Fluorescent Silicon Carbide Quantum Dots for Bioimaging And Sensing

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Fluorescent Silicon Carbide Quantum Dots for Bioimaging And Sensing

- Motivation
- Synthesis
- Caracterization
- First step to bioimaging

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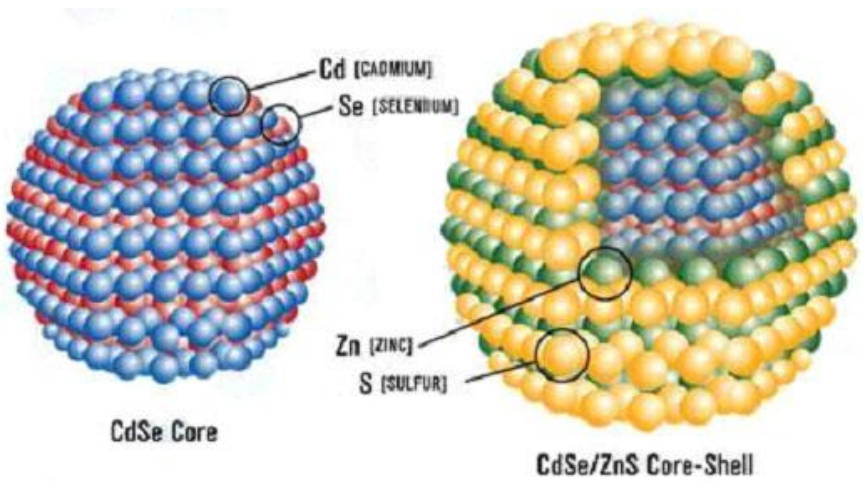
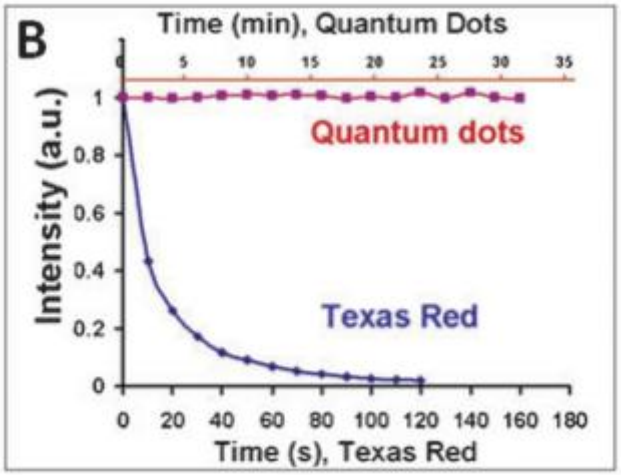
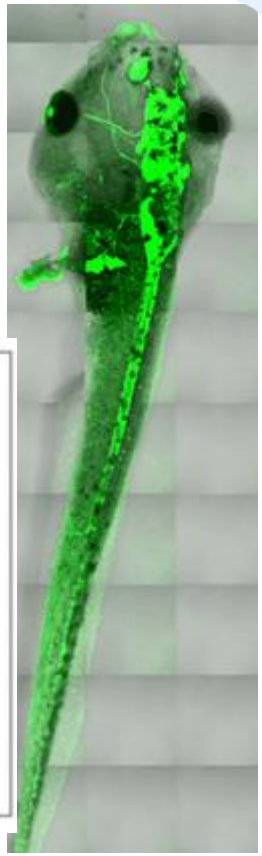
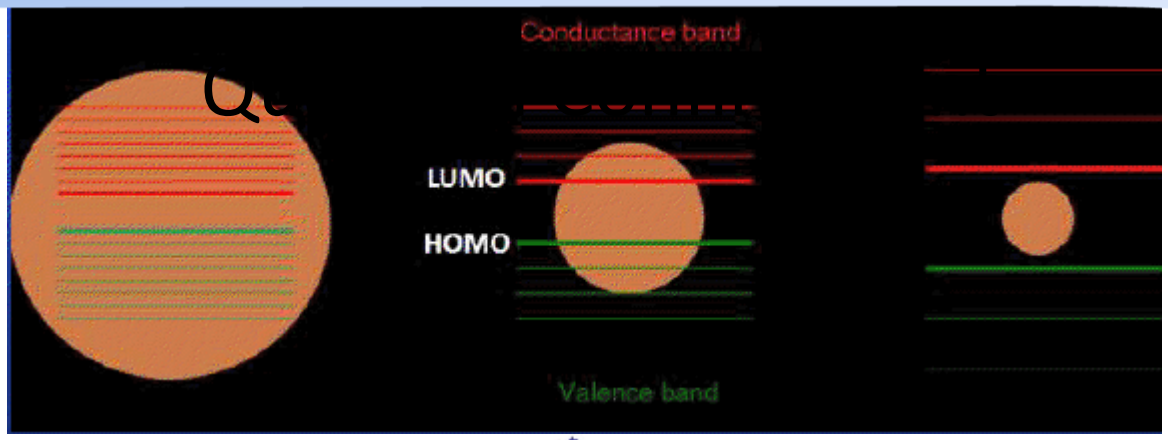
Bioimaging

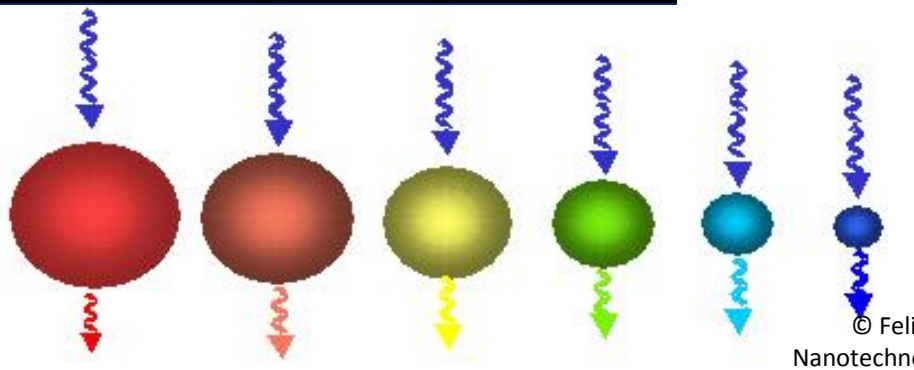

Cd [CADMIUM]
Se [SELENIUM]
Zn [ZINC]
S [SULFUR]
CdSe Core
CdSe/ZnS Core-Shell


B
Time (min), Quantum Dots
5 10 15 20 25 30 35
Intensity (a.u.)
1
0.8
0.6
0.4
0.2
0
Quantum dots
Texas Red
0 20 40 60 80 100 120 140 160 180
Time (s), Texas Red




D





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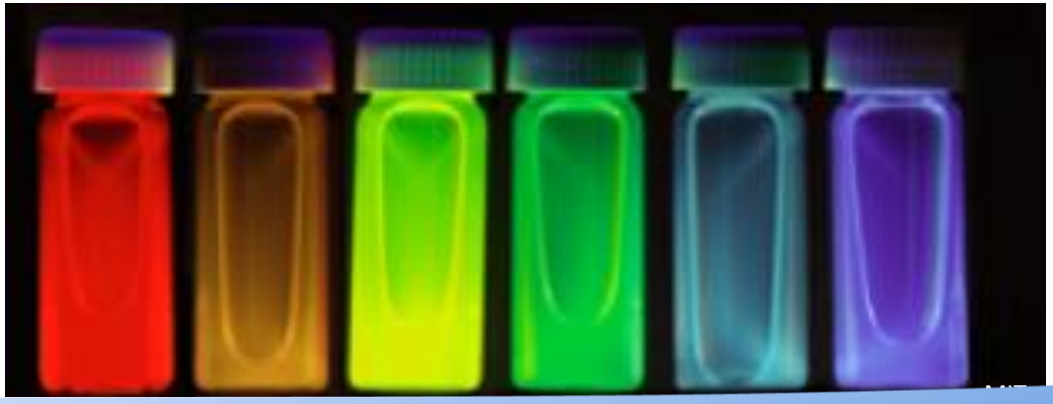
Nanotechnology Now

The quantum confinement effect can be observed once the diameter of the particle is of the same magnitude as the wavelength of the electron wave function.

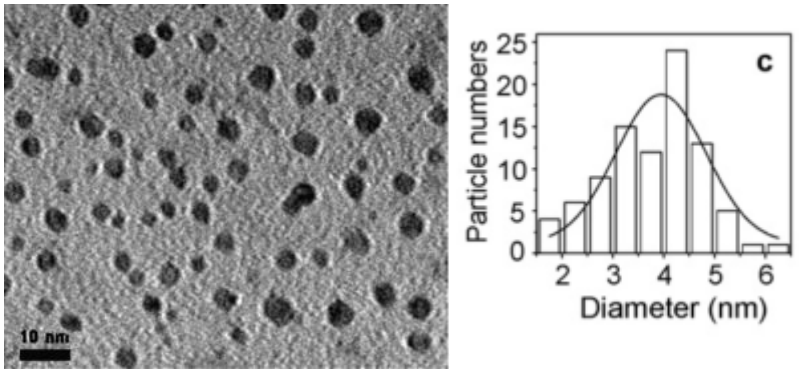


Motivation: Bioimaging

For imaging we have to use nanoclaster that

- small enought
- biocompatable
- has emission is in the optical window

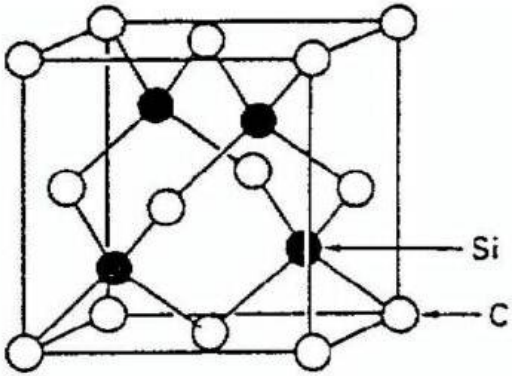
SiC QDs

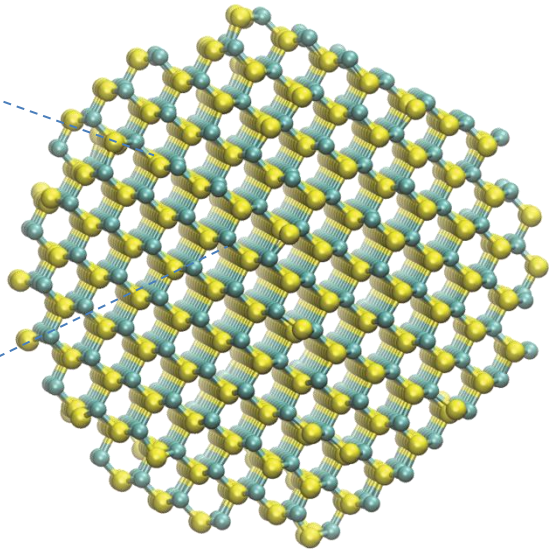


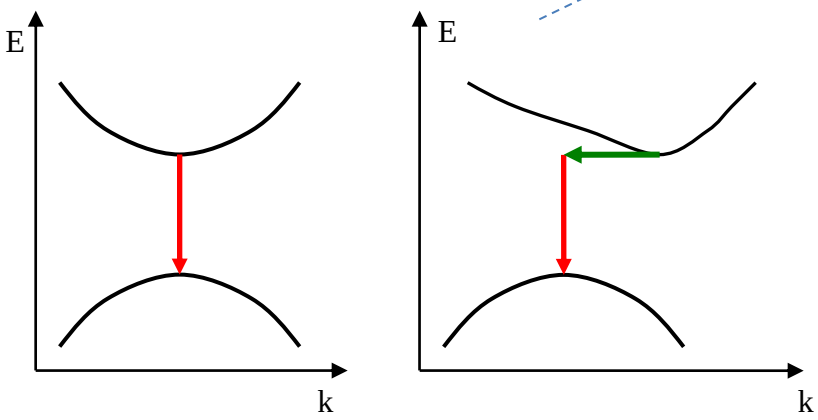
Wu XL, Fan JY, Qiu T, Yang X, Siu GG, Chu PK.
Phys Rev Lett 2005;94:026102.

Properties of SiC

paraméter	Si	3C-SiC	GaAs	2H-GaN	Diamond
Band Gap[eV]	1,12	2,4	1,43	3,4	5,5
a [Ă]	5,43	4,36	5,65	3,189	3,567
c [Ă]	n.a	n.a.	n.a.	5,185	n.a.
Bond lenght	2.35	1,89	2,45	1,95	1,54
T.E.C [10^{-6}/K]	2,6	3,0	5,73	5,6	0,8
Density [g/cm3]	2,3	3,2	5,3	6,1	3,5
Hőv. tényező [W/cmK]	1,5	5,0	0,5	1,3	20,0
Melt. point [°C]	1420	2830	1240	2500	4000
Mohs hardness		9,5			10



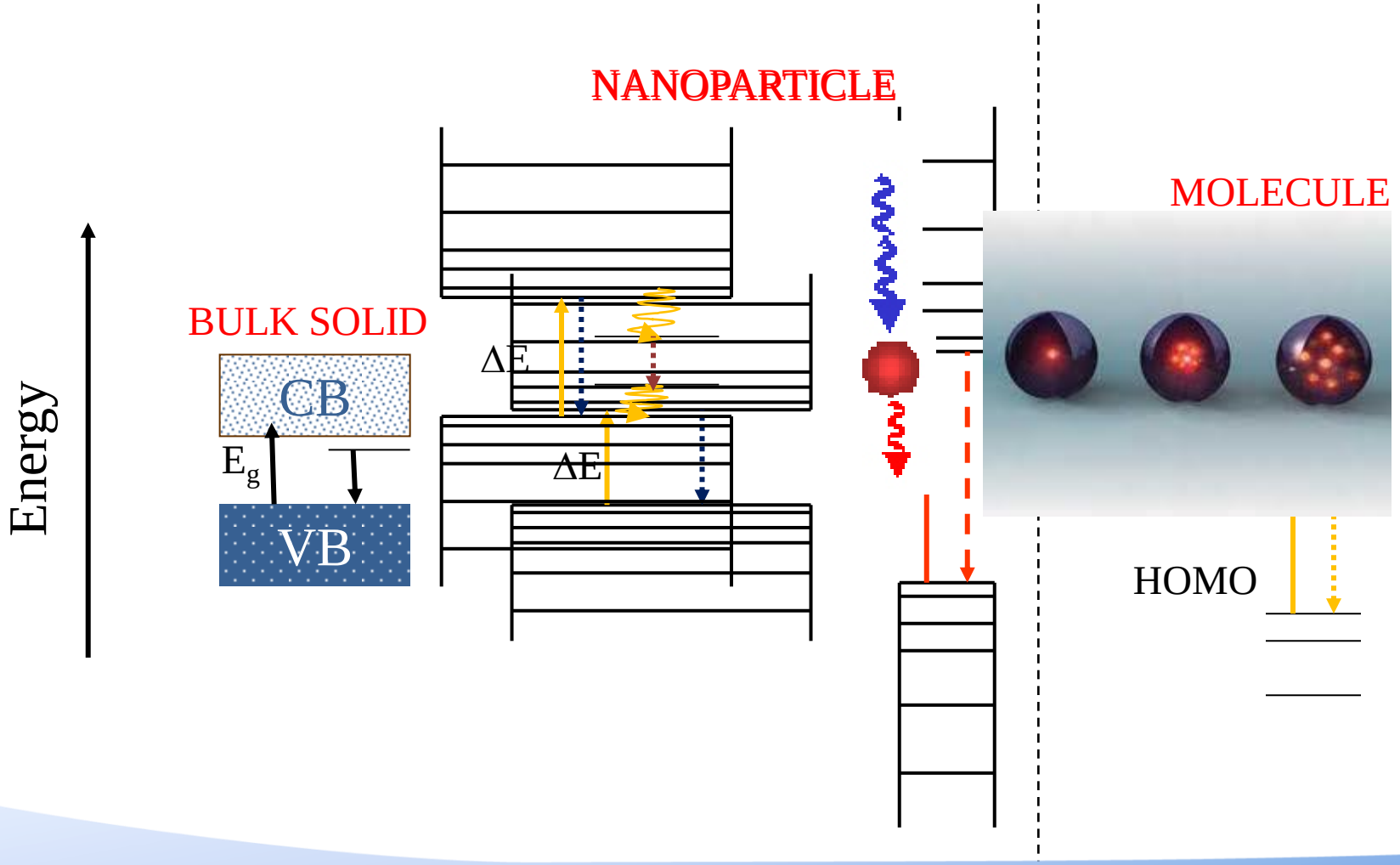




direct band-gap

indirect band-gap esetén

„Band Gap engineering”



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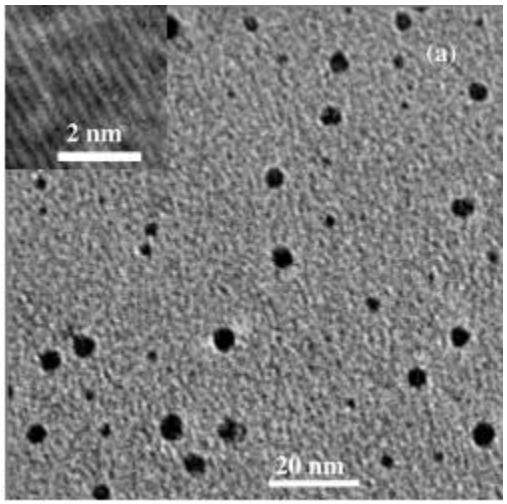
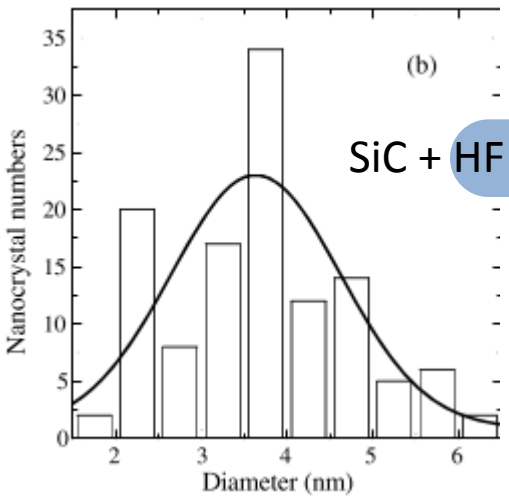
Microsize → nanosize

J. Zhu, Z. Liu, X. L. Wu, L. L. Xu, W. C. Zhang, and P. K. Chu, "**Luminescent small-diameter 3C-SiC nanocrystals fabricated via a simple chemical etching method**," *Nanotechnology*, vol. 18, no. 36, p. 365603, Sep. 2007.





Wet chemical etching
„Stain etching"

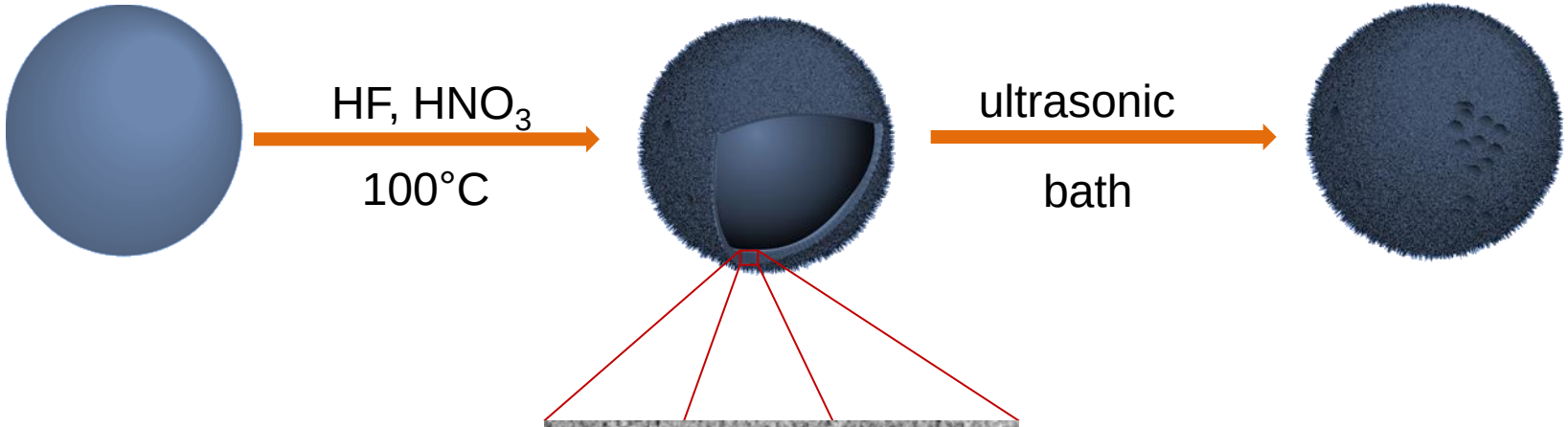
$SiC + HF + HNO_3 \xrightarrow[100\ °C]{} H_2SiF_6\ H_2O + H_2 + CO_2$

$$SiC + 2HNO_3 + 2H_2O \rightarrow 2HNO_2 + 4OH^- + SiC^{4+},$$

$$SiC^{4+} + 4OH^- \rightarrow SiO_2 + CO_2 + 2H_2,$$

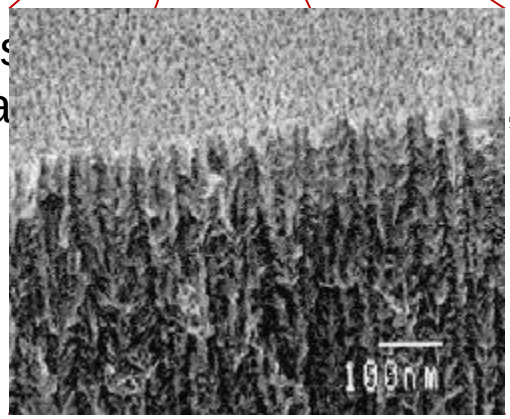
$$SiO_2 + 6HF \rightarrow H_2SiF_6 + 2H_2O.$$

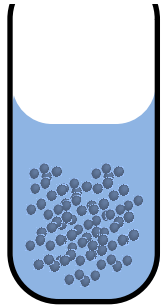
Stain Etching



Results: SiC QDs

- Stabile in pola , PBS)
- Hydrofil





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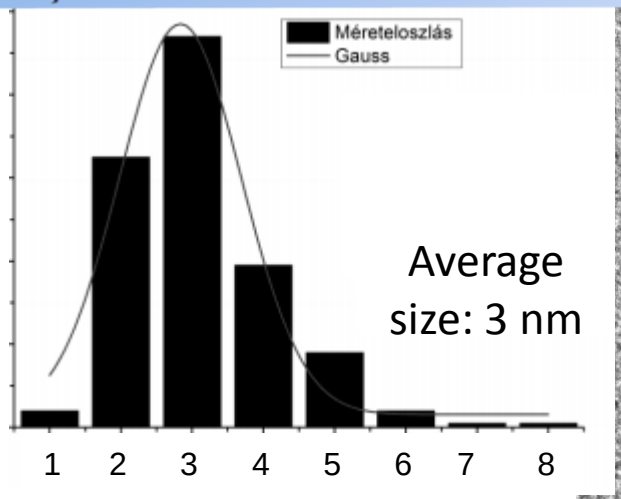
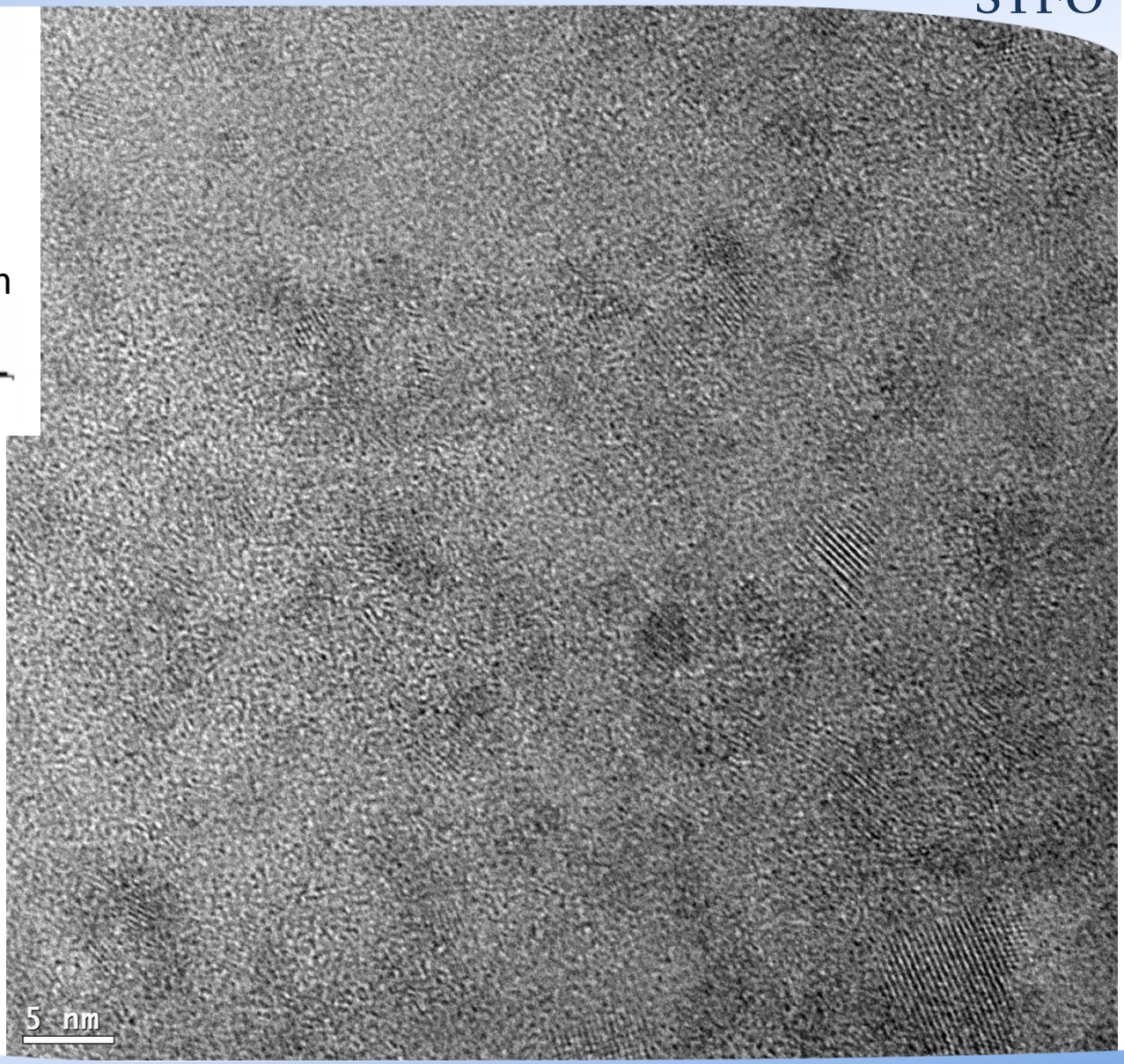
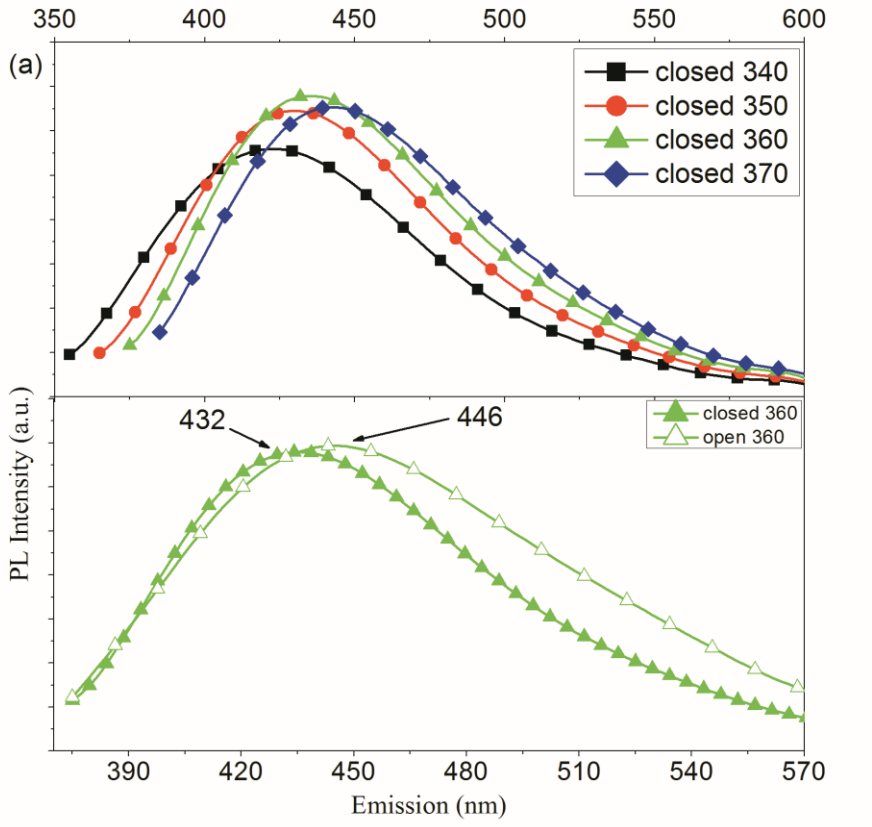


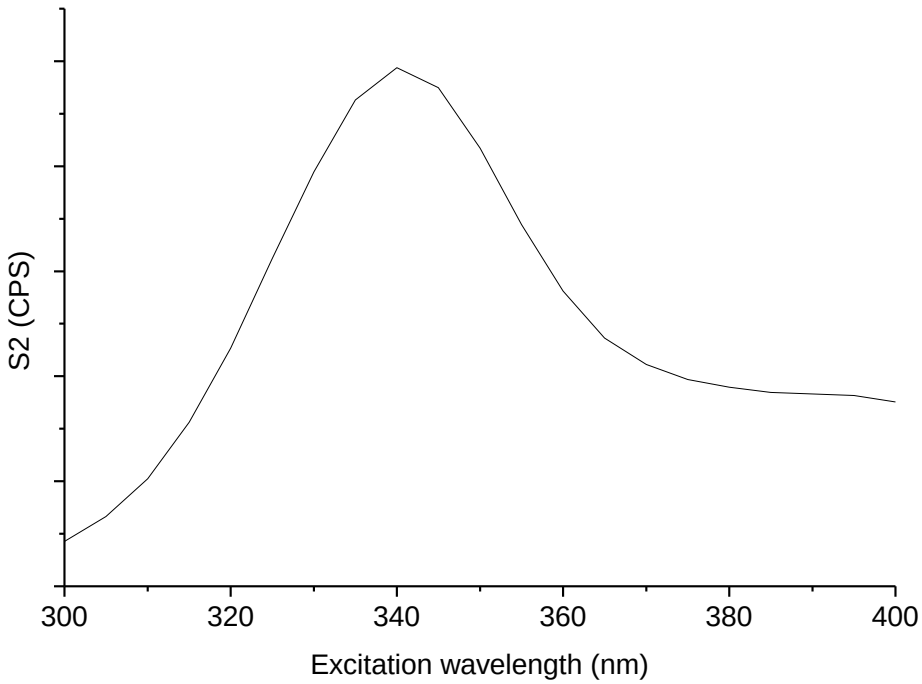
Average size: 3 nm

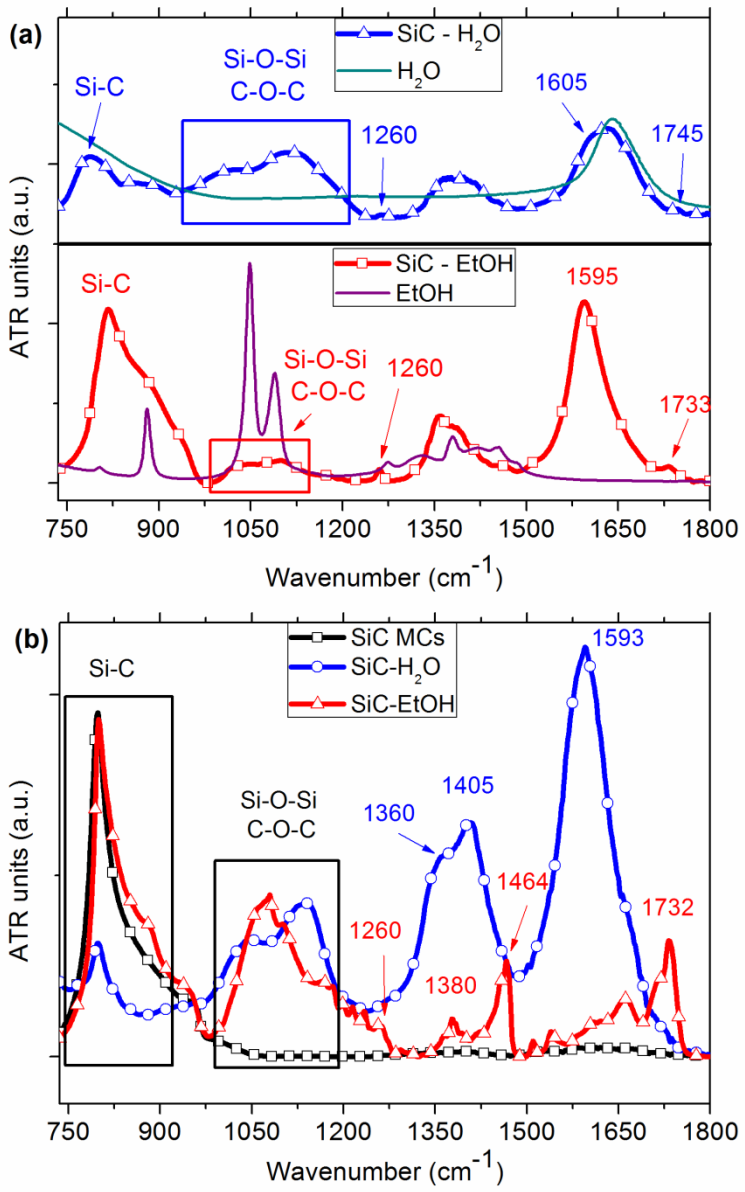
HR-TEM



Photoluminescence Study







Surface Study

ATR-FTIR spectroscopy

- Surface are oxidized
  - Carboxyl groups
  - Hydroxyl groups
  - Oxygen bridge

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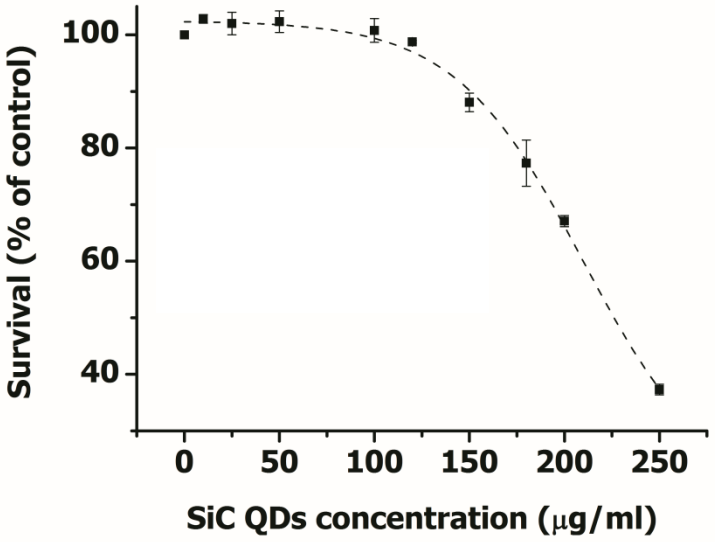
Toxicity



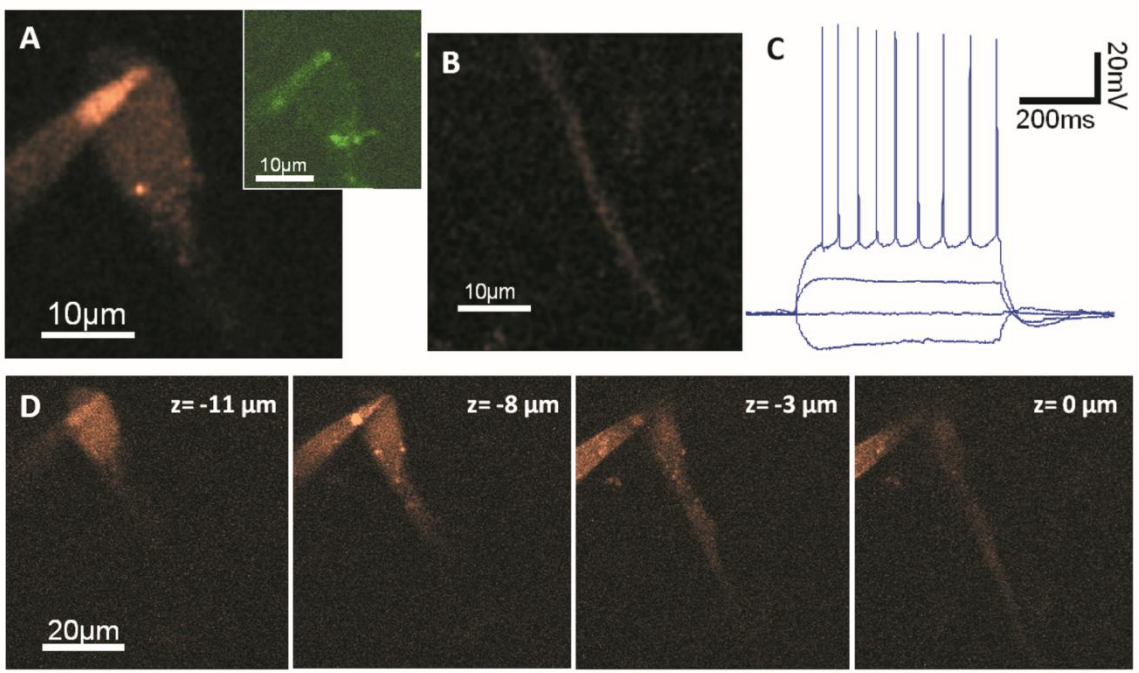
Human cervical adenocarcinoma, HeLa, Cels

AlamarBlue™ Cell Viability Assay Kit

48 h exposition

IC_{50} = 227.5 μg/ml

Two photon microscopy



Excitation: 800 nm
Emission window: 525-625 nm

- CA1 pyramidal neurons in acute 300 µm mice hippocampal slices.
- Cells were filled with intracellular solution (ICs) and SiC QDs (<5%) via the patch-pipette (6-9 MΩ).
- Images were taken at ~40 µm under the slice surface. In red channel the soma was clearly visible

Conclusions

- SiC QDs are water soluble
- Low citotoxicity
- Emission at 420-550nm
- **No blinking, no bleaching**
- Surface is ready to derivatisation.

Thank you for your atention

Wigner RCP

Balogh István
Szekrényes Zsolt

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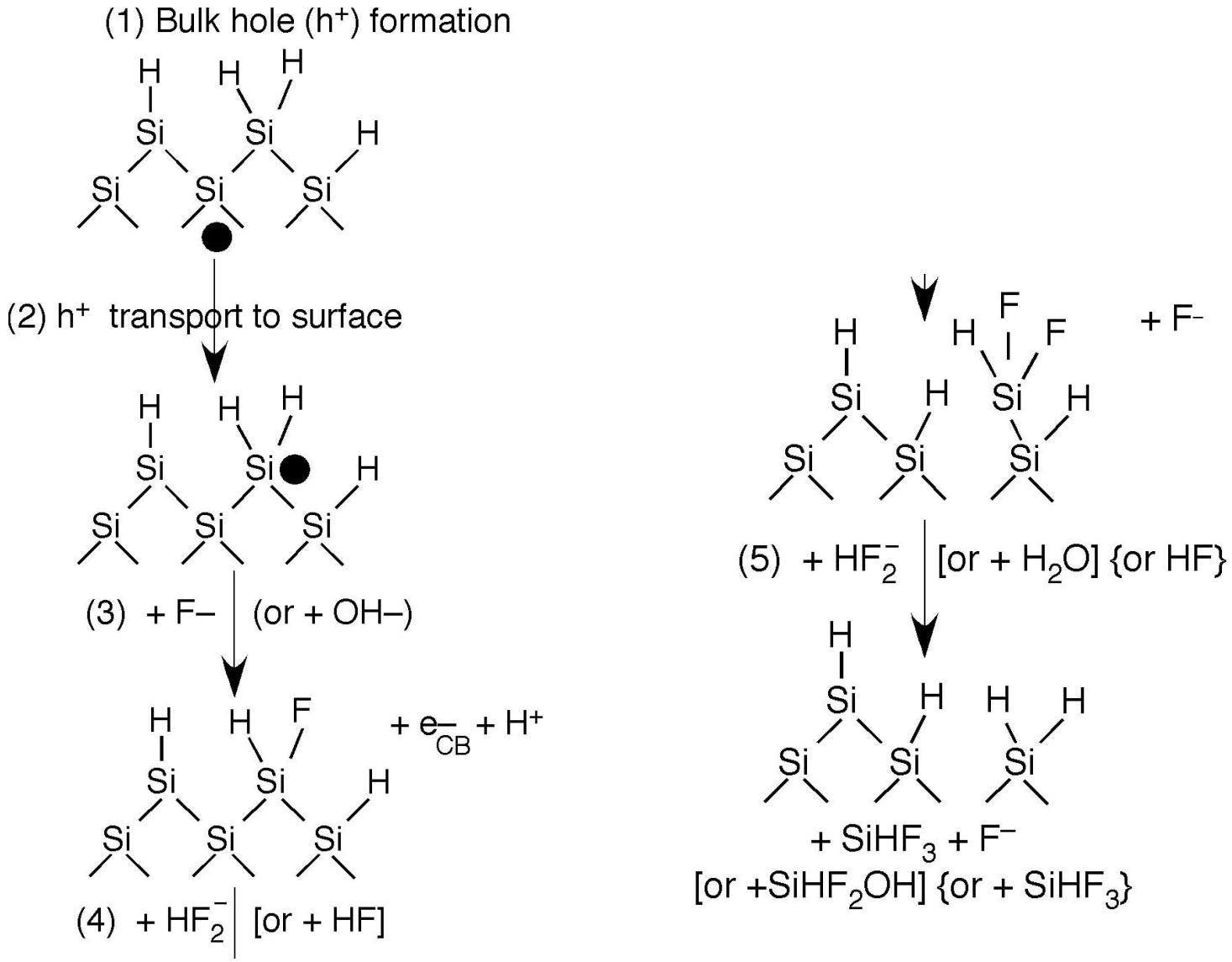
Vértessy Beáta
Róna Gergely

Institute of Experimental Medicine

Rózsa Balázs
Pálffi Dénes

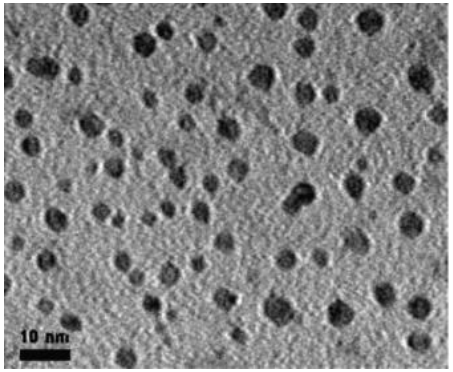
Pórusos morás

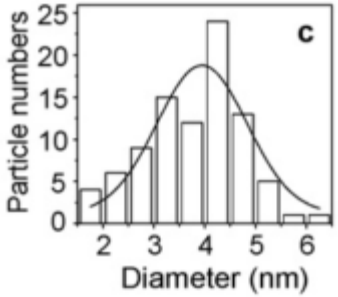


Cél: Biológiai képalkotás

Használjunk olyan félvezető nanoklasztert, Amely

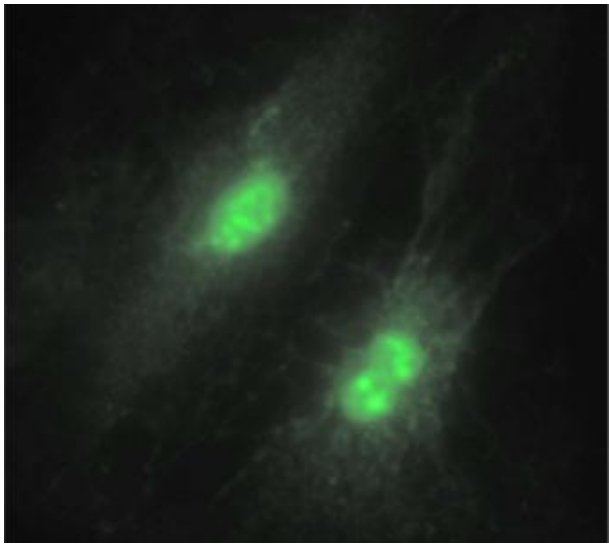
- eléggé kisméretű
- biokompatibilis
- Infravörös fénykibocsátása van





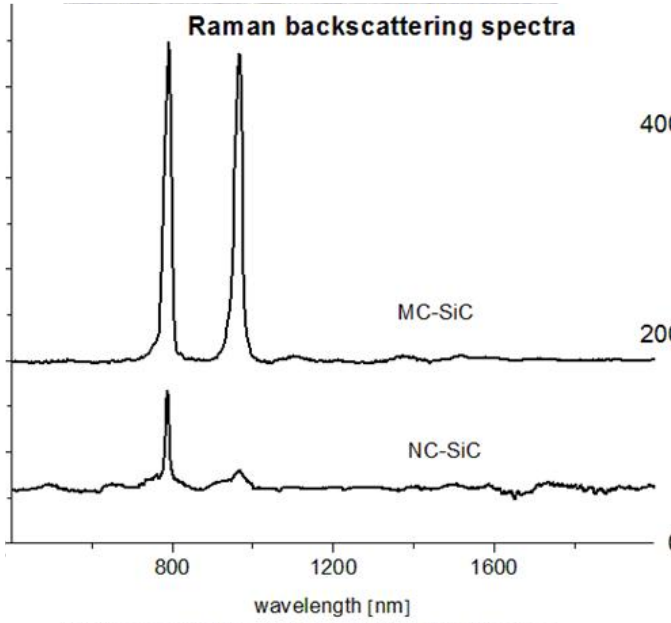
Wu XL, Fan JY, Qiu T, Yang X, Siu GG, Chu PK. Phys Rev Lett 2005;94:026102.

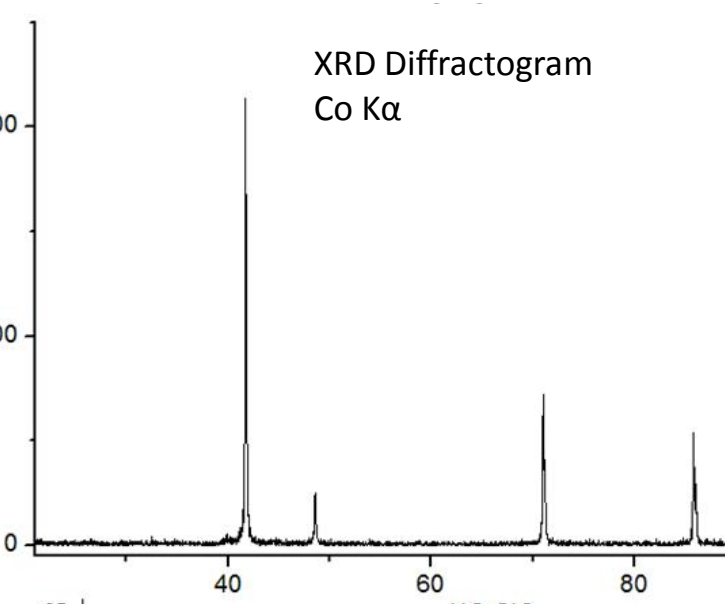
SiC

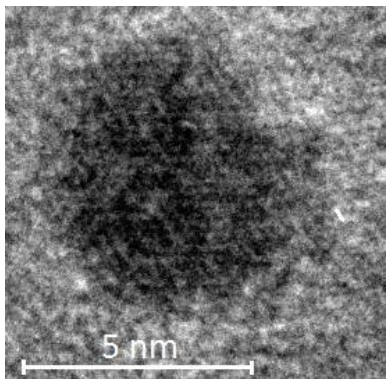


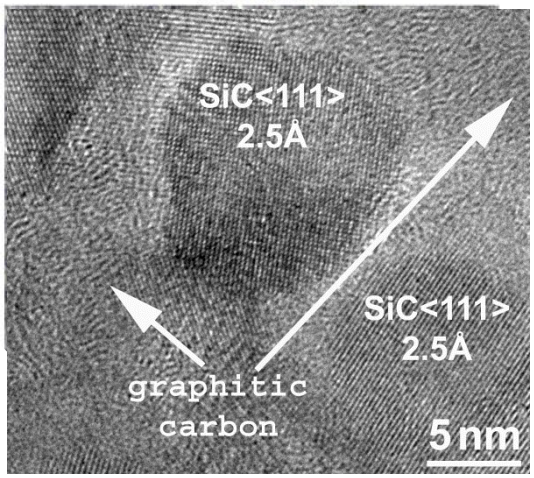
J. Botsoa, V. Lysenko, a Géloën, O. Marty, J. M. Bluet, and G. Guillot, “Application of 3C-SiC quantum dots for living cell imaging,” *Applied Physics Letters*, vol. 92, no. 17, p. 173902, 2008.

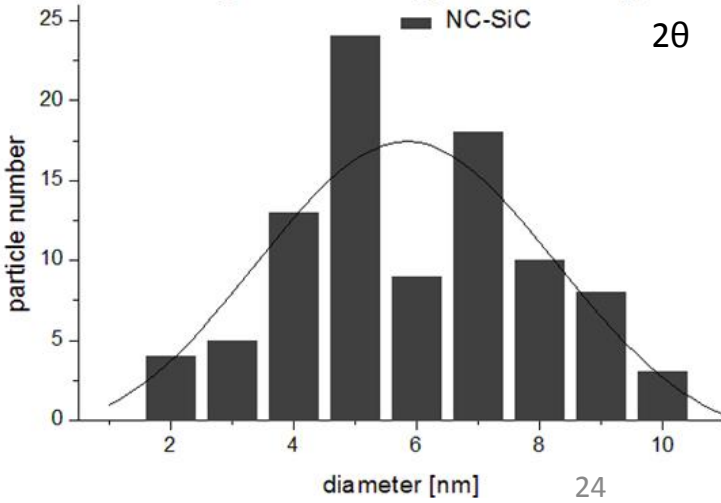
Beke, Szekrényes et all**: Characterization of luminescent silicon carbide nanocrystals prepared by reactive bonding and subsequent wet chemical etching**. APL; Subm.: 2011, 09, 16,

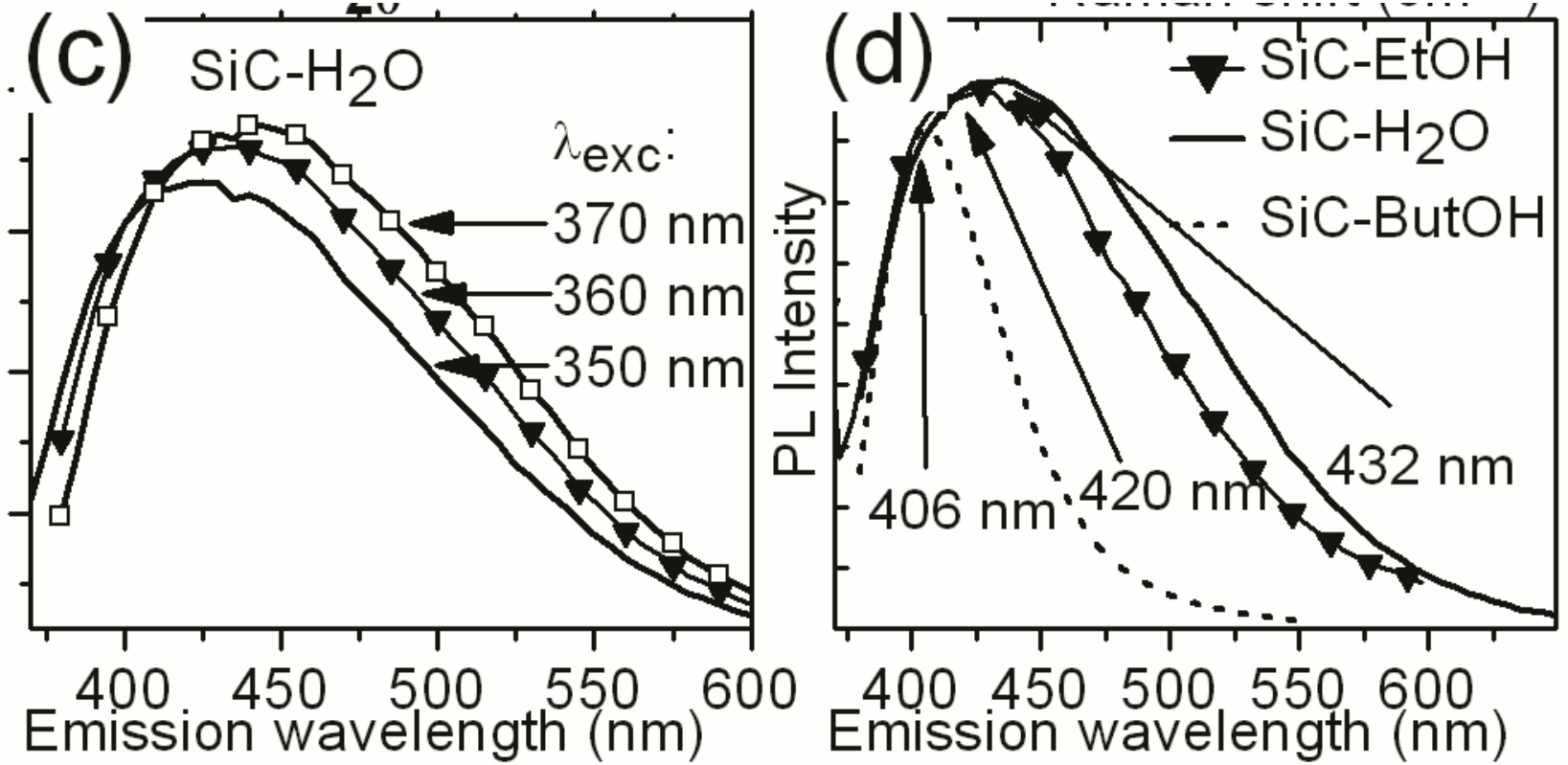




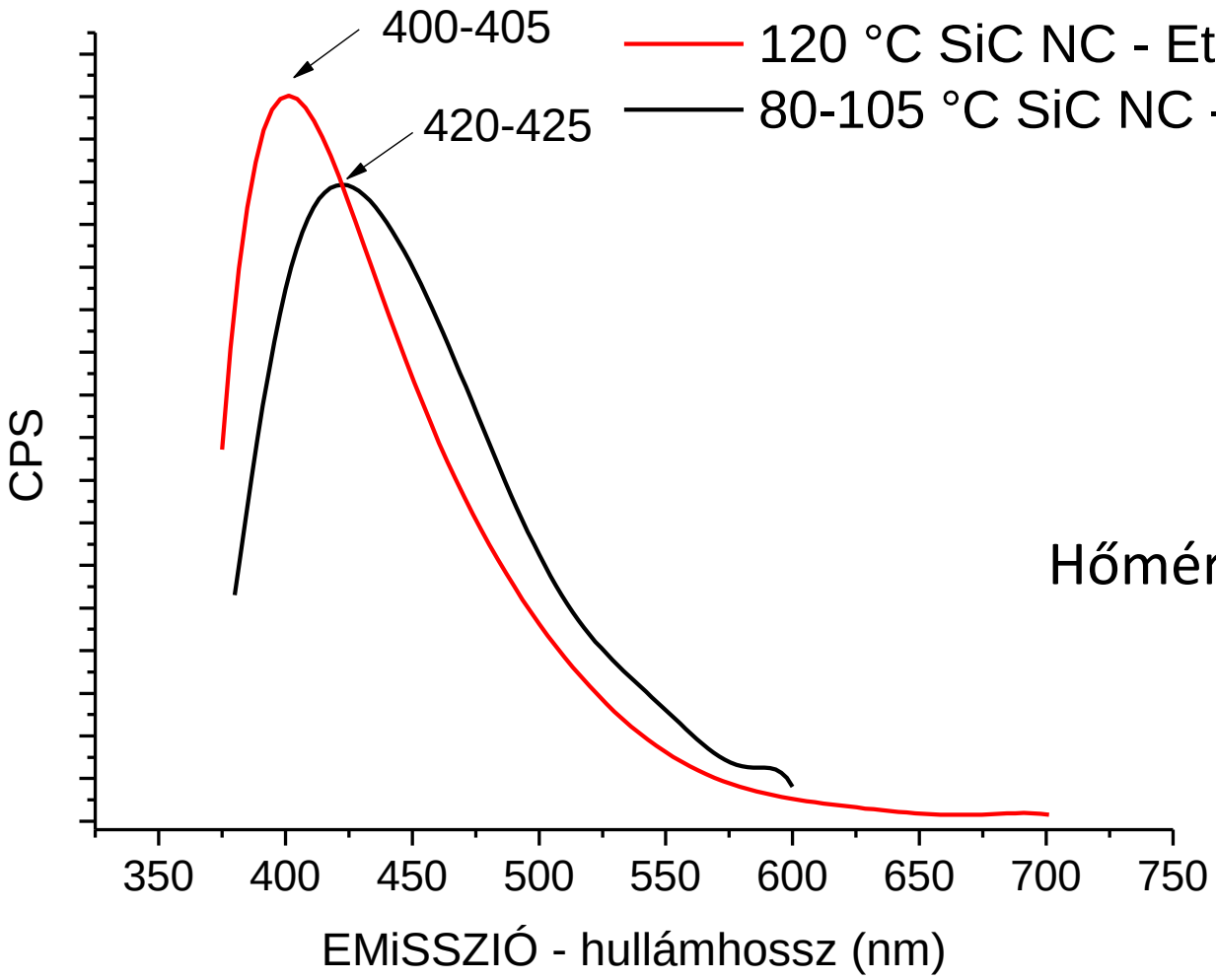


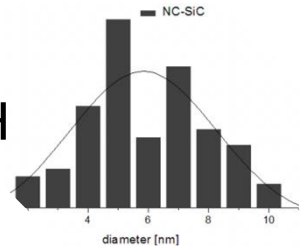





(c)
SiC-H2O
λexc:
370 nm
360 nm
350 nm
400 450 500 550 600
Emission wavelength (nm)
(d)
SiC-EtOH
SiC-H2O
SiC-ButOH
PL Intensity
406 nm
420 nm
432 nm
400 450 500 550 600
Emission wavelength (nm)

Hőmérséklet - ”átmérő” összefüggés

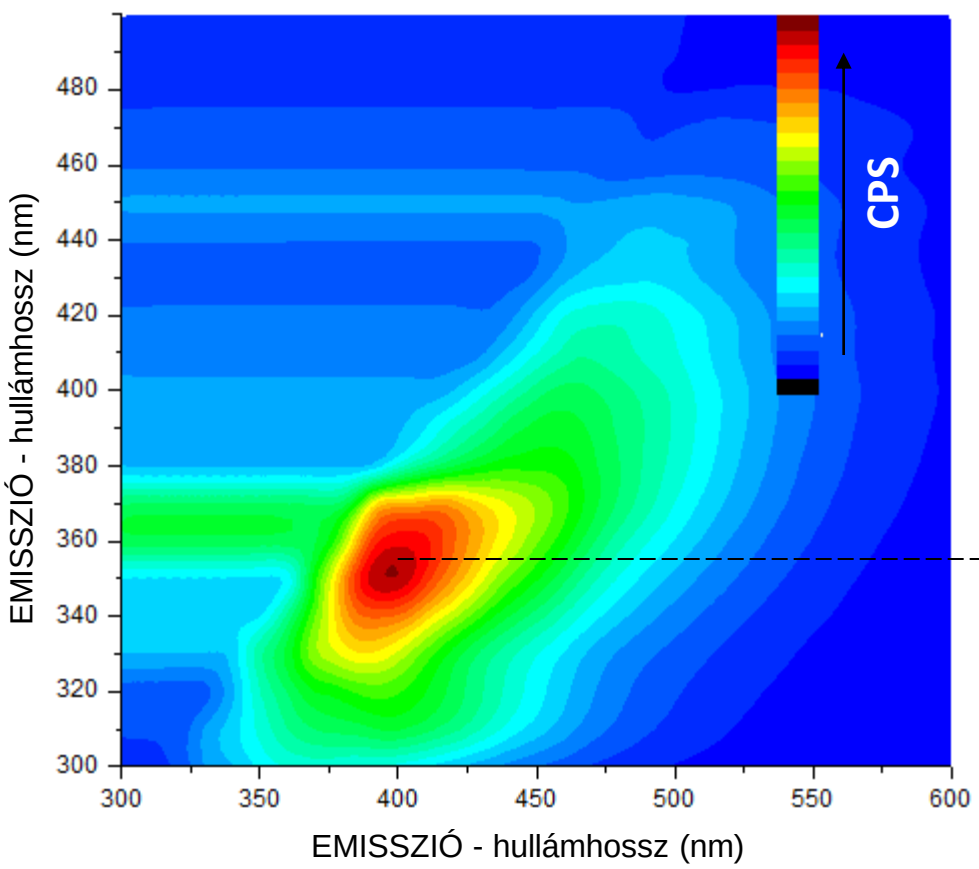


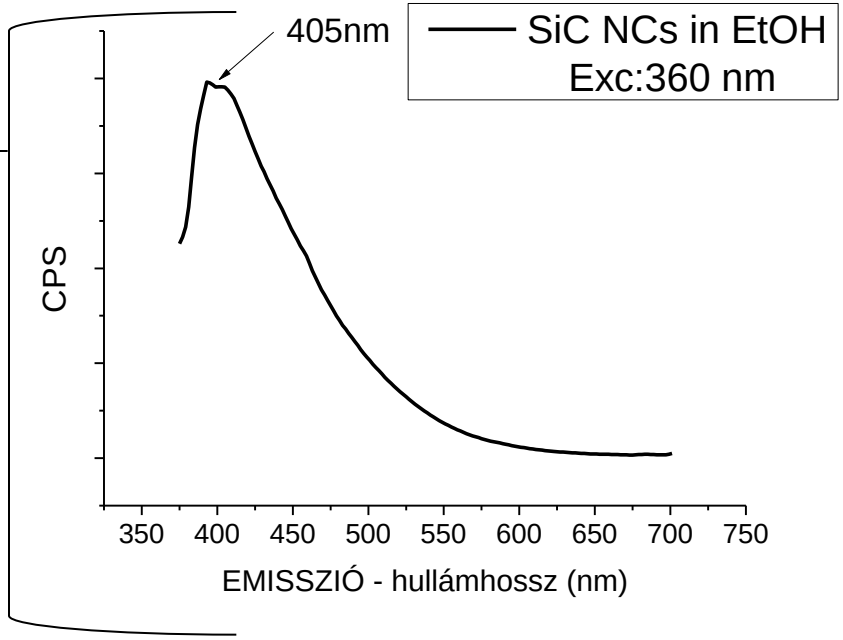


Hőmérséklet növelése:

Rendszer:
nyilt → zárt

SiC NC – etanol kolloid





C= 0,5mg/ml

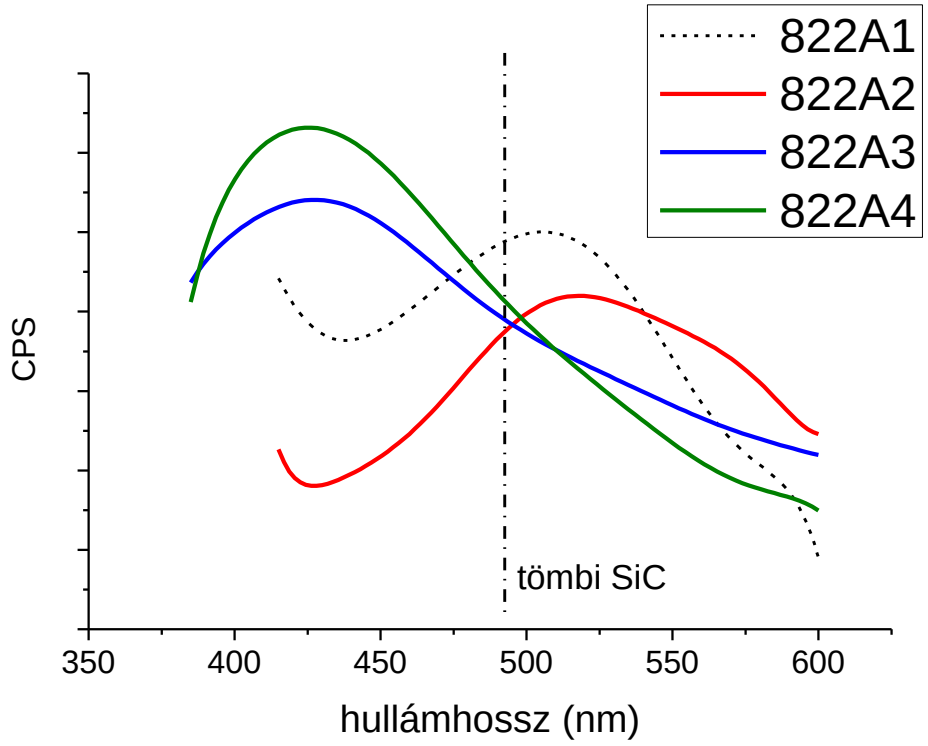
SiC „fogyás”: 200mg/g

Teljes kitermelés kb 1mg/100mg

EMISSZIÓ - Hullámhossz (nm)

Eredmény: méret szerinti szeparálás

Polinorm. Illesztett görbék, A1-3 A4-hez normálva.



A1: 1,5h pörgetés utáni (alsó 3mll)
A2: 8h pörgetés pellet rázva
A3: 8h pörgetés alsó 3 ml
A4: 8h pörgetés felülúszója