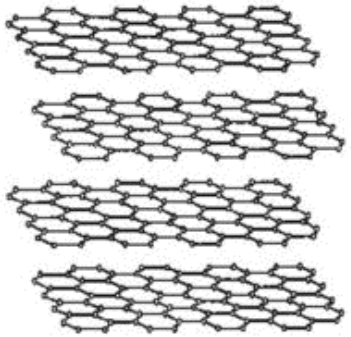
Obsah

Substrát

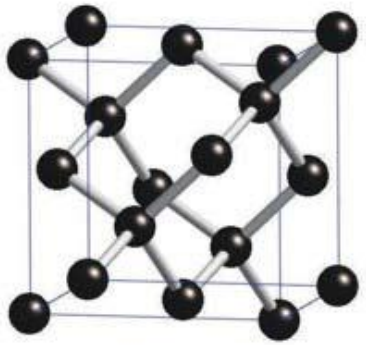

1 I A
2 II A
3 III B
4 IV B
5 V B
6 VI B
7 VII B
8 VIII
9 VIII
10 VIII
11 I B
12 II B
13 III A
14 IV A
15 V A
16 VI A
17 VII A
18 0
nekovy
alkalické kovy
alkalické zemní kovy
vzácné plyny
halogeny
metalloidy
přechodné kovy
jiné kovy
vzácné zemní prvky
název prvku
protonové číslo
značka prvku
relativní atomová hmotnost
Lanthanoidy:
Aktinoidy:

Grafén

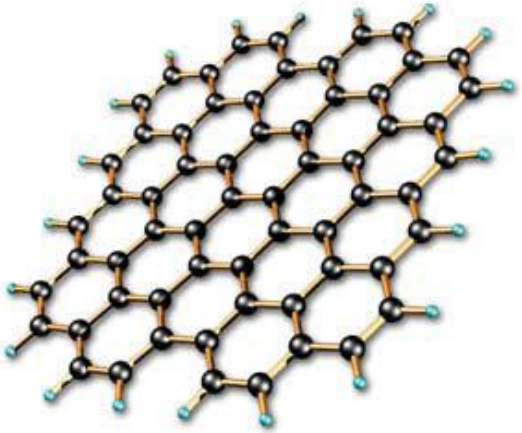
Grafit

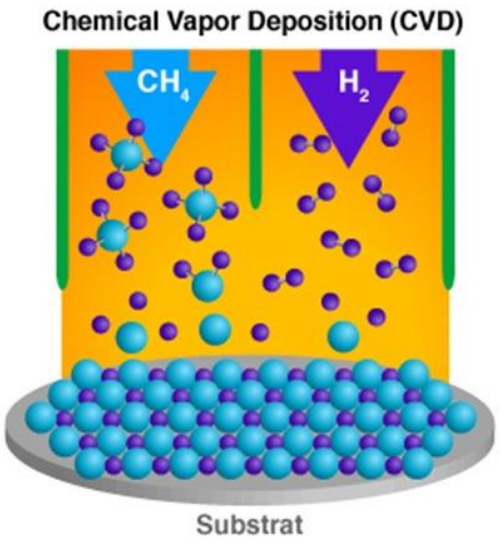


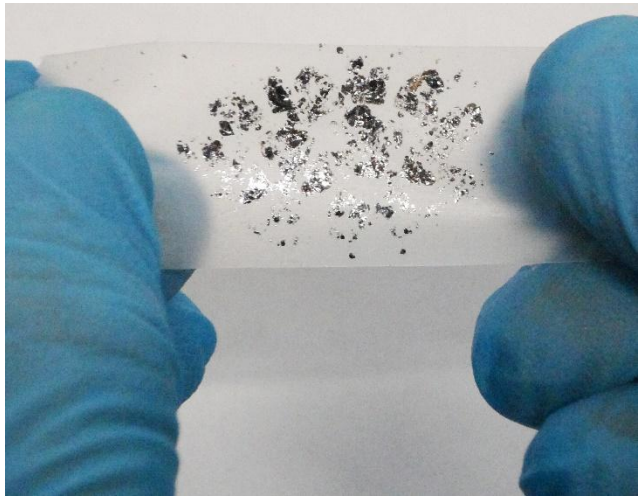
Diamant

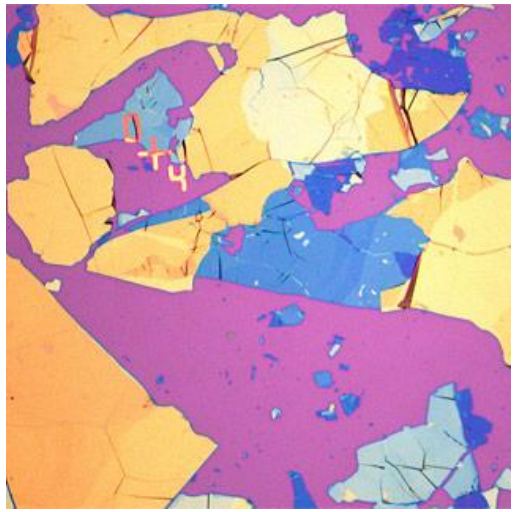


Grafén

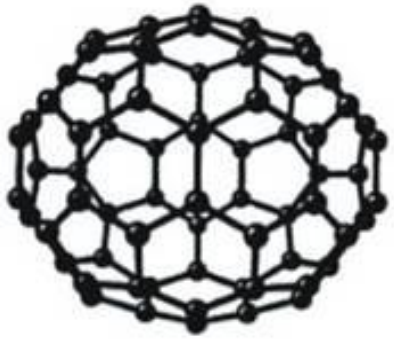


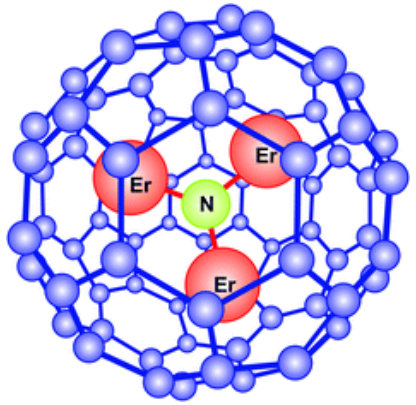


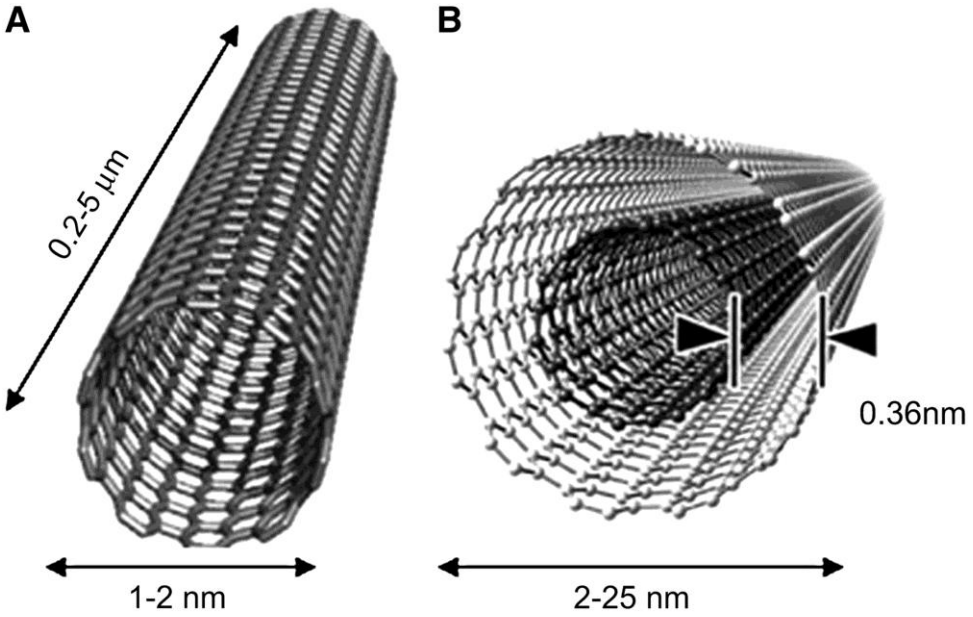


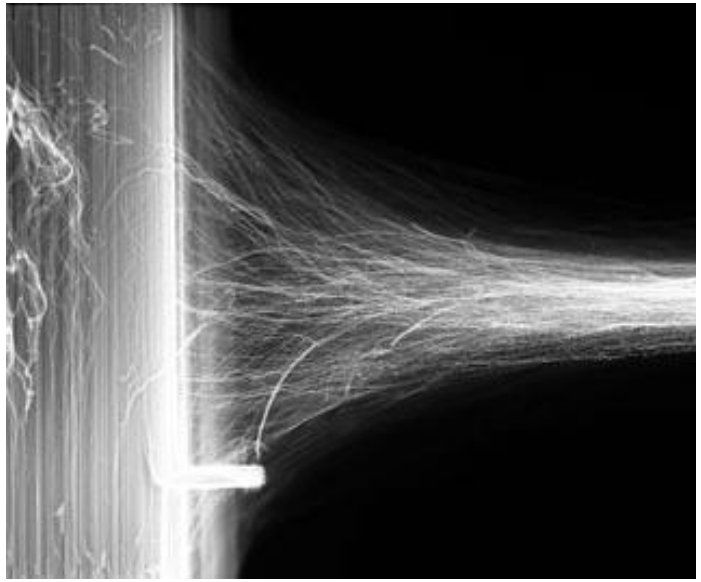


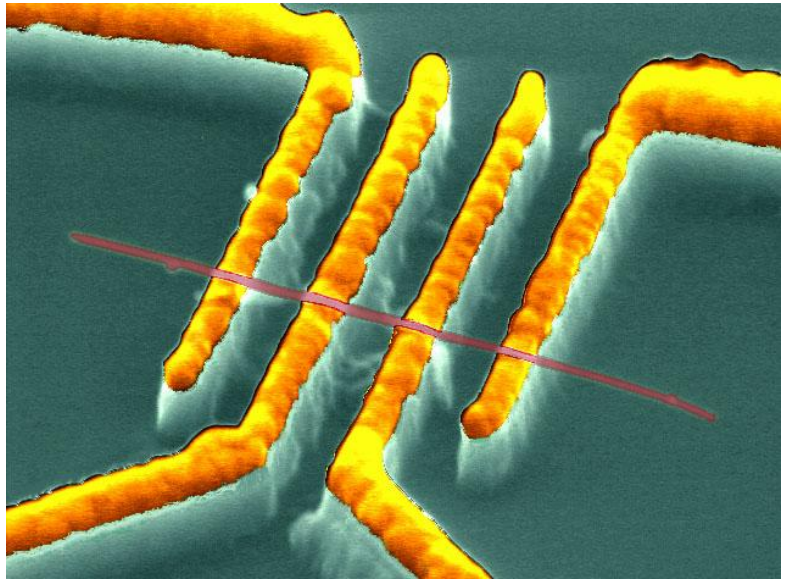
Fullaren & Nanotubes



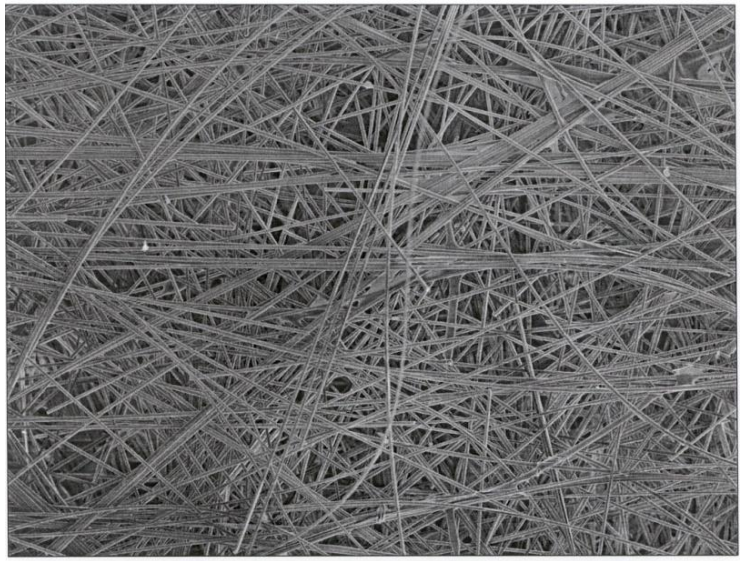


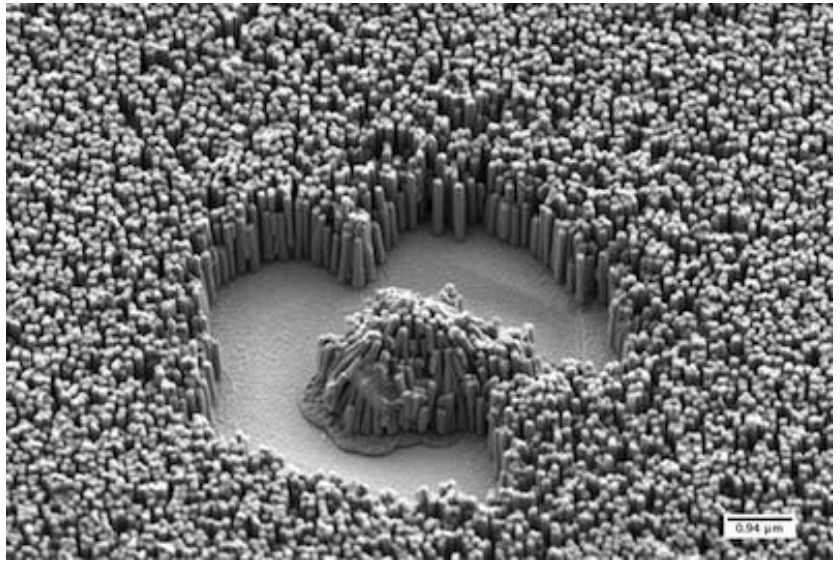


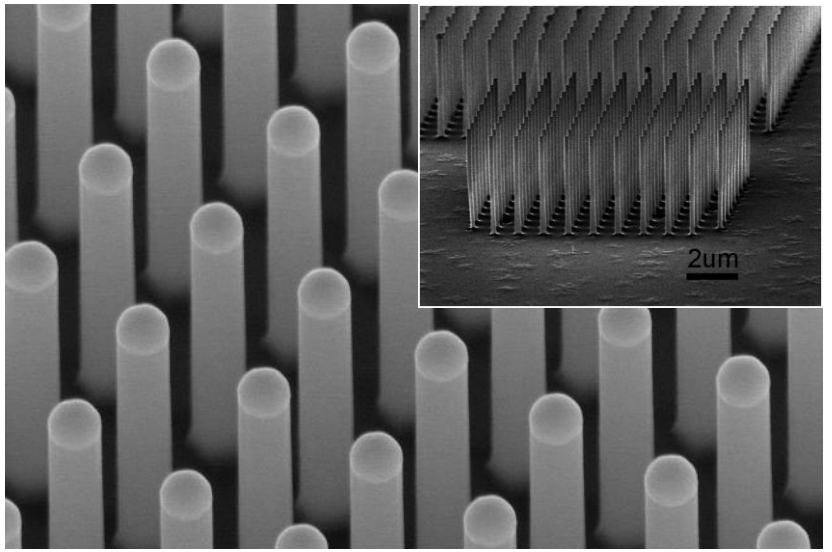


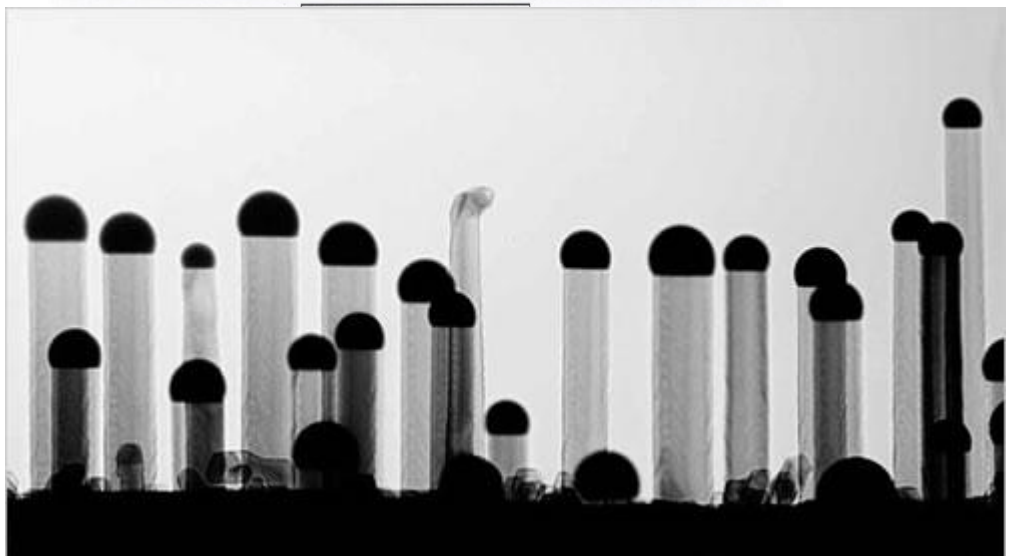


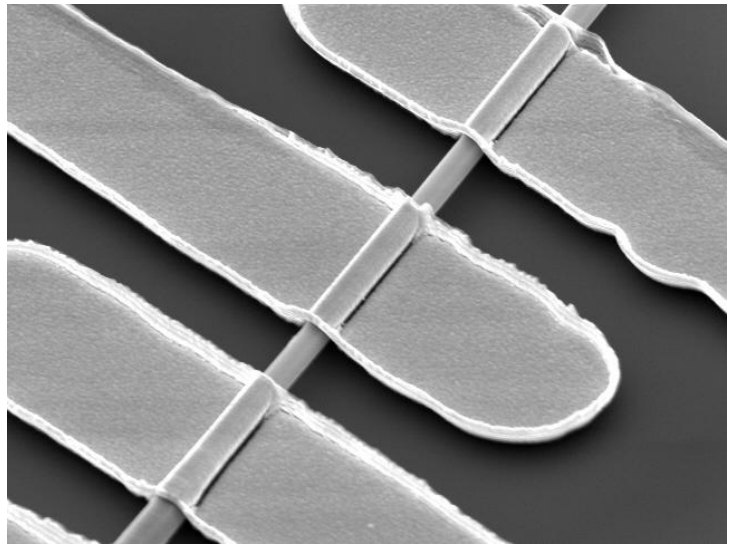
Nanodráty

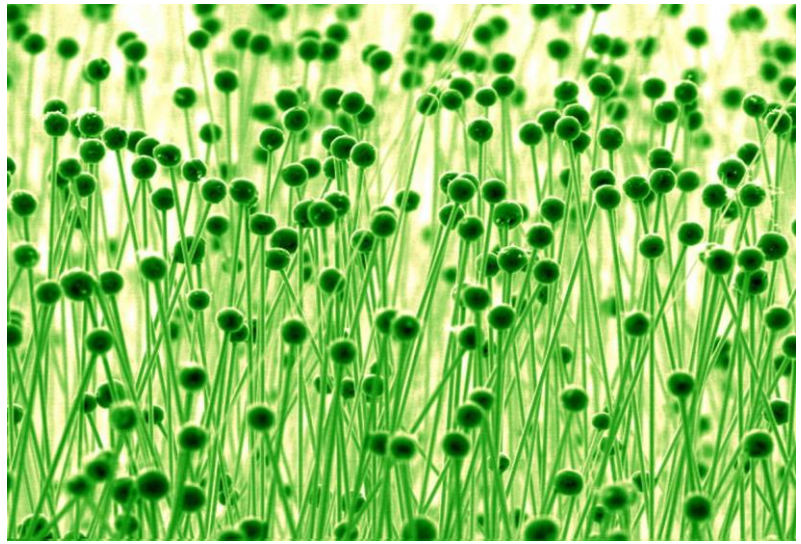




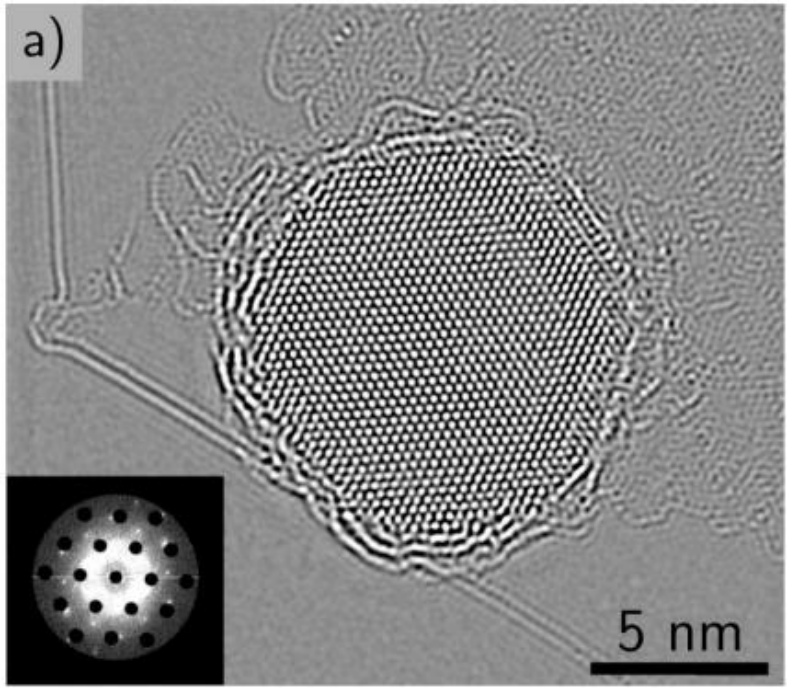


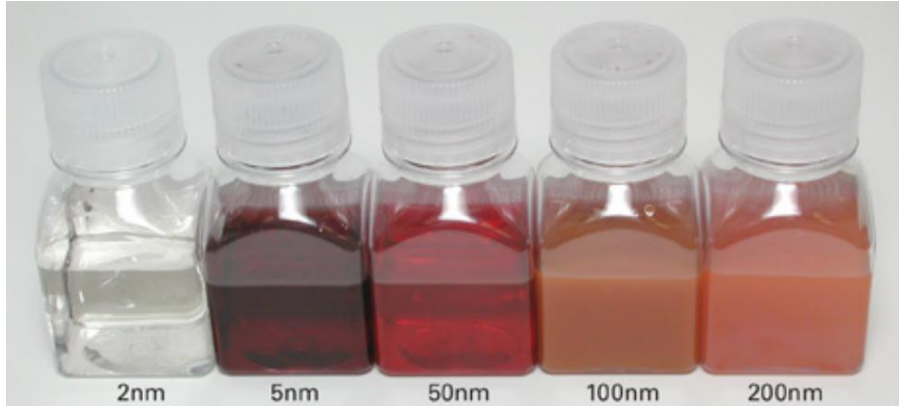


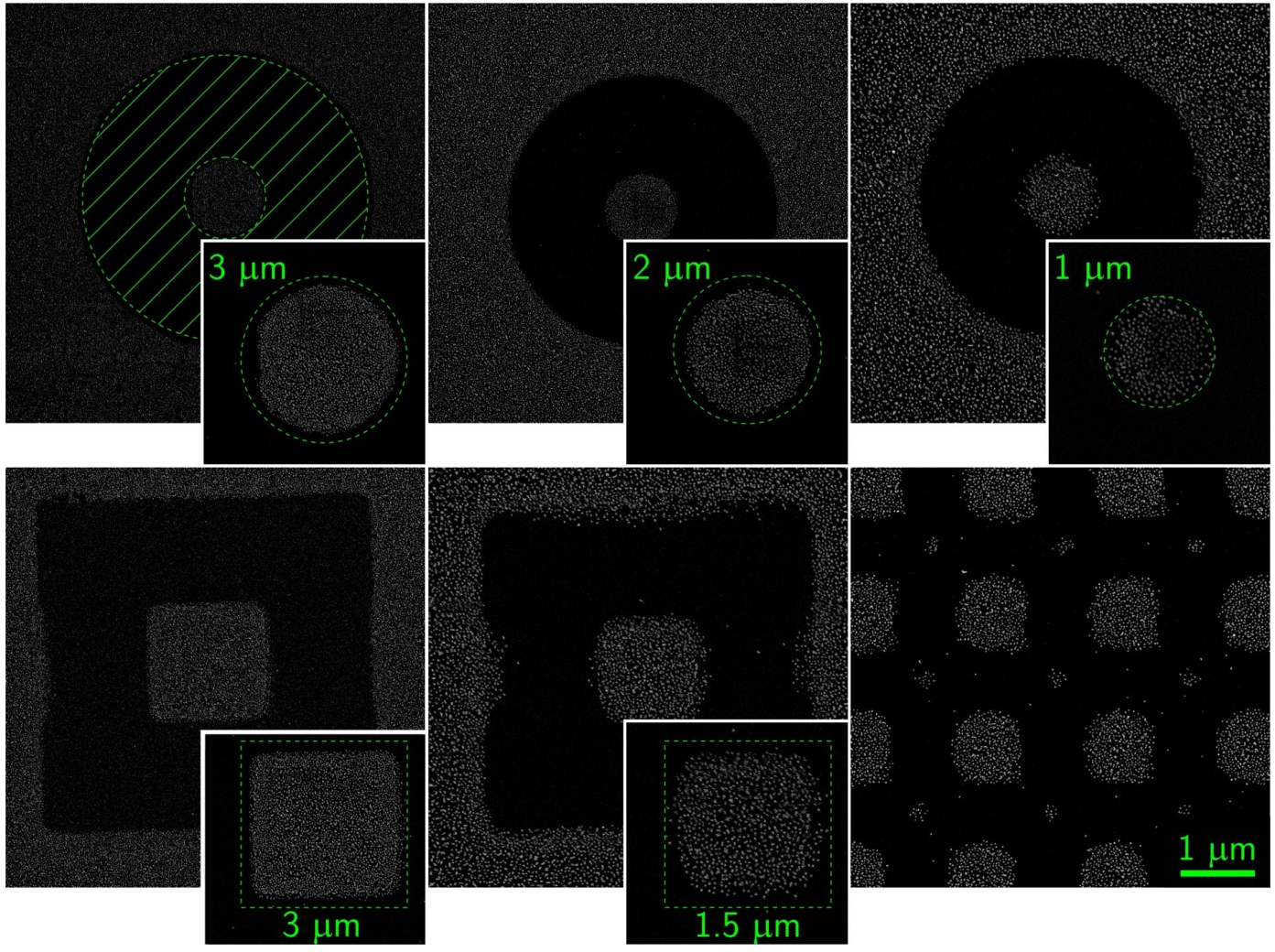




Koloidní roztoky



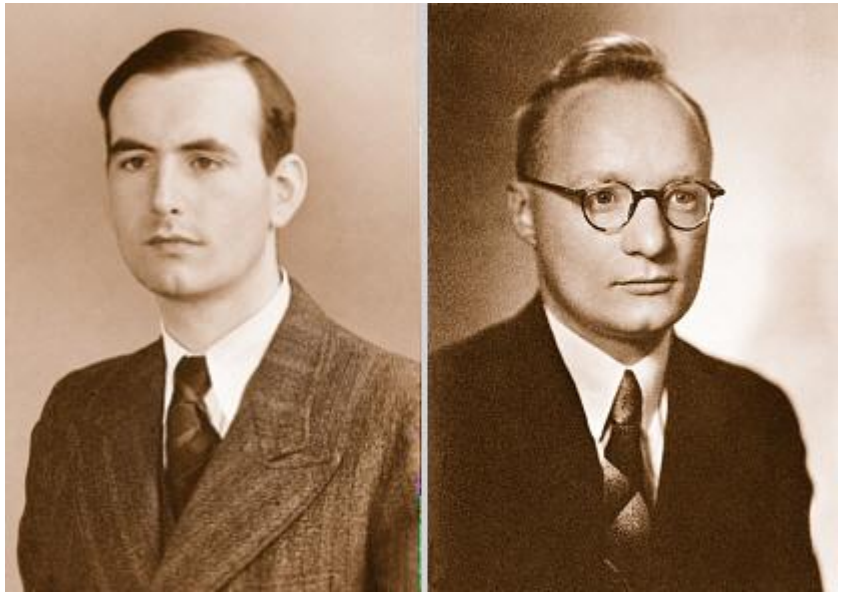


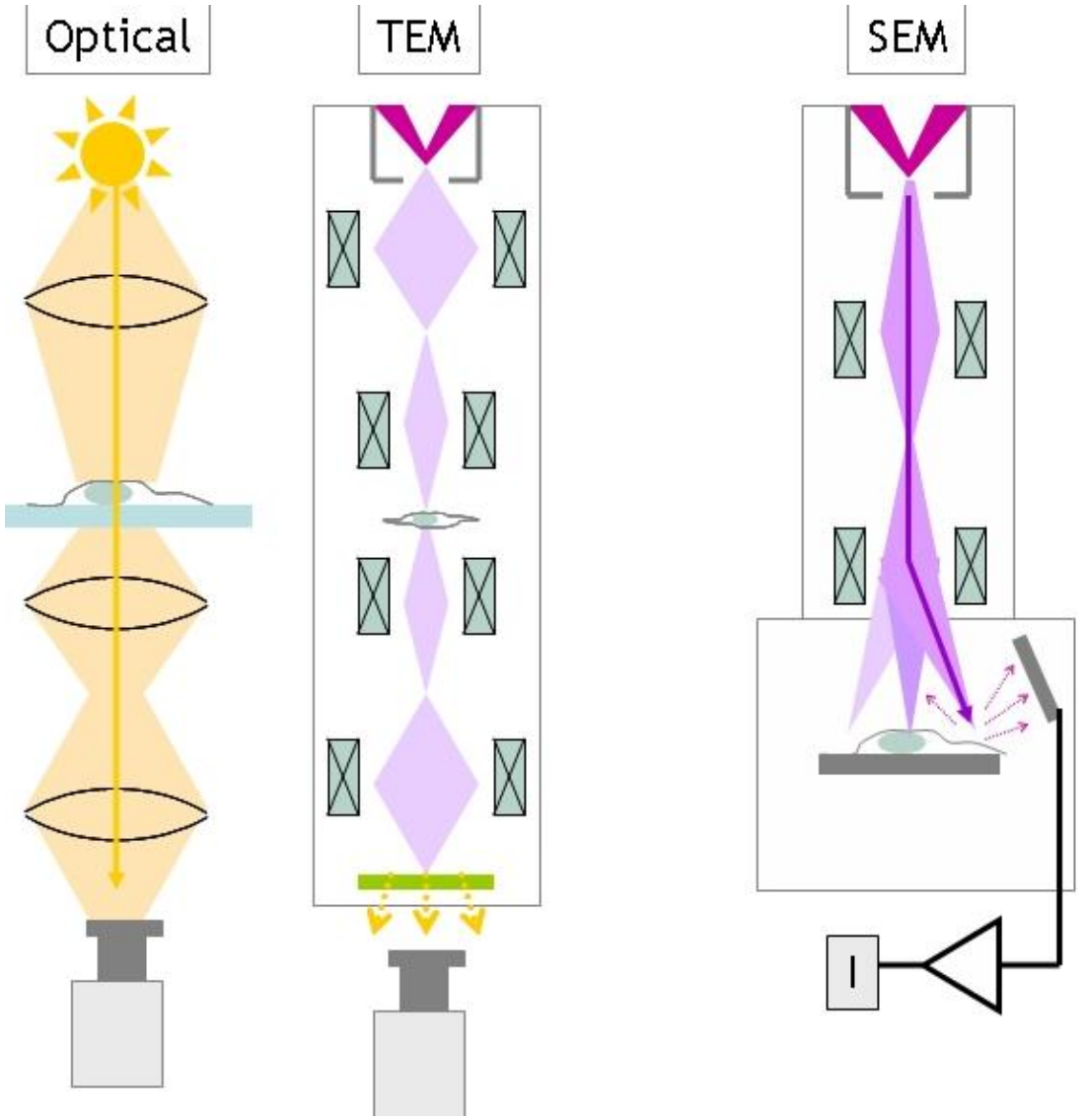


Obsah

Mikroskopy a Nanoskopy

- Elektronový mikroskop (1931 – 1933)
- Ernst Ruska, Max Knoll





Mikroskopy a Nanoskopy

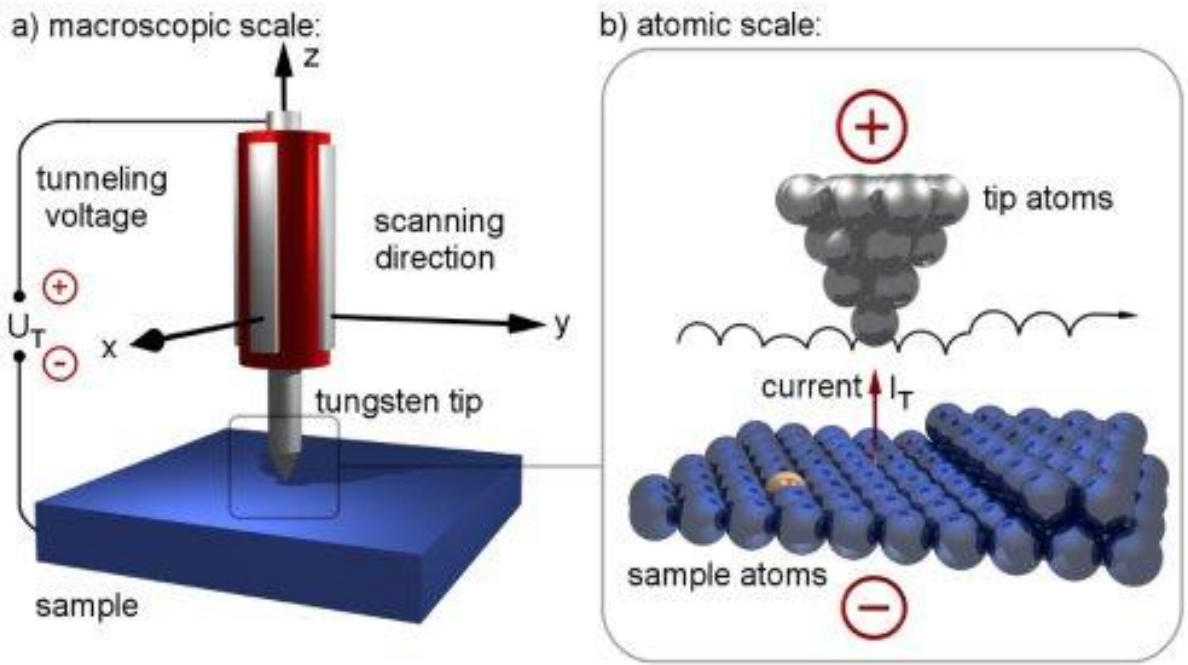
Tescan BS 242

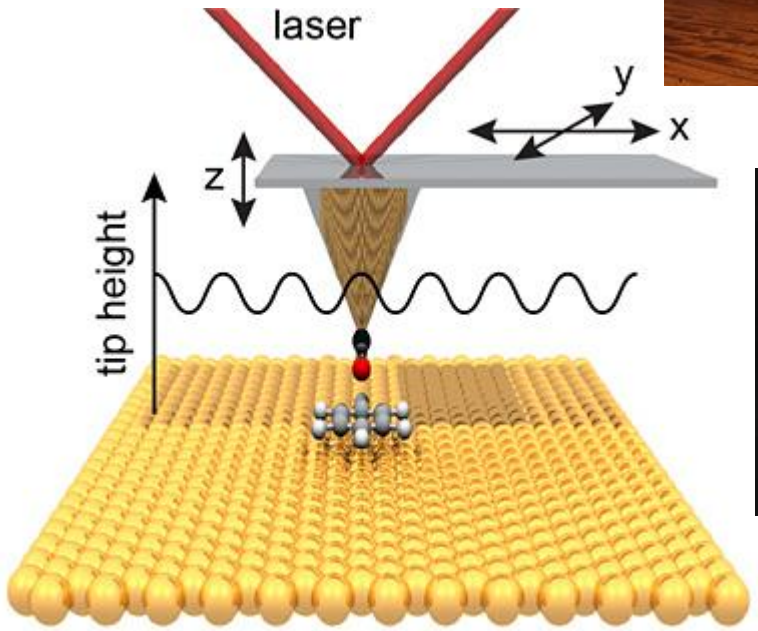
FEI Titan

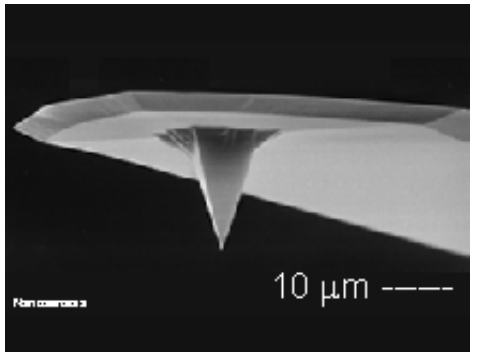
Tescan Lyra GM

Mikroskopy a Nanoskopy

- Rastrovací tunelovací mikroskop (STM)
- Mikroskop atomárních sil (AFM)

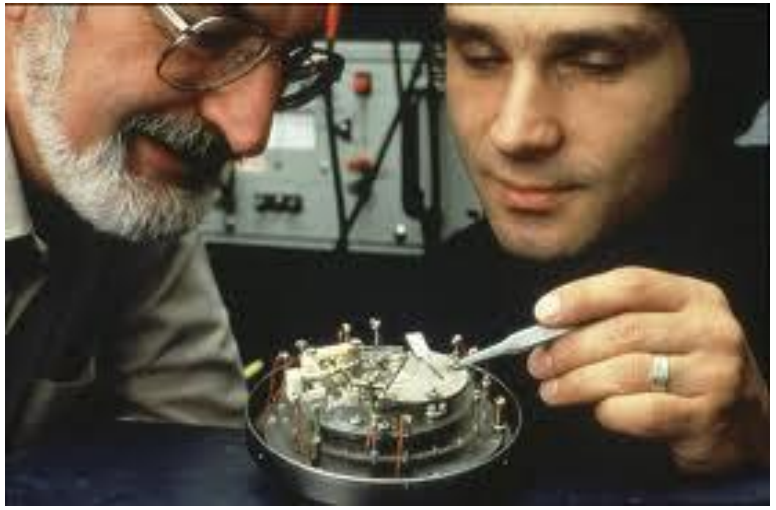


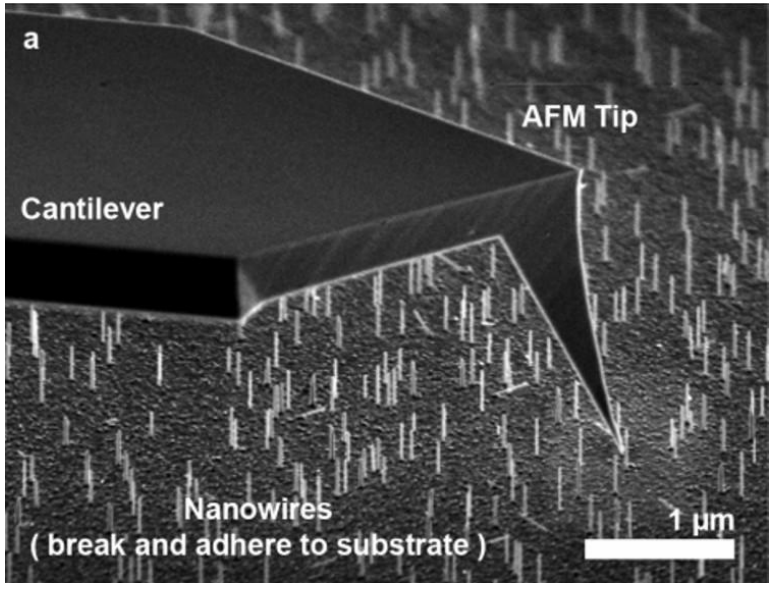


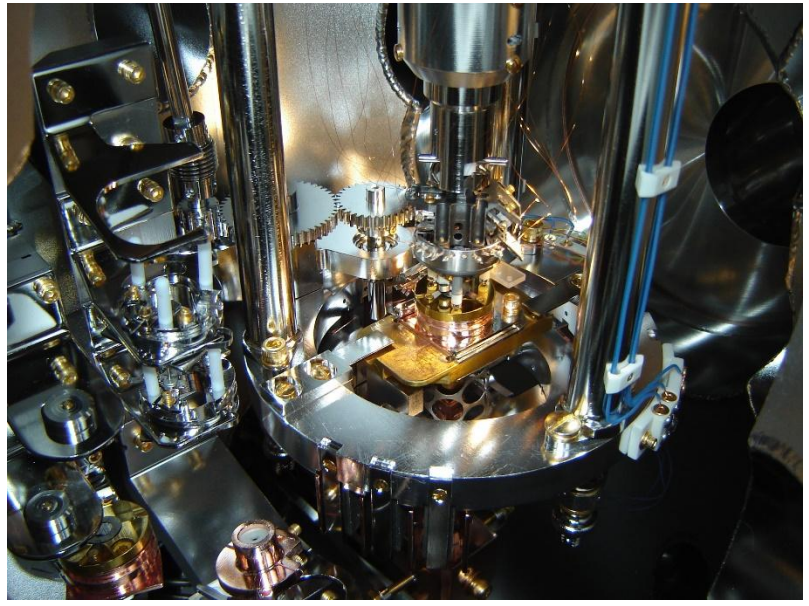


G. Binnig, H. Rohrer (1986). "Scanning tunneling microscopy". *IBM Journal of Research and Development* **30**: 4.

Mikroskopy a Nanoskopy



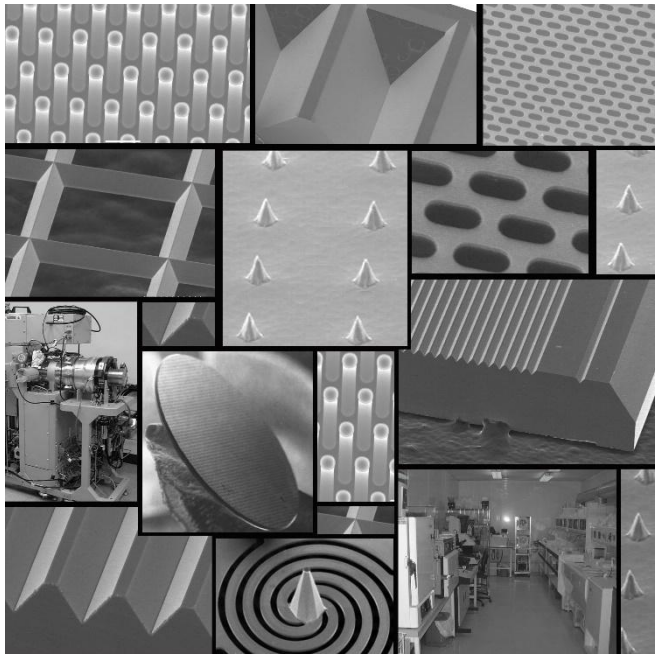


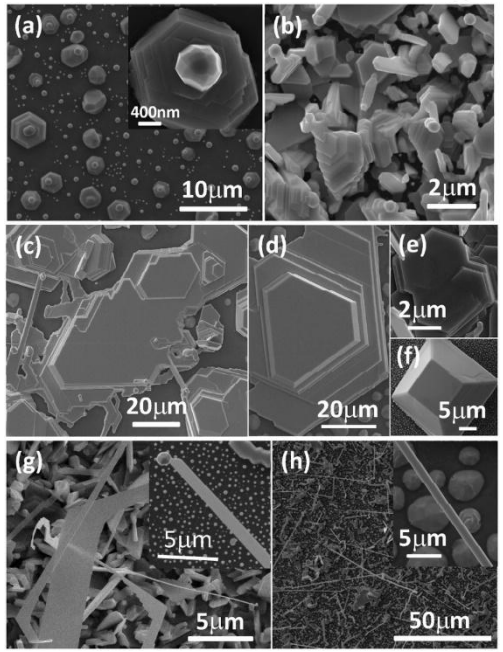


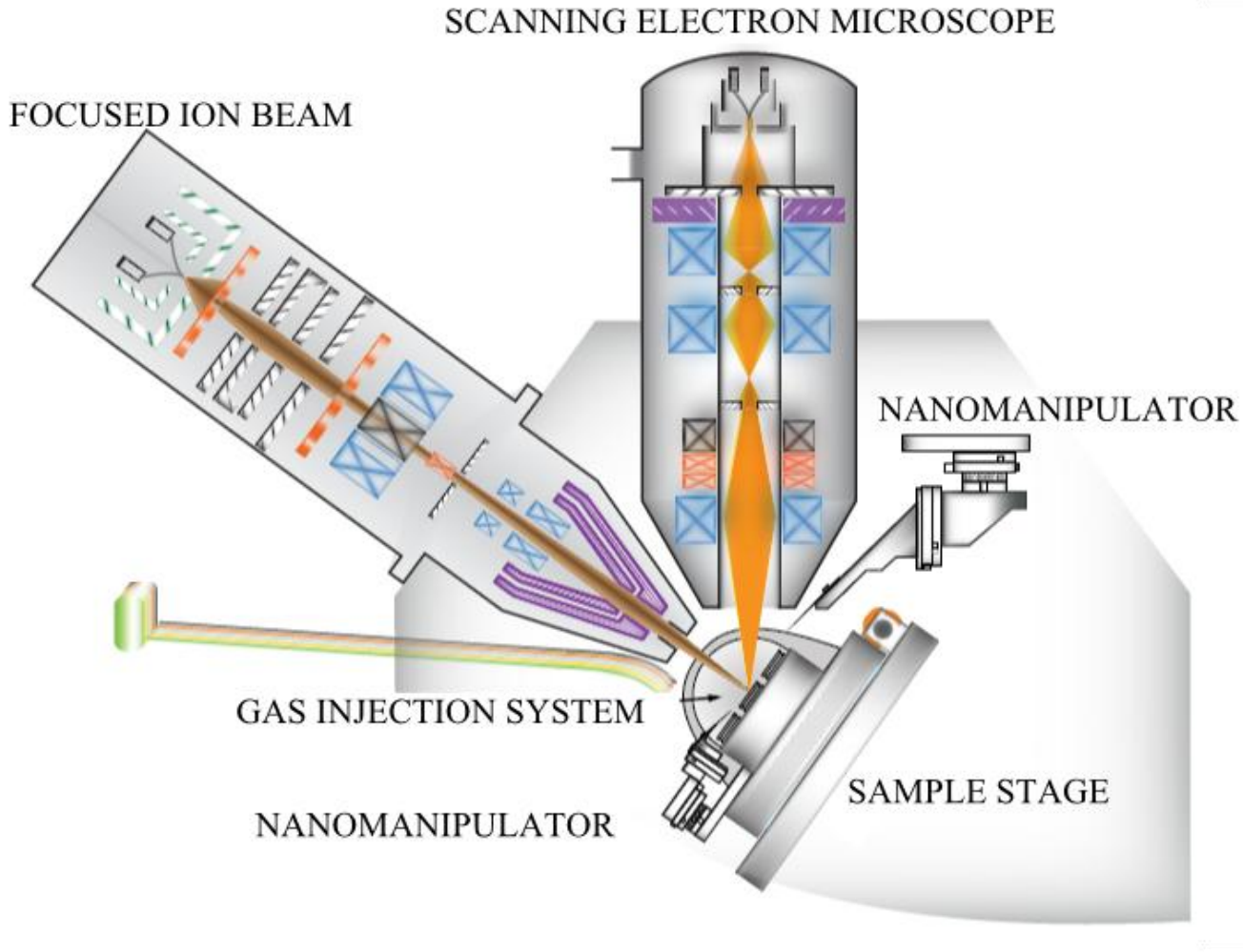
Obsah

Výroba nanostruktur

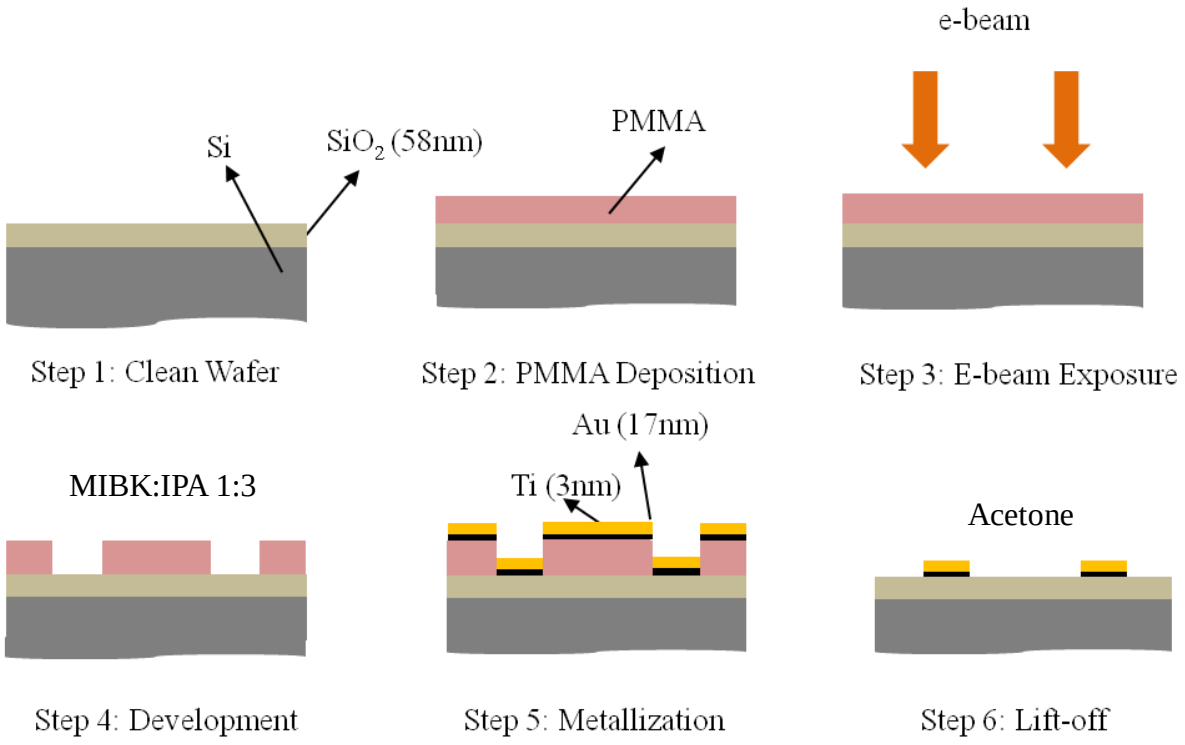
- Elektronová litografie
- Samouspořádávání
- Iontové leptání

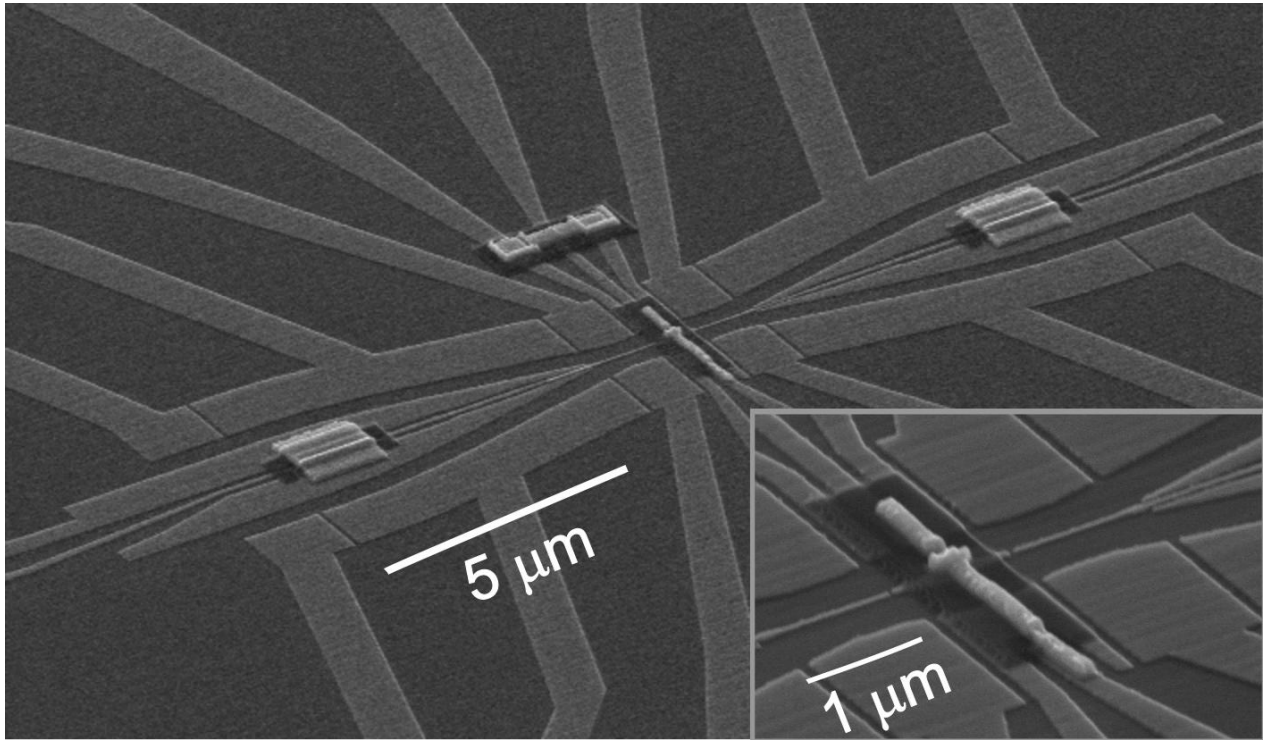




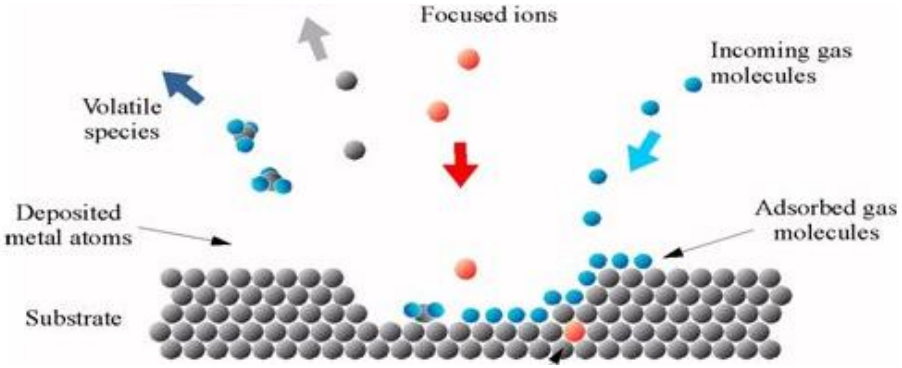


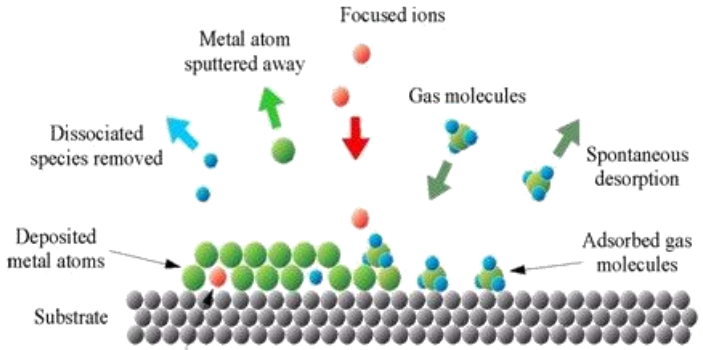
Elektronová litografie

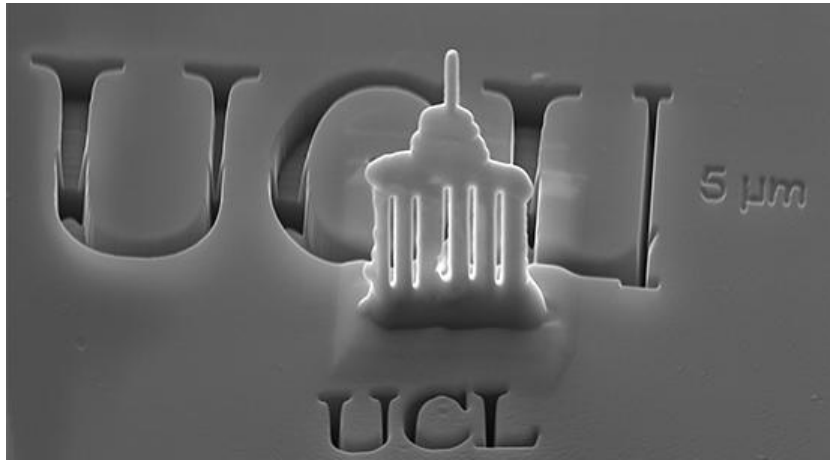


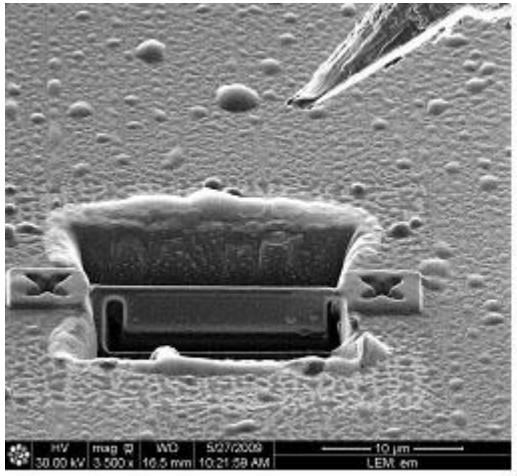


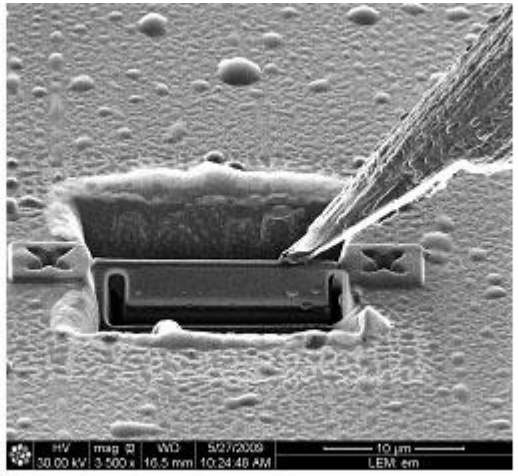
Fokusovaný iontový svazek

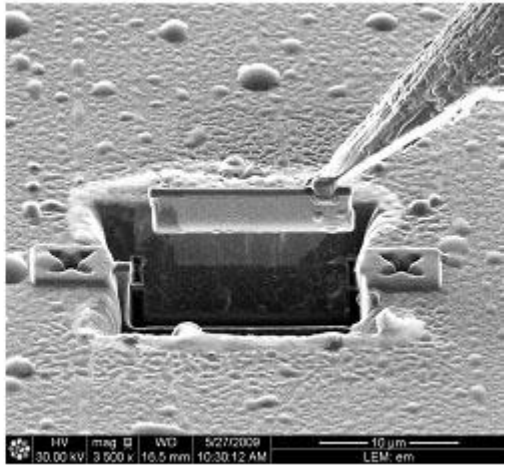


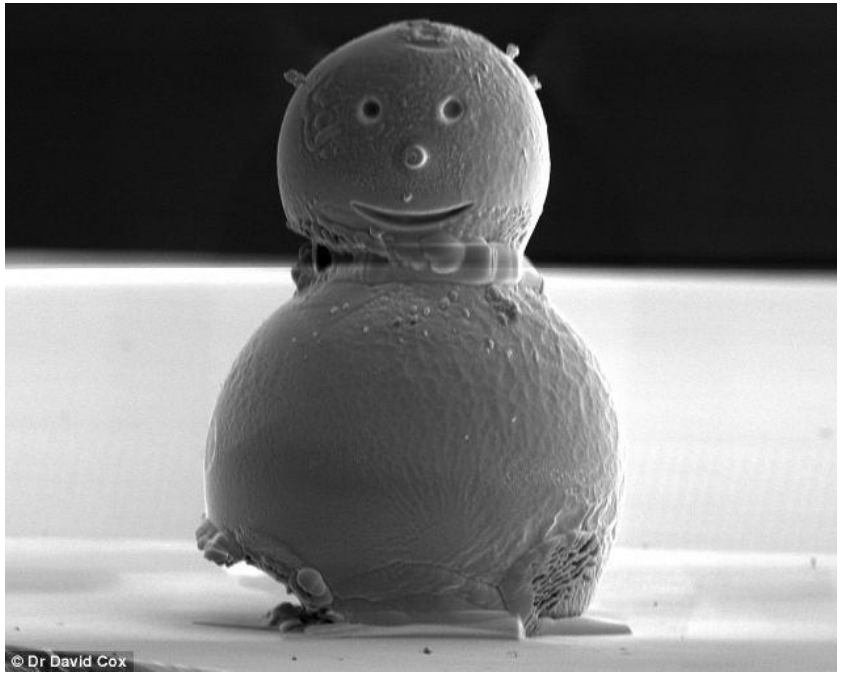




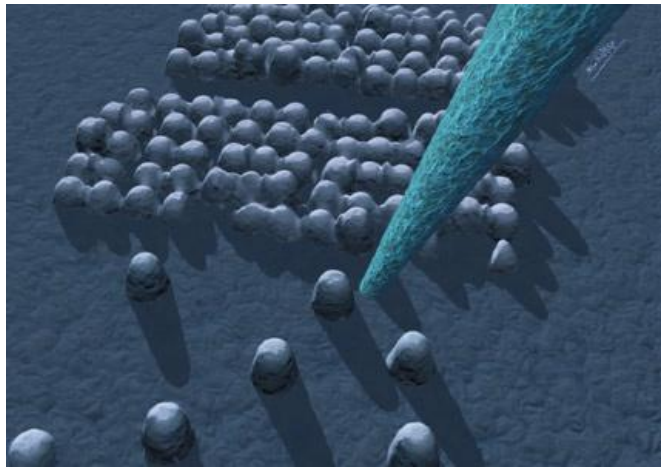


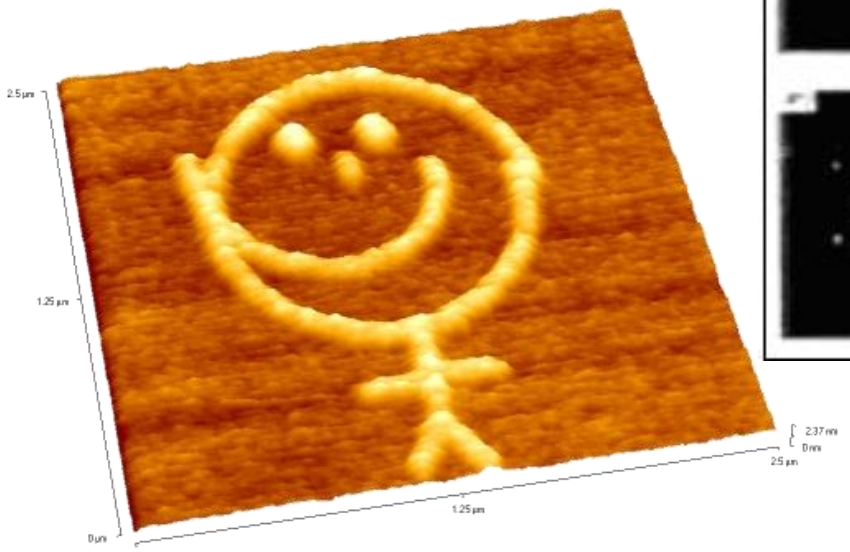


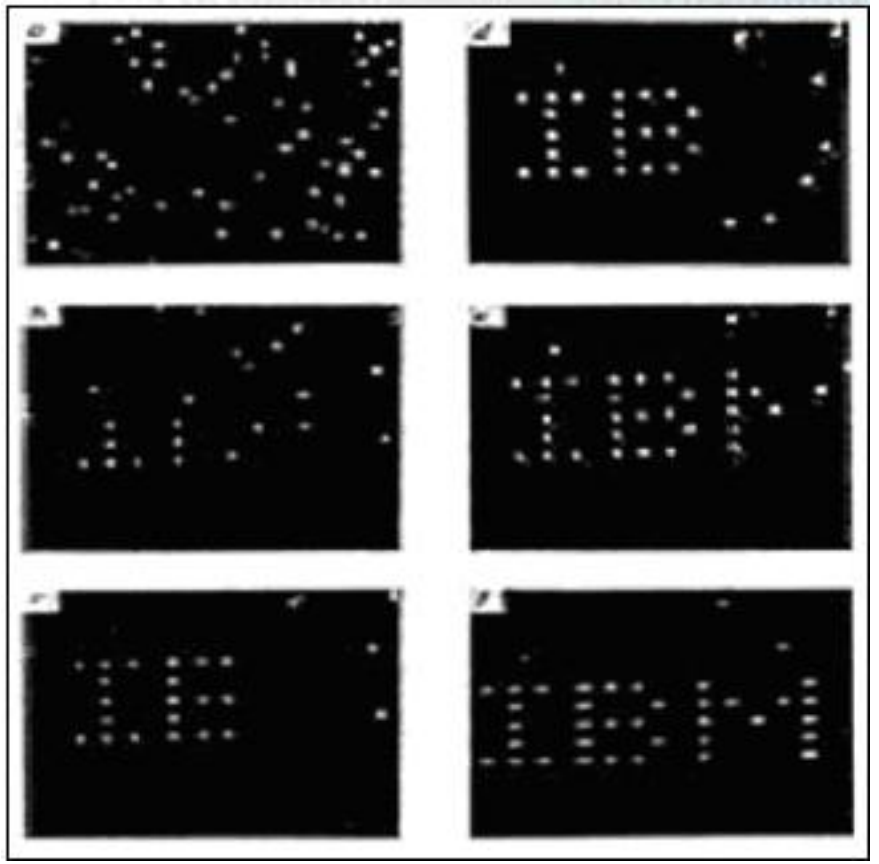




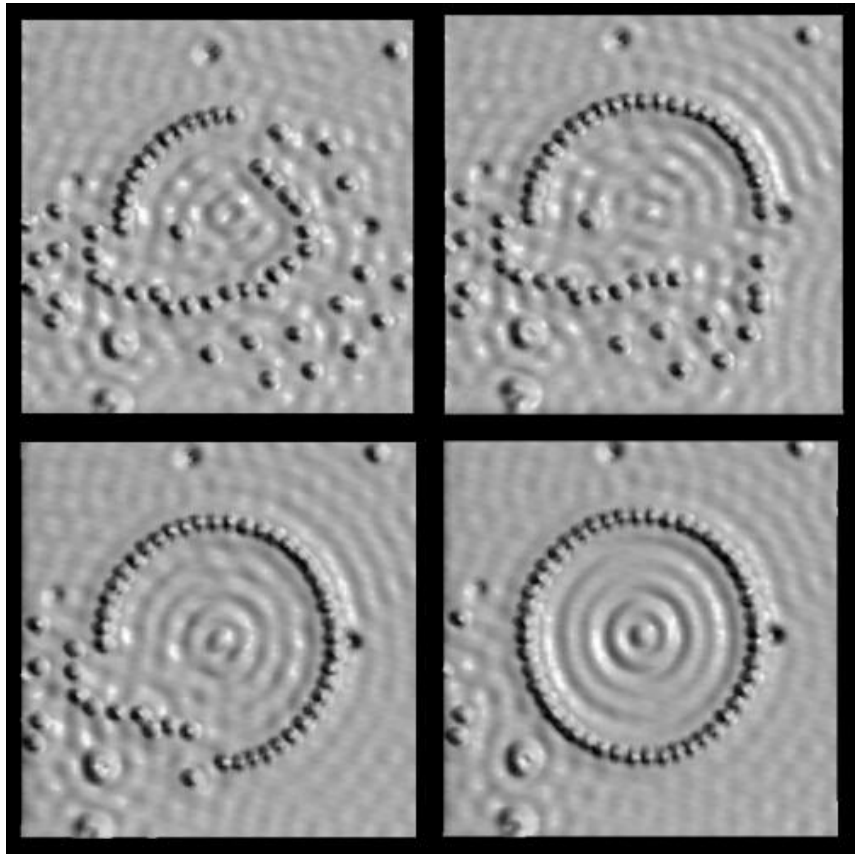
Hrotové metody





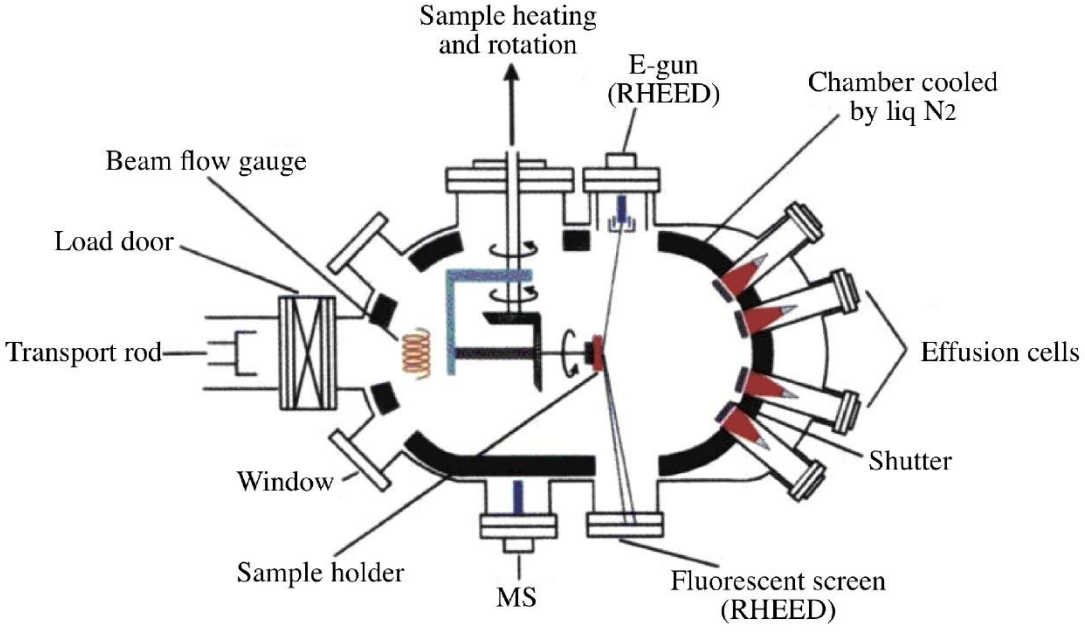


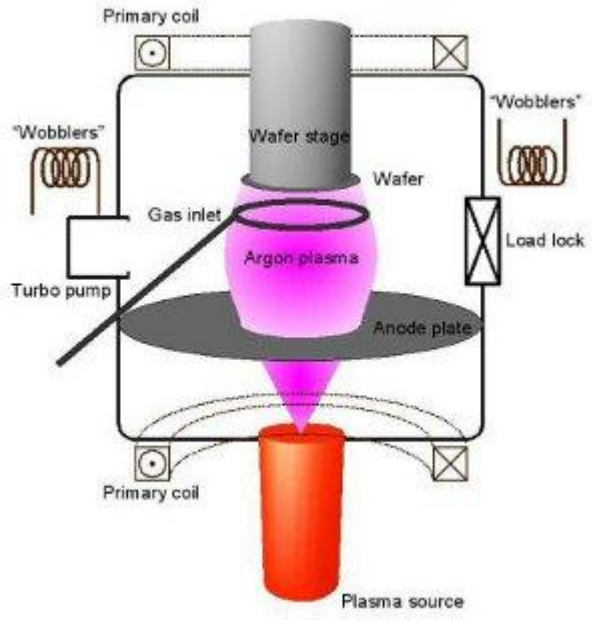
Xe atomy na Si substrátu

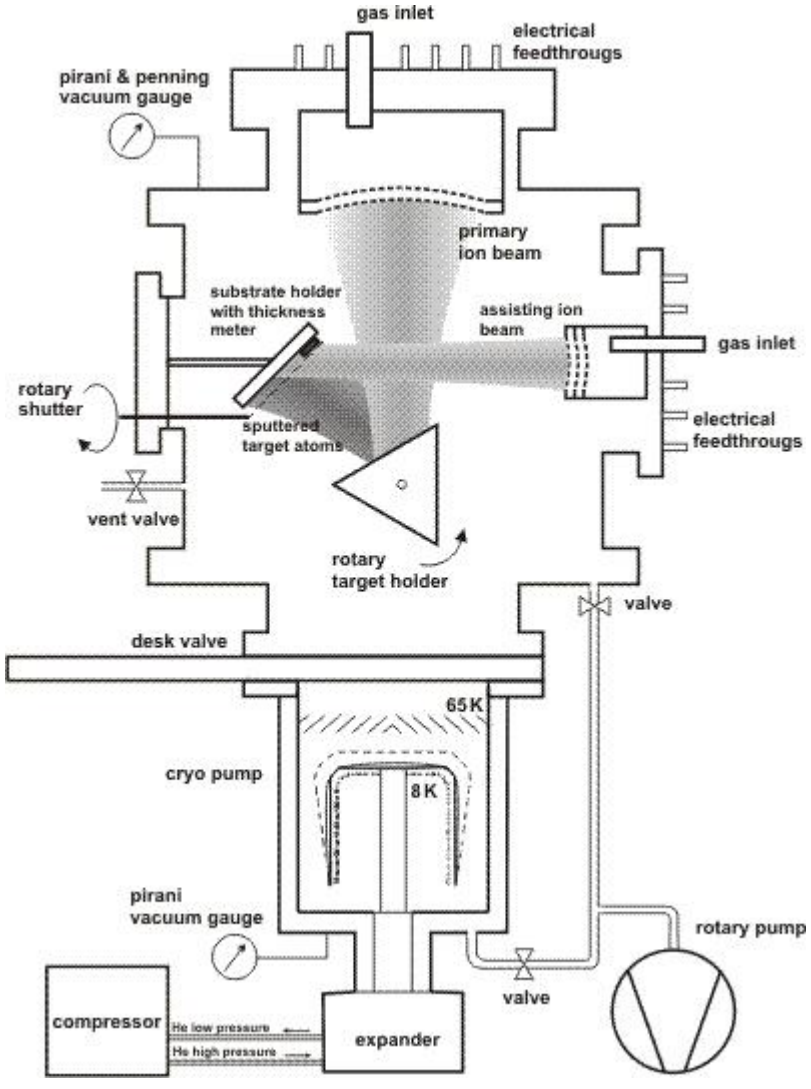


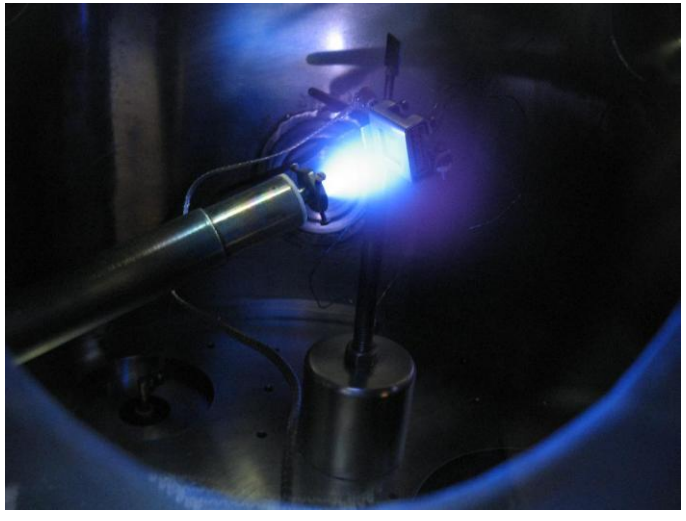
Fe atomy na Cu substrátu

Depozice tenkých vrstev

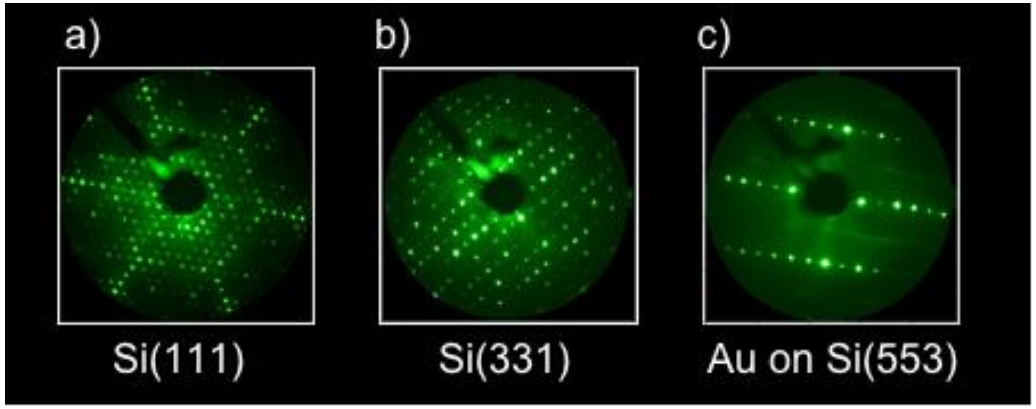


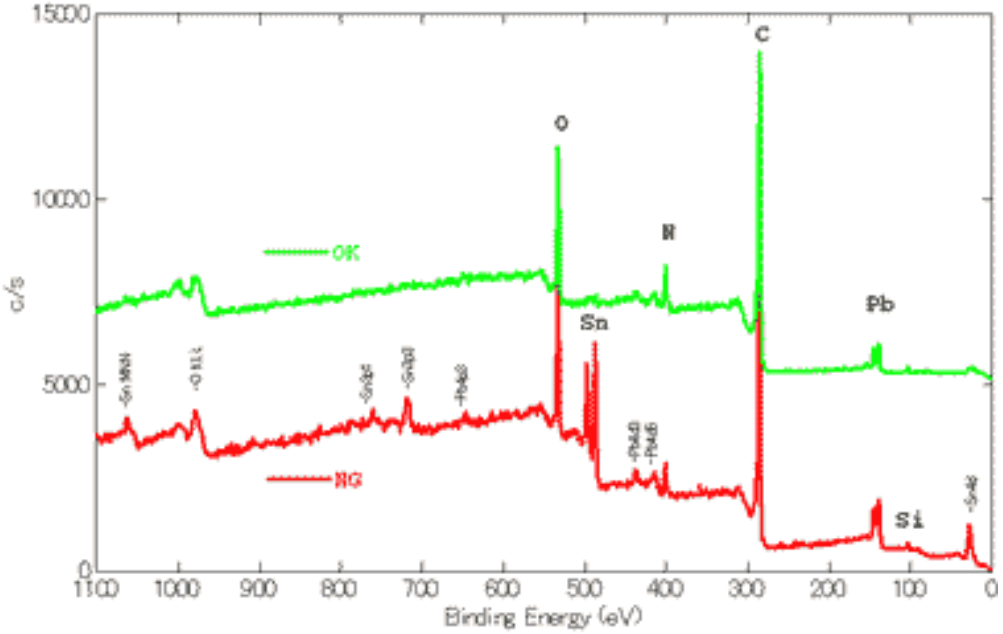


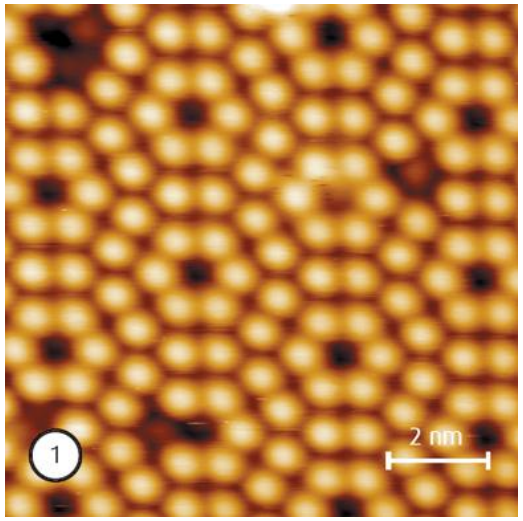




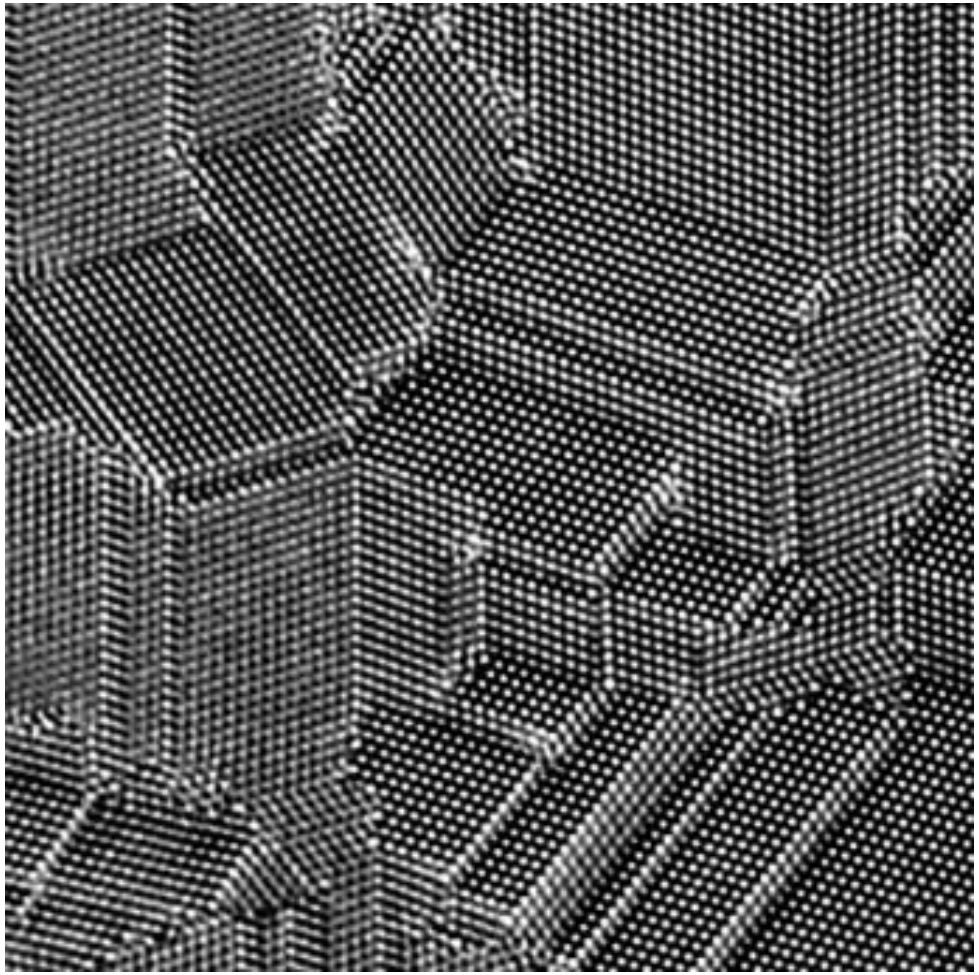
Mechanické a chemické vlastnosti





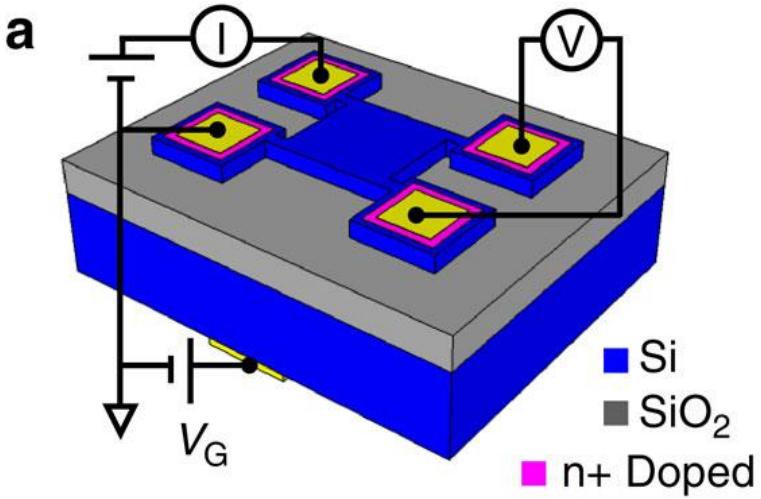


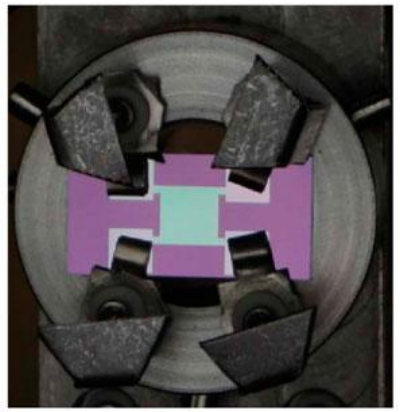
Krystalický Si

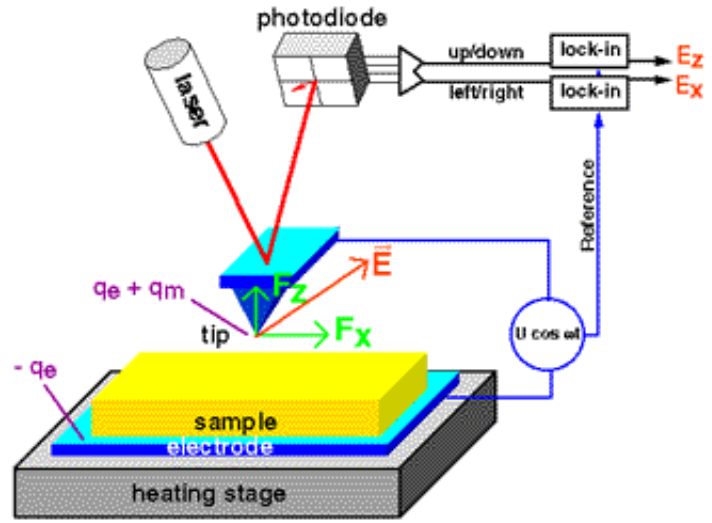


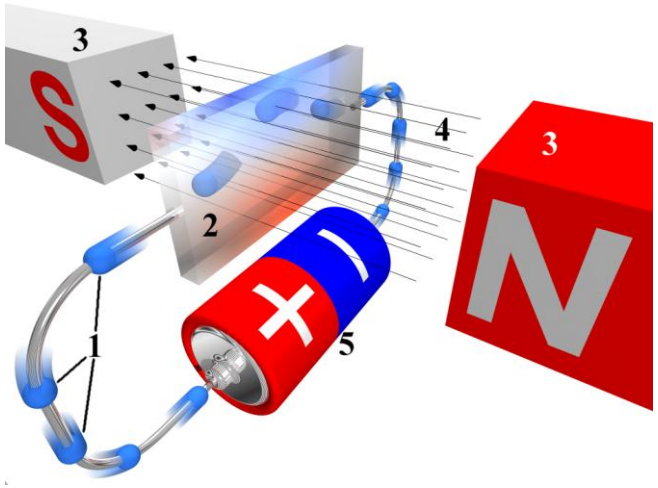
Polykrystalický Si [T. Vystavěl, CEA Grenoble, Francie]

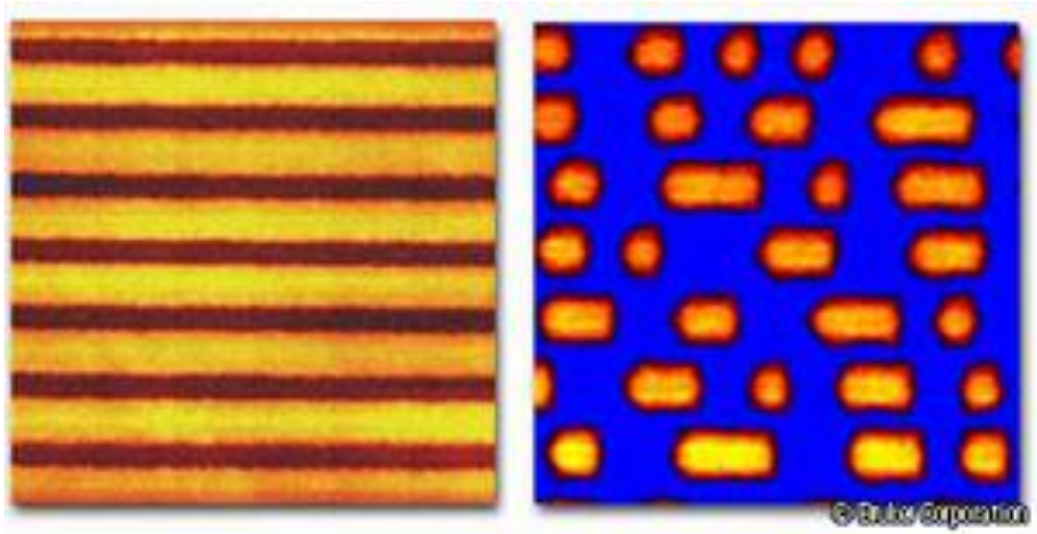
Elektrické vlastnosti





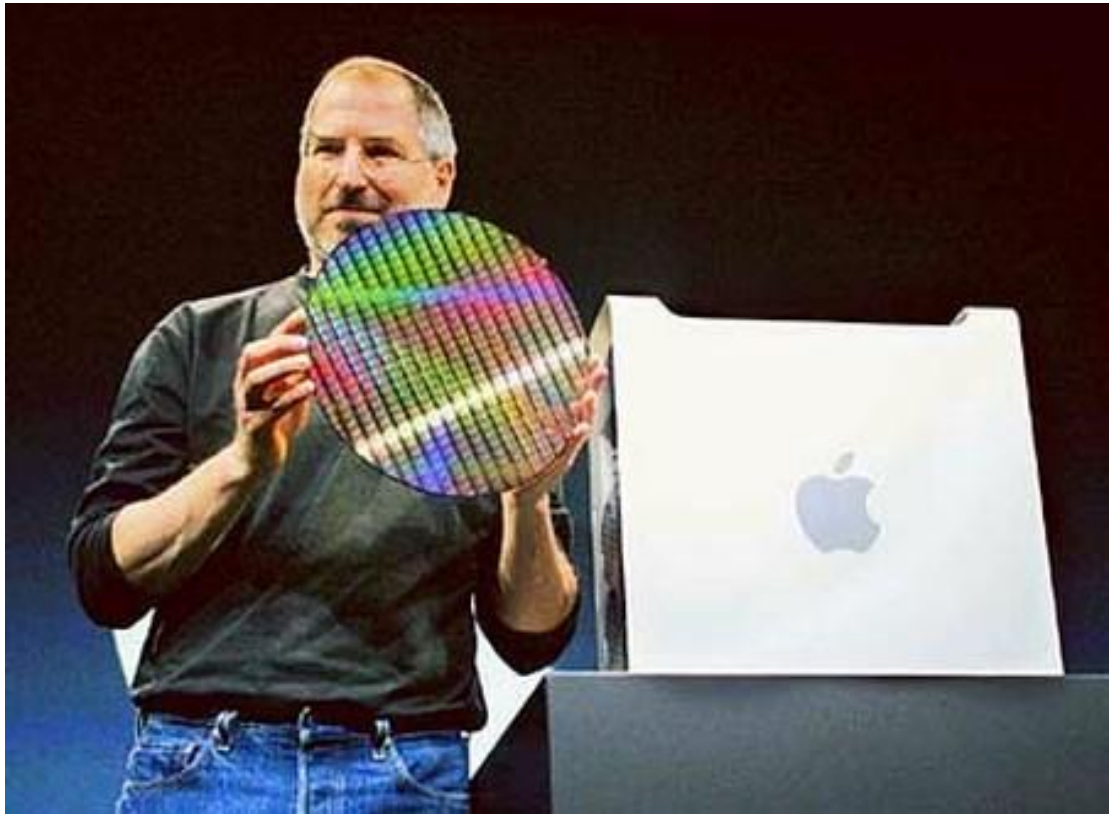


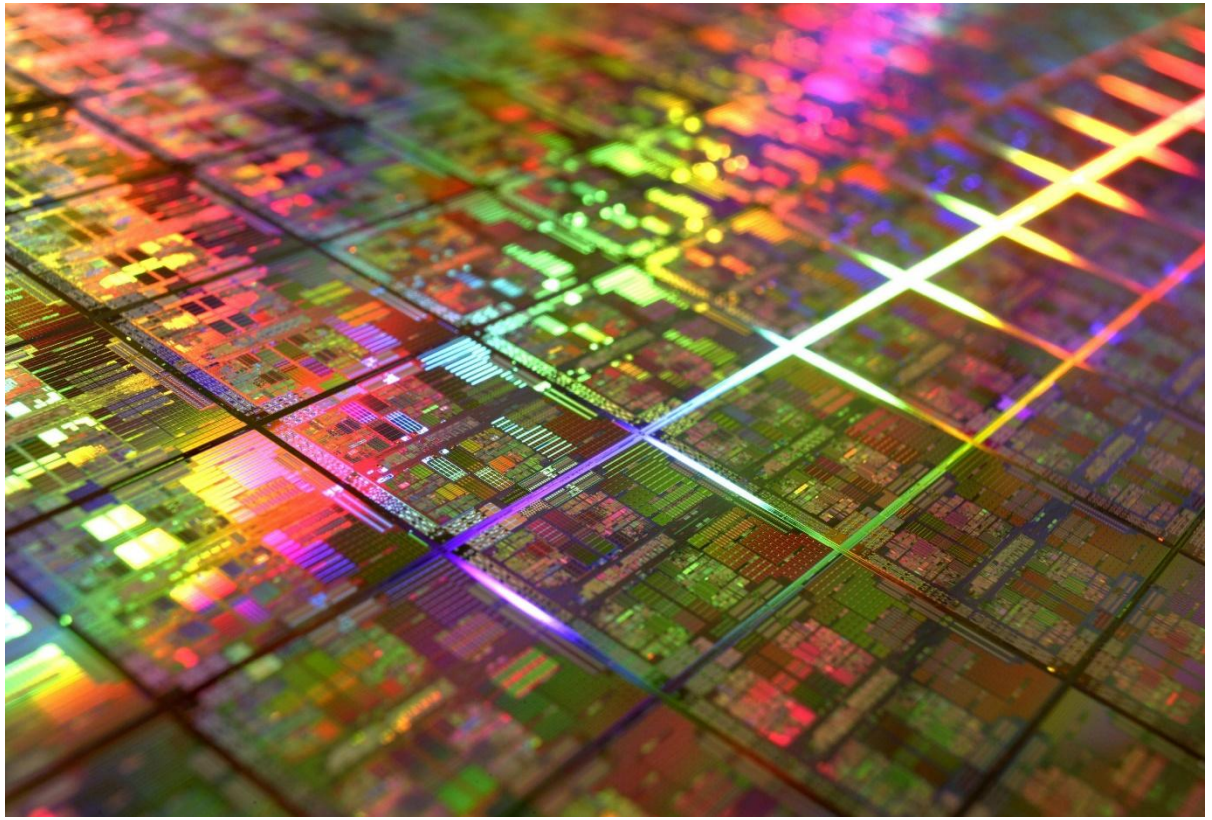




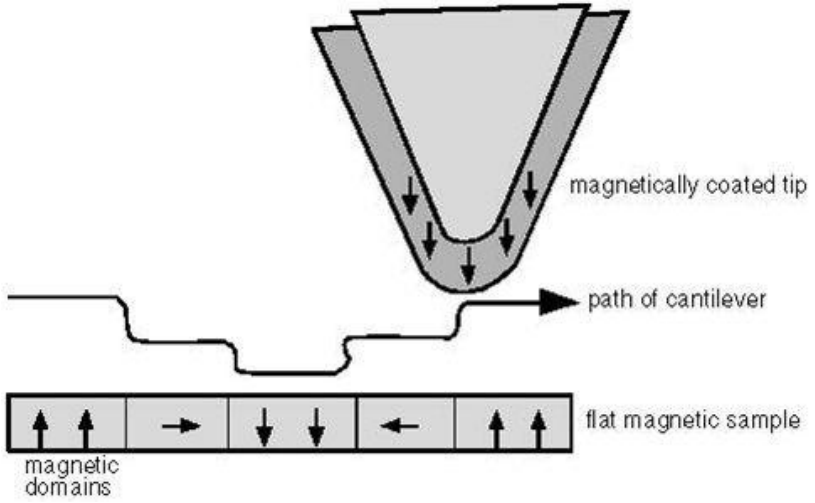
DVD-RW [Yasuko Ichikawa, Toyo Corporation, Japan] (5 x 5) um²

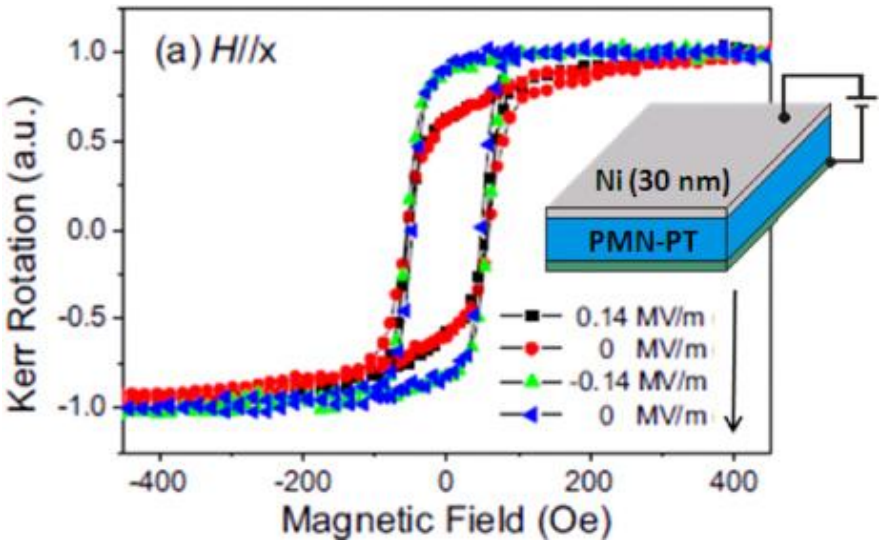
Mikroelektronika





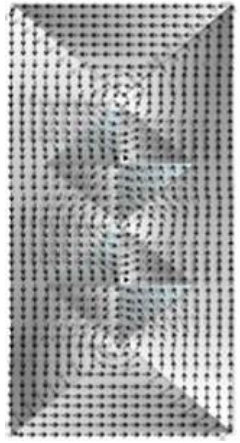
Magnetické vlastnosti

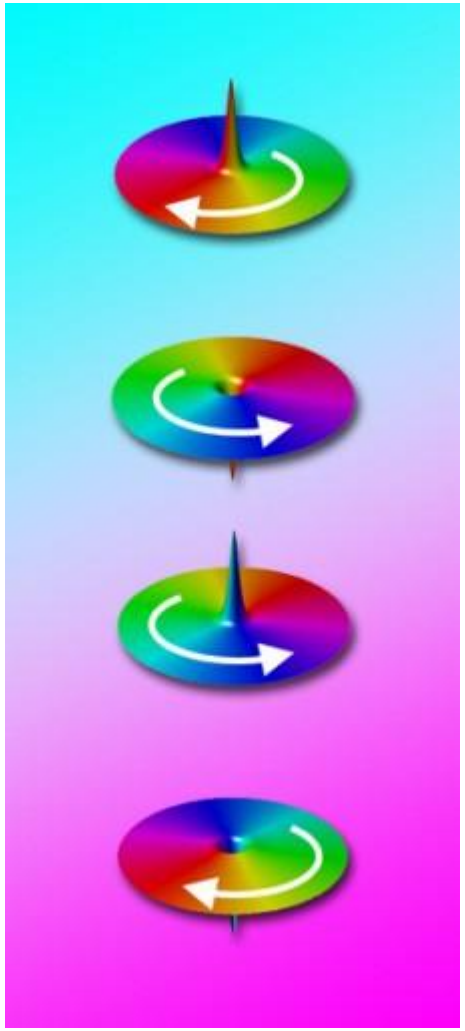


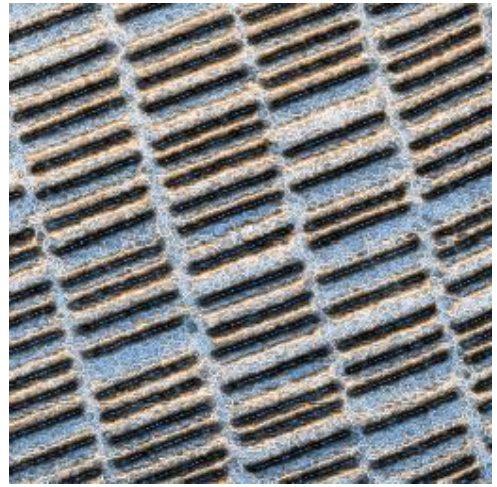


MFM Image

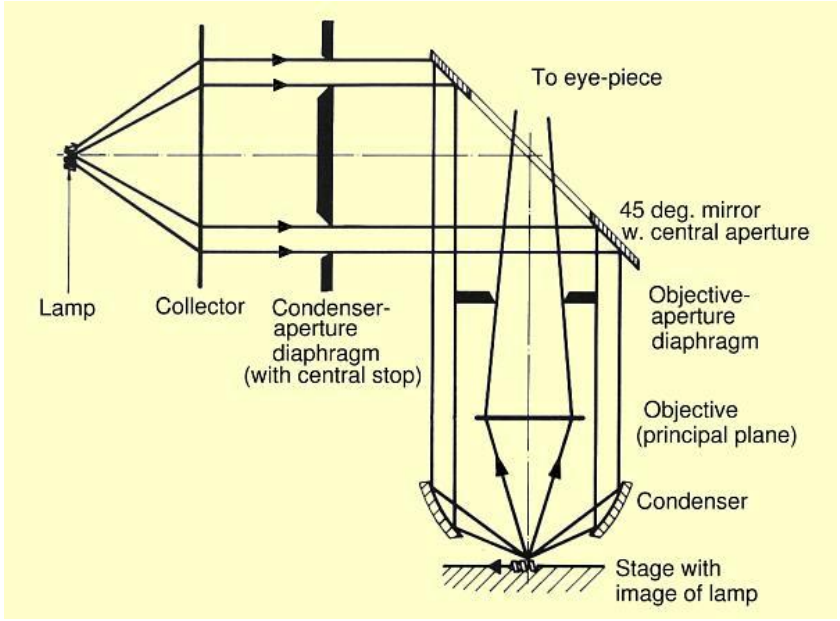
Micromagnetics

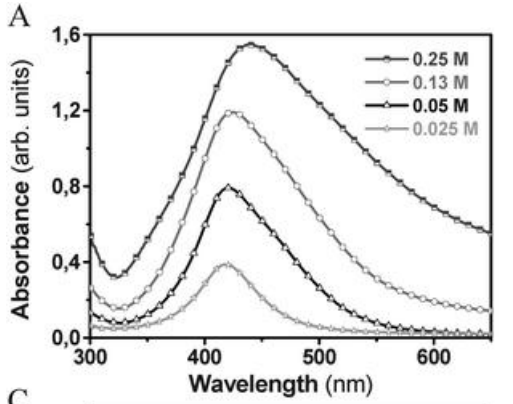


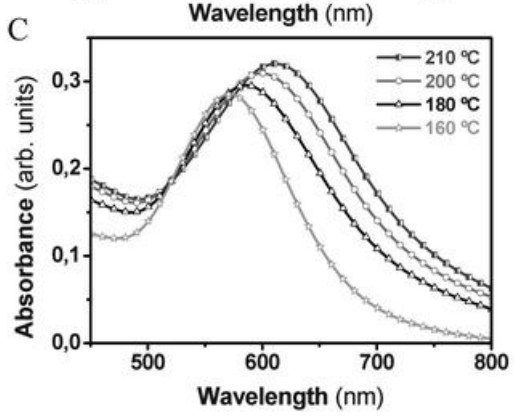


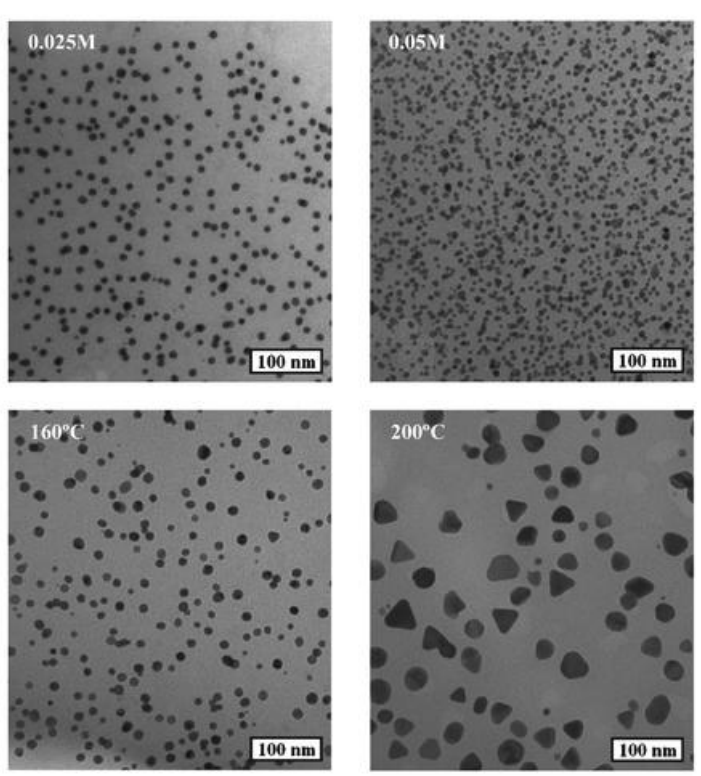


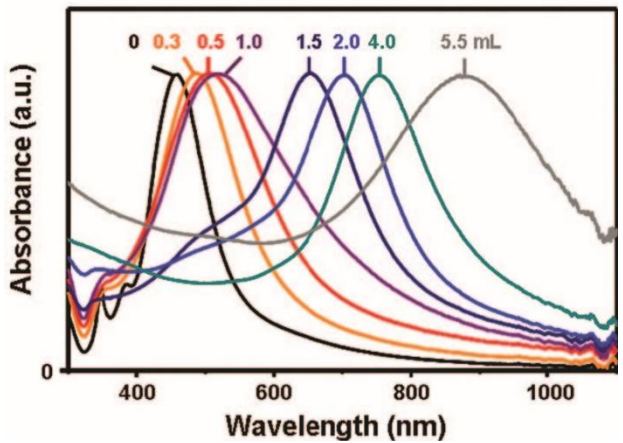
Optické vlastnosti



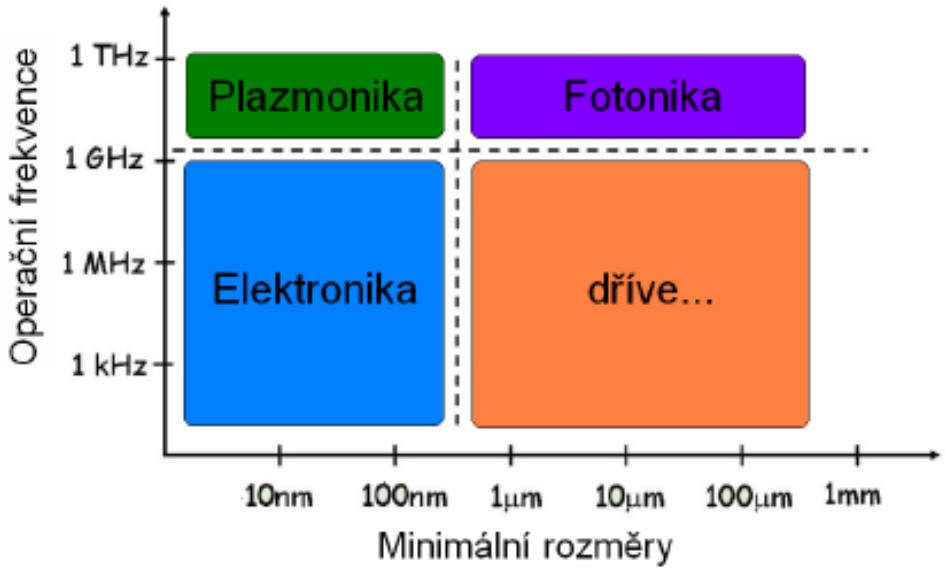


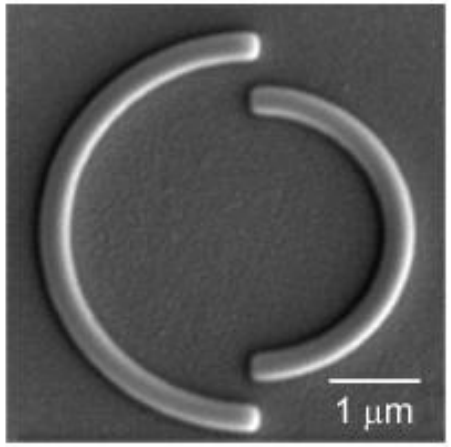


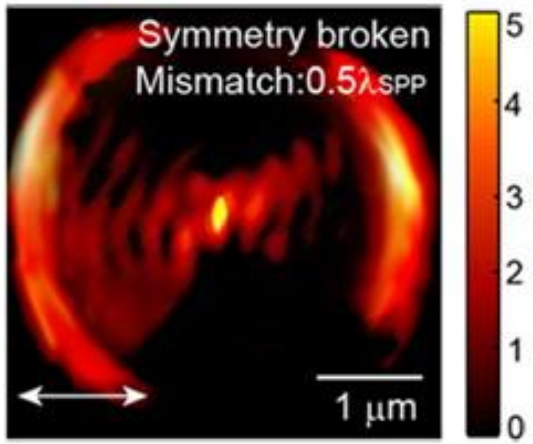


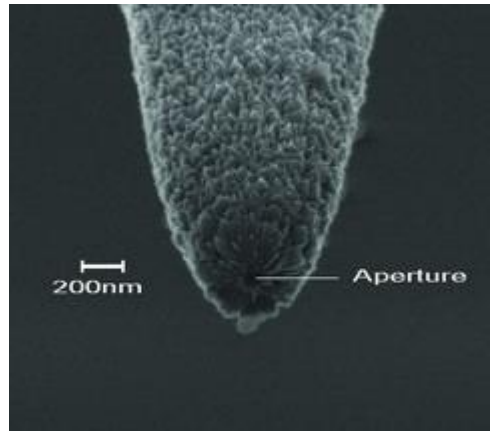


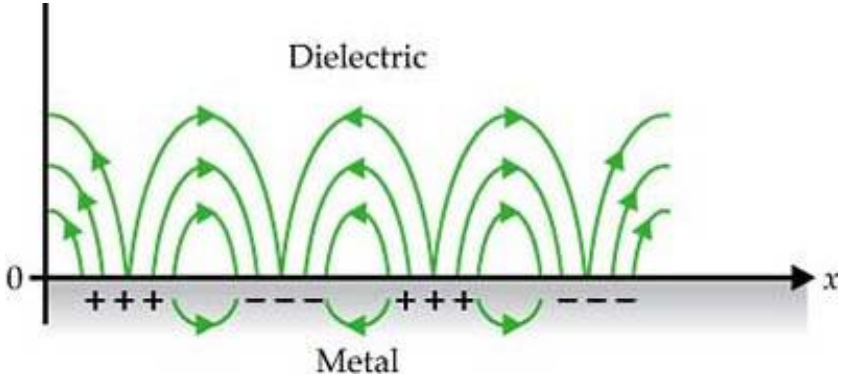
Plazmonika

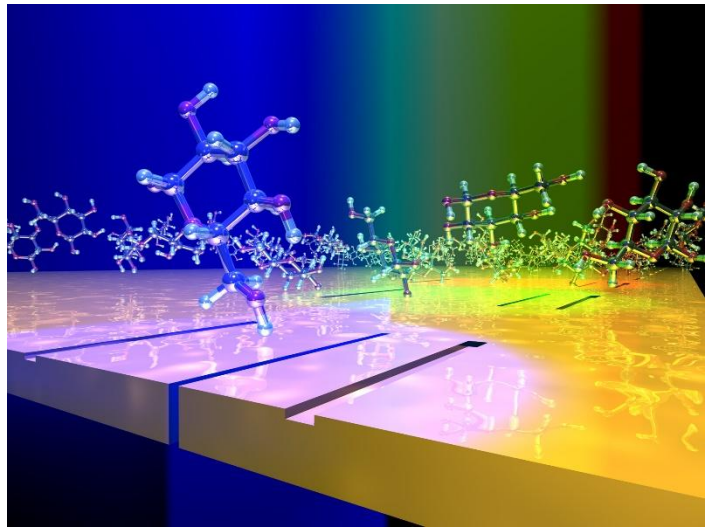

Operační frekvence
1 THz
1 GHz
1 MHz
1 kHz
Plazmonika
Fotonika
Elektronika
dříve...
10nm
100nm
1μm
10μm
100μm
1mm
Minimální rozměry


1 μm

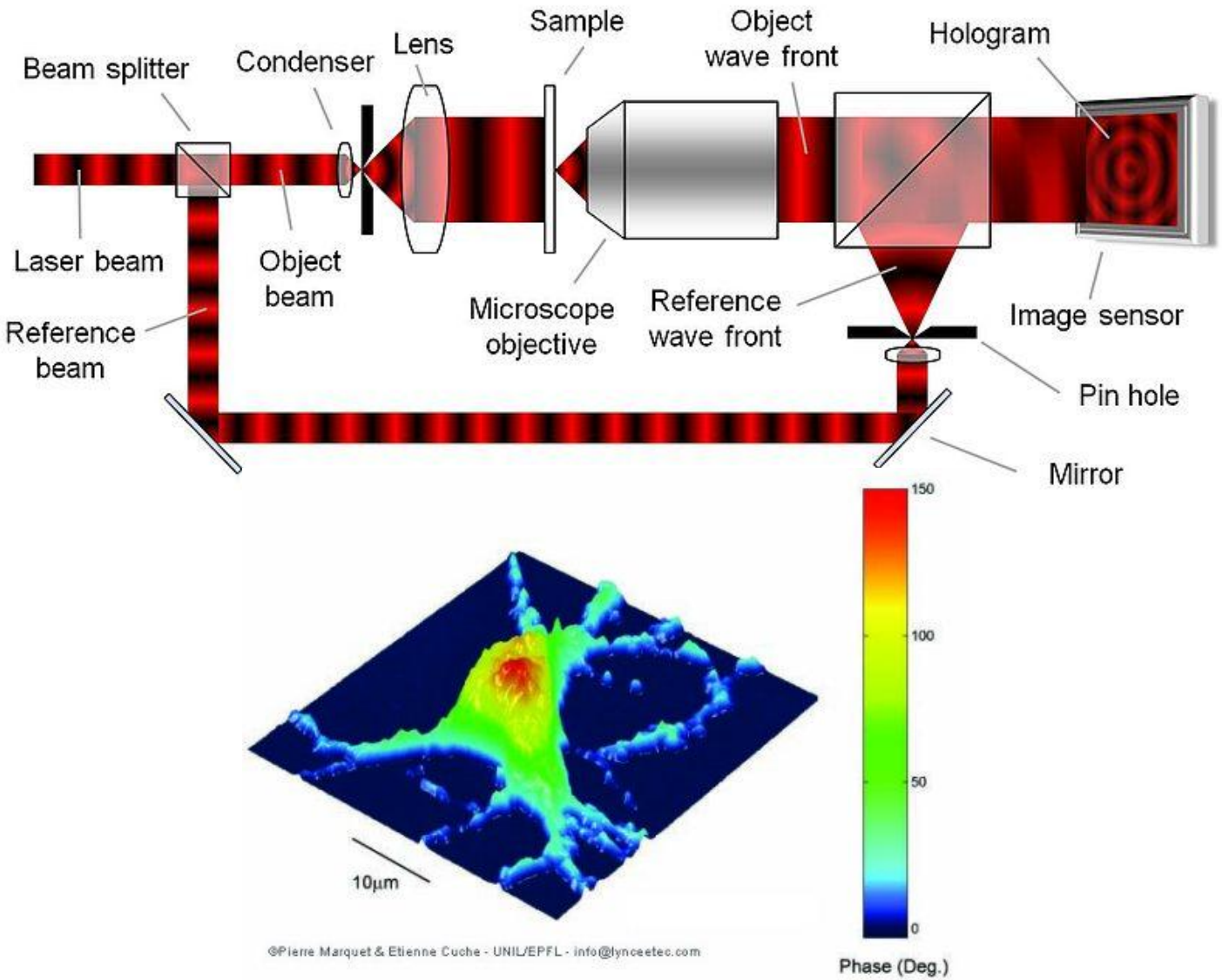

Symmetry broken
Mismatch:0.5λSPP
1 μm
5
4
3
2
1
0

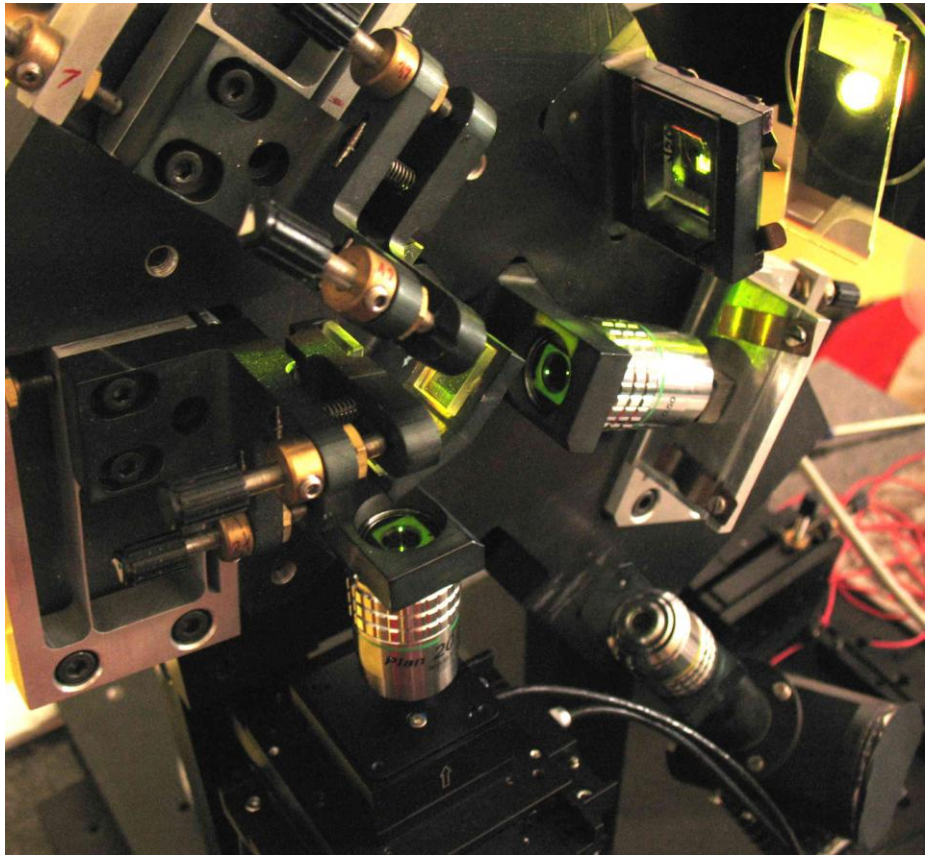

200nm
Aperture


Dielectric
0
x
+++
−−−
+++
−−−
Metal

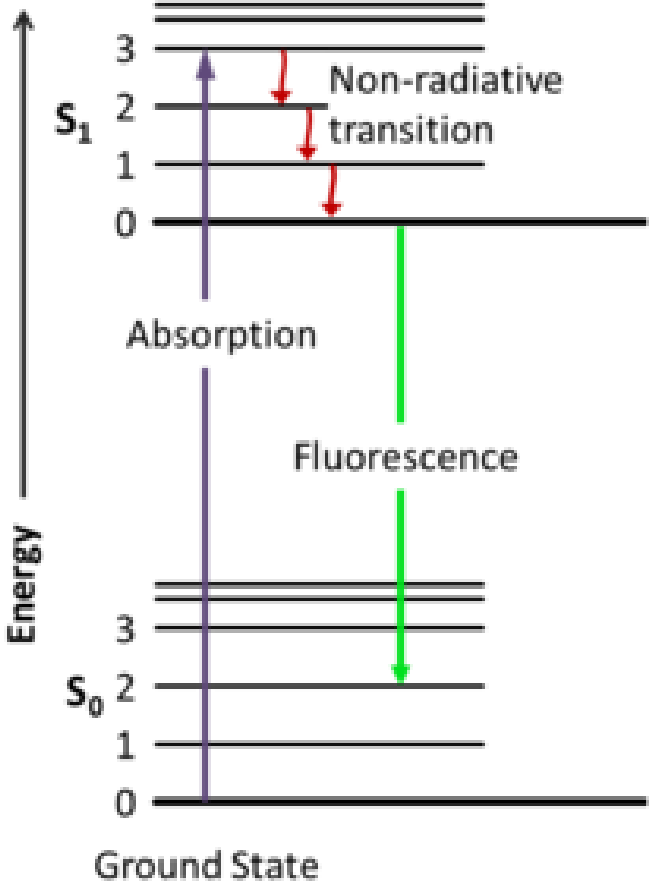


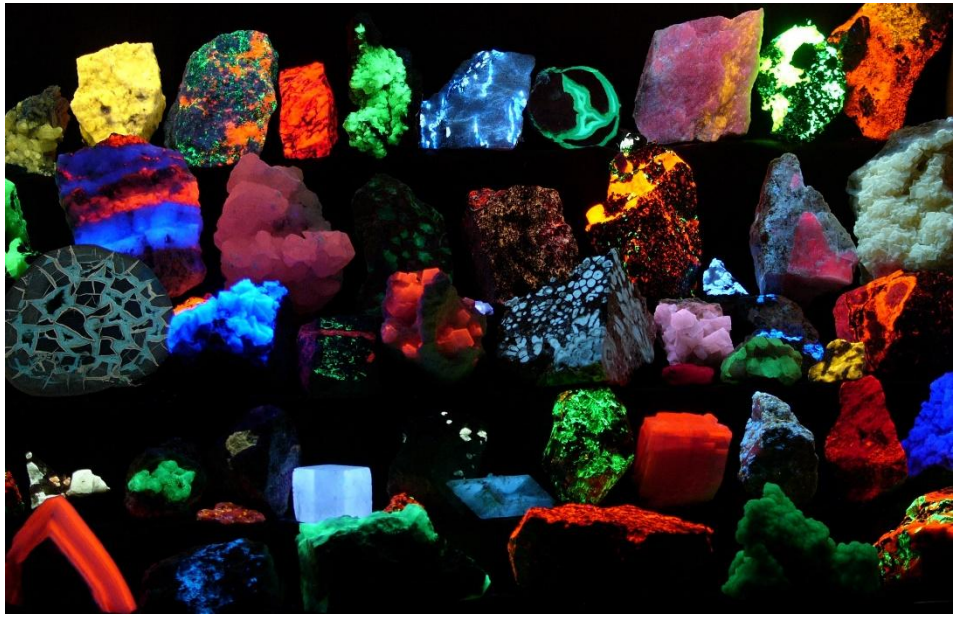
Holografická mikroskopie

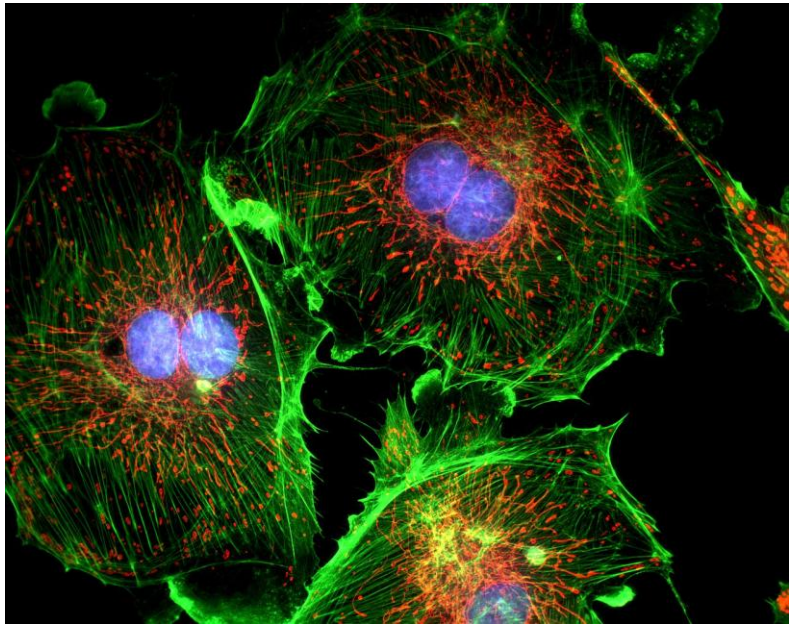


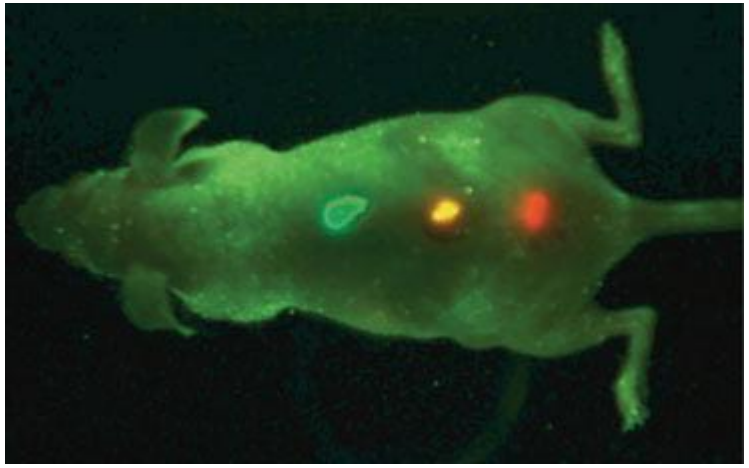


Fluorescence



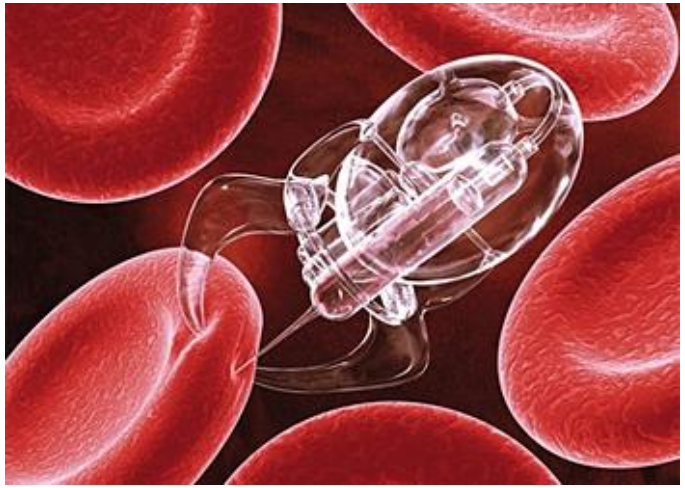


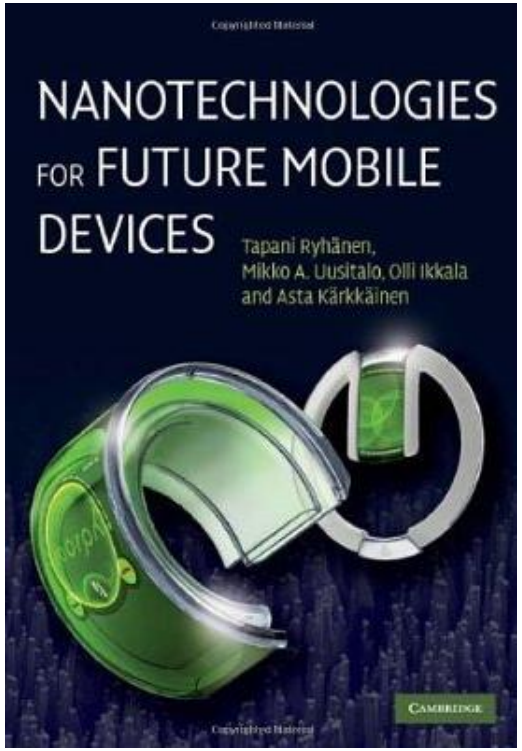


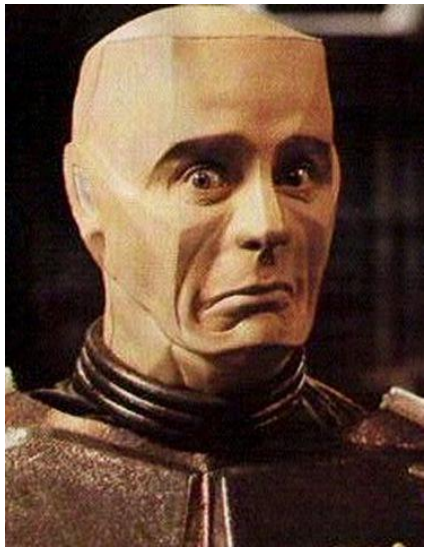


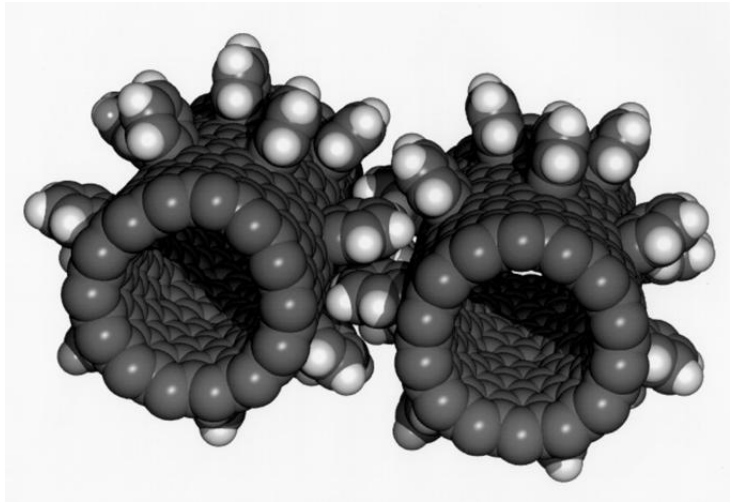
Obsah

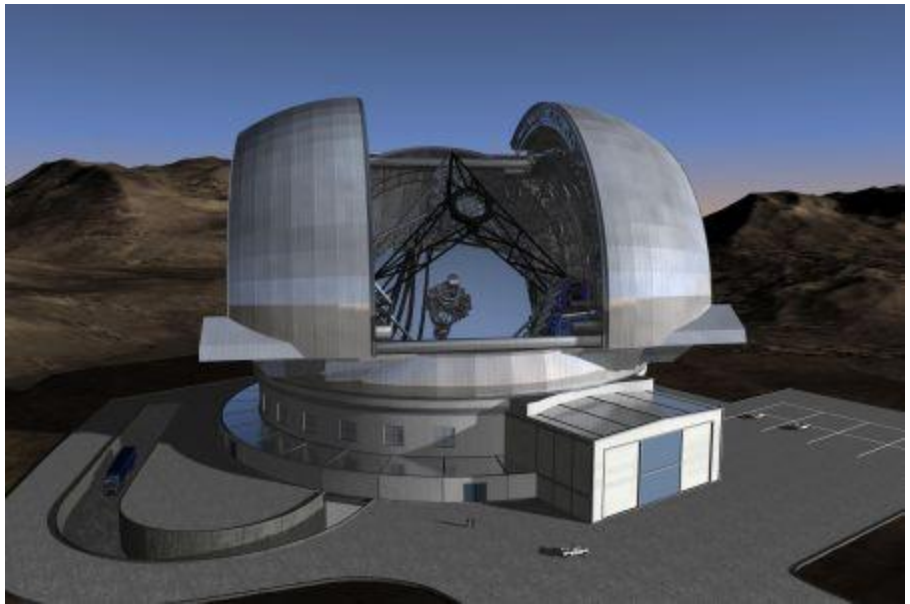
Budoucnost nanotechnologií











evropský sociální fond v ČR
EVROPSKÁ UNIE
MINISTERSTVO ŠKOLSTVÍ, MLÁDEŽE A TĚLOVÝCHOVY
OP Vzdělávání pro konkurenceschopnost
INVESTICE DO ROZVOJE VZDĚLÁVÁNÍ

Děkuji za pozornost

petr.dvorak@ceitec.vutbr.cz

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FACULTY OF MECHANICAL ENGINEERING
BRNO UNIVERSITY OF TECHNOLOGY

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