National Institute of Materials Physics

Nanoclusteri magnetici sintetizati printr-o noua metoda de agregare in vid ultrainalt; aplicatii in nanoelectronica si nanomedicina

Ovidiu Crisan

Institutul National de C-D pentru Fizica Materialelor, Magurele, Ilfov

OBIECTIV:

Arhitecturi nanometrice hibride realizate prin asamblarea atom cu atom sau molecula cu molecula in unitati constructive pentru nanodispozitive inovative

Sinteza nanoclusterilor metalici / oxidici printr-o metoda inovativa de agregare de clusteri

Functionalizare in-situ prin adaugarea de atomi sau diverse molecule pe suprafata clusterilor astfel formati.

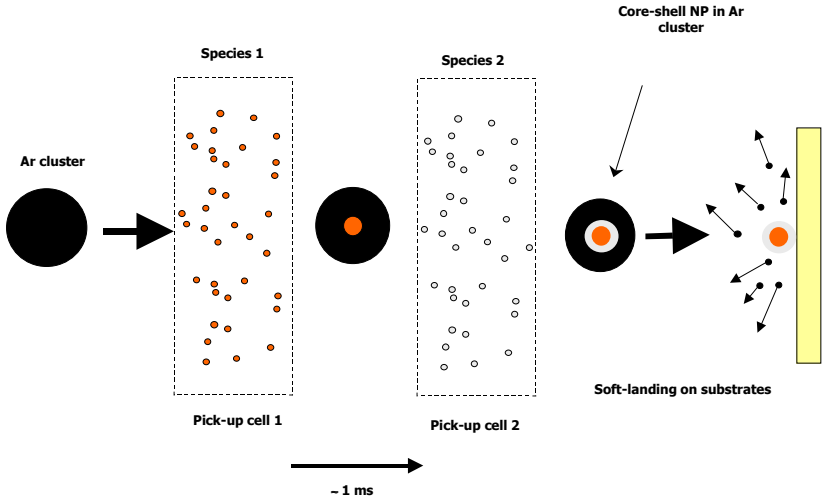
CUPRINS:

- **Principiul metodei si schema facilitatii**
- **Nanoclusteri de Fe: sinteza, structura and morfologia**
- **Nanoparticule core-shell Fe/Fe oxid**
- **Functionalizare pentru diverse aplicatii**
- **Concluzii si output stiintific**

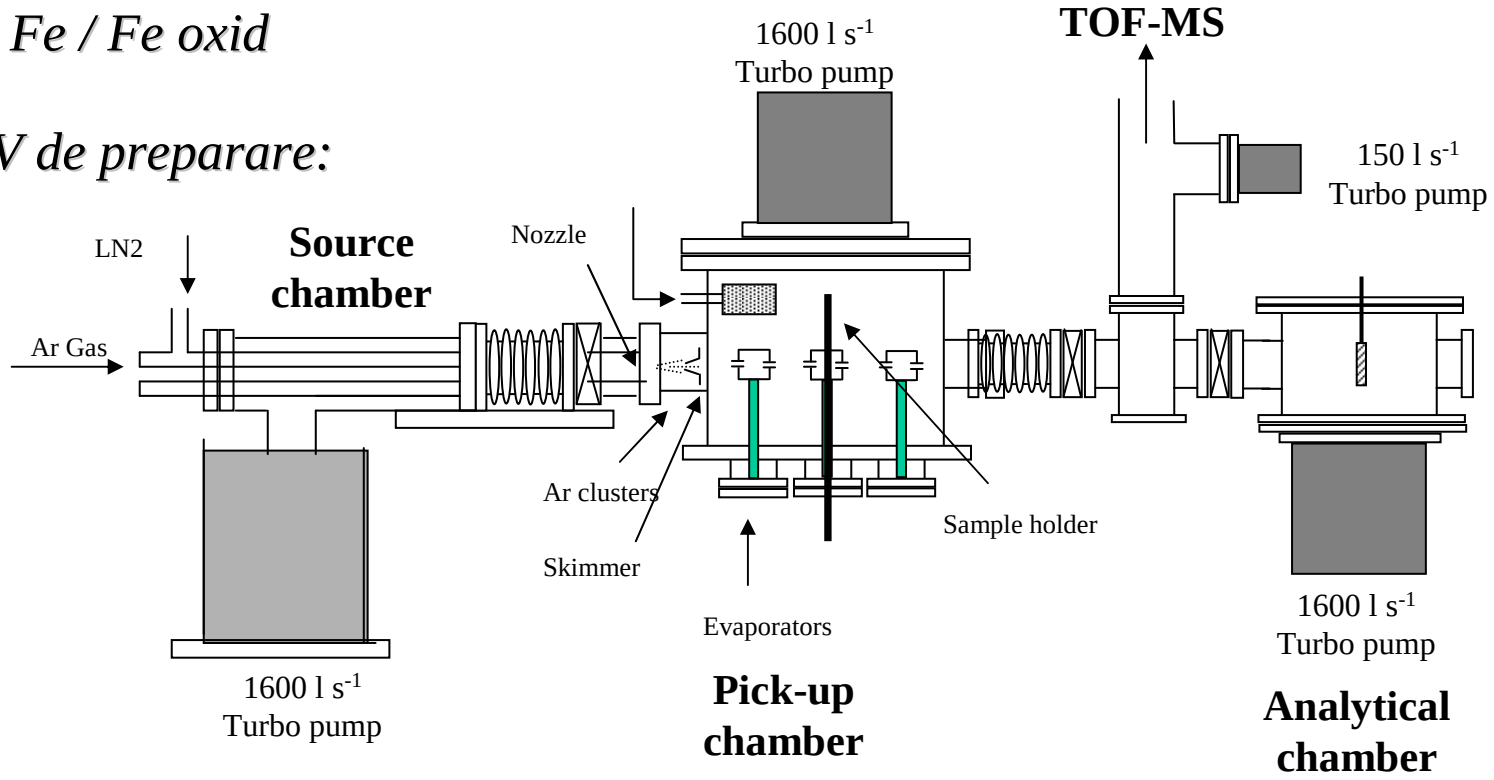
Nanoclusteri metalici core-shell

Principiul de sinteza:

- *O metoda mixta de agregare de clusteri si agregare in gaz cu condensare succesiva*
- *Instalatie UHV multi-chamber cu evaporatoare in linie*
- *S-au obtinut nanoclusteri de Fe metalic si Fe / Fe oxid*



Instalatia UHV de preparare:



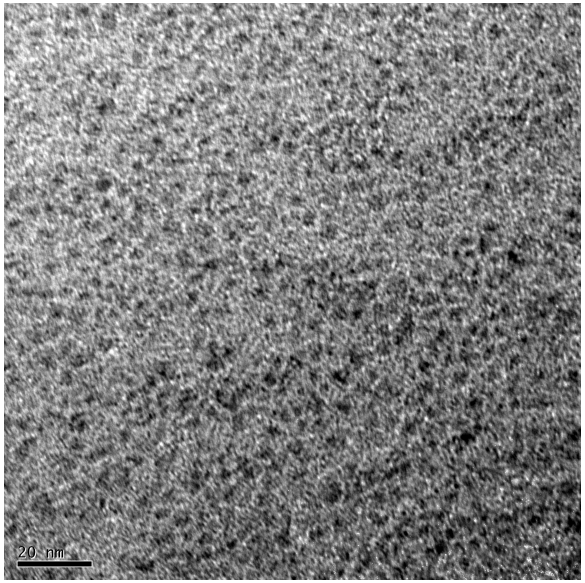
Conditii de sinteza :

- Substrates: TEM grids: 300 mesh Cu coated by C film
- Initial pressure: 10^{-7} -10^{-8} mbar (depending on T)
- Ar gas pressure: 10^{-3} mbar
- Cold nozzle (LN_2)
- Metal evaporators: carefully out-gassed
- Crucible temperature: varied between 1400K and 1500K
- Metal vapor pressure: varied between 10^{-5} and 10^{-4} mbar
- Exposure time: 5 minutes
- Nozzle xyz position and distance to crucible: optimized

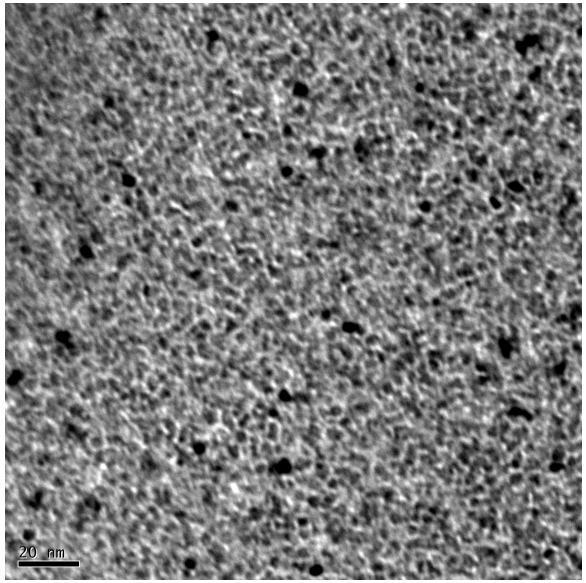
Analiza structurala si magnetica:

- Transmission electron microscopy (TEM):
- Electron diffraction patterns (EDP):
- Atomic force microscopy (AFM):
- Vibrating sample magnetometry (VSM):

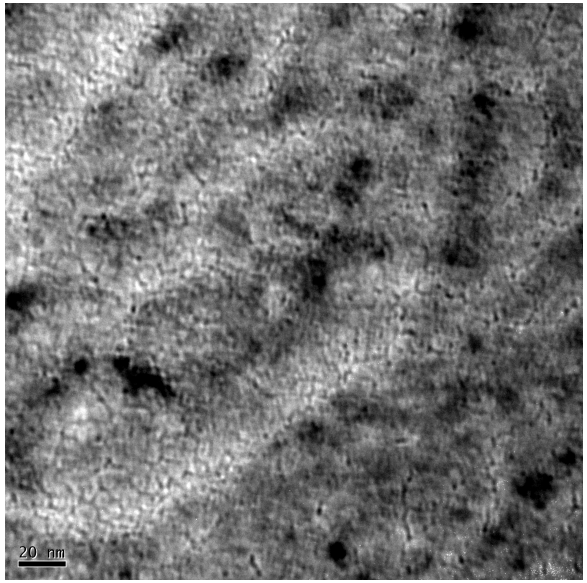
Influenta presiunii de vapori metalici: Imagini TEM ale nanoclusterilor de Fe



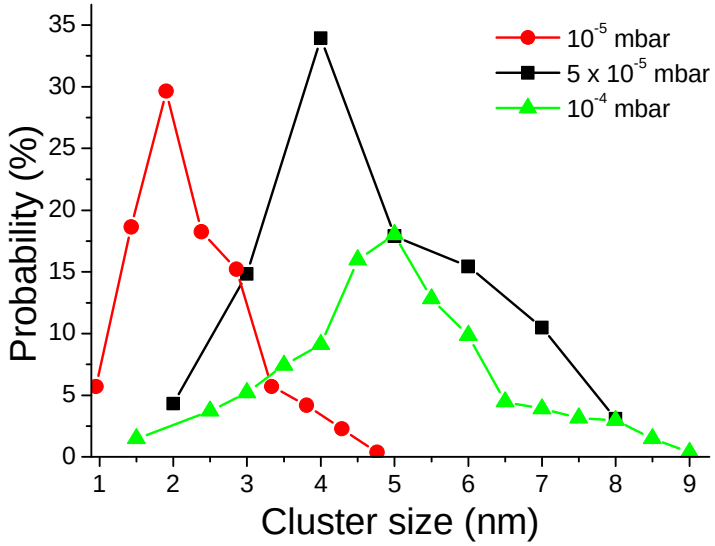
10^{-5} mbar

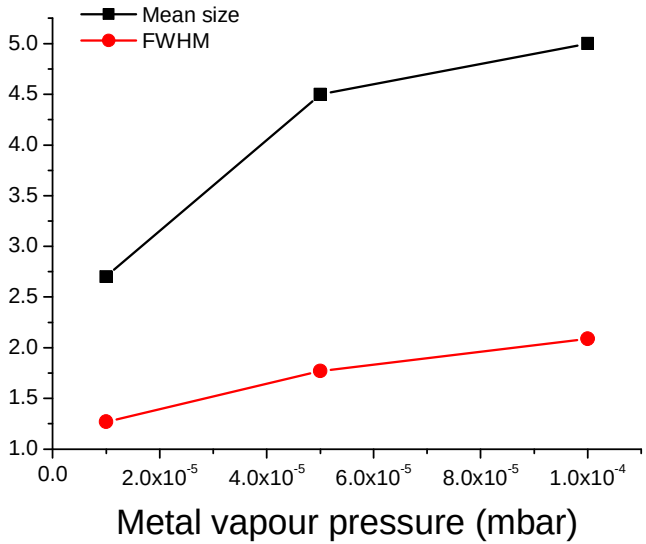


5×10^{-5} mbar

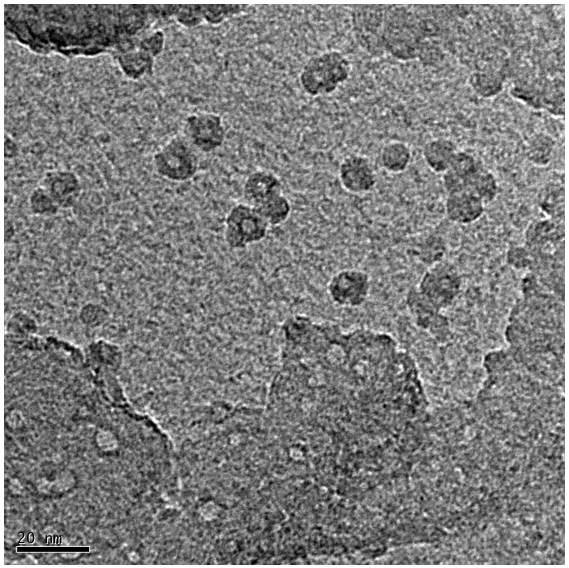


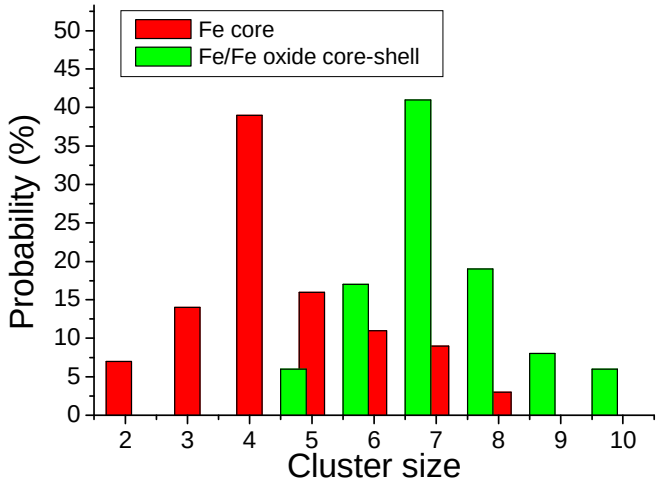
10^{-4} mbar



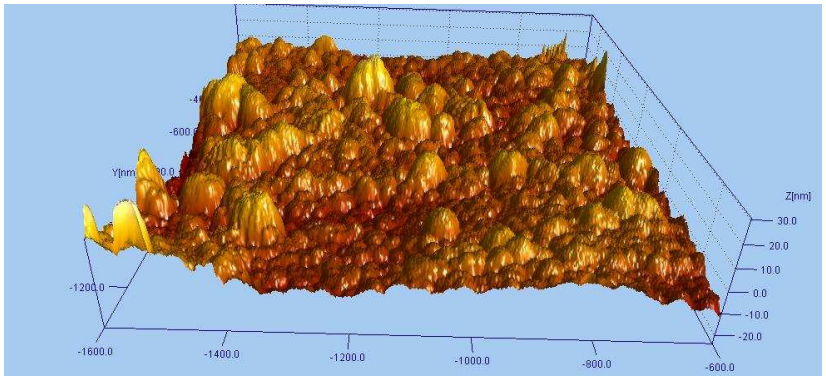


Caracterizare structural-morfologica





Fe / Fe oxid



AFM: mecanism columnar de crestere a nanoclusterilor (cca. 10 nm) periodicitate de 4 nm observata in profilul liniar

TEM: morfologie core-shell confirmata:

$d_{Fe} = 4.4$ *nm*, $d_{Fe/Feoxid} = 6.8$ *nm*

Dimensiunea tunabila prin presiunea partiala de oxigen + $T_{evaporator}$

Caracterizare magnetica

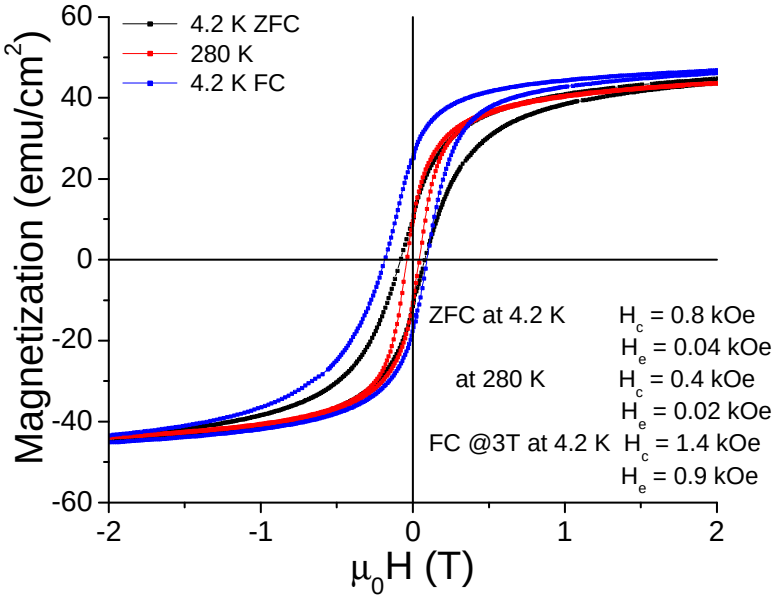
Exchange bias:
efectul de deplasare a campului coercitiv spre campuri negative in sisteme FM/AFM

$$H_e = \left(\left| H_c^- \right| - H_c^+ \right)$$

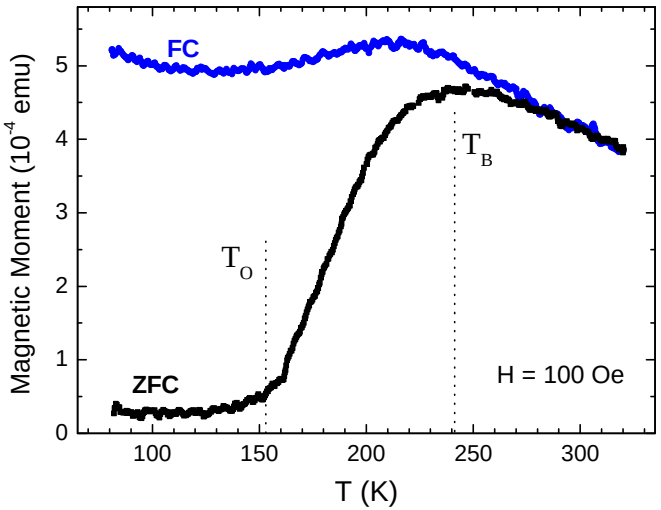
La 4.2K:
He = 0.9kOe
pt Fe / Fe oxid

He scade cu T ann pt Co / Co oxid: in proba netratata termic He = 1.5 kOe

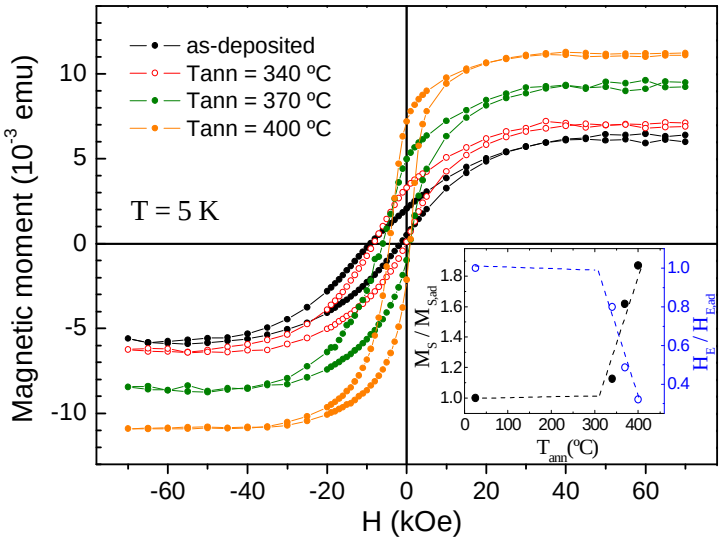
Fe / Fe oxid



Co / Co oxid

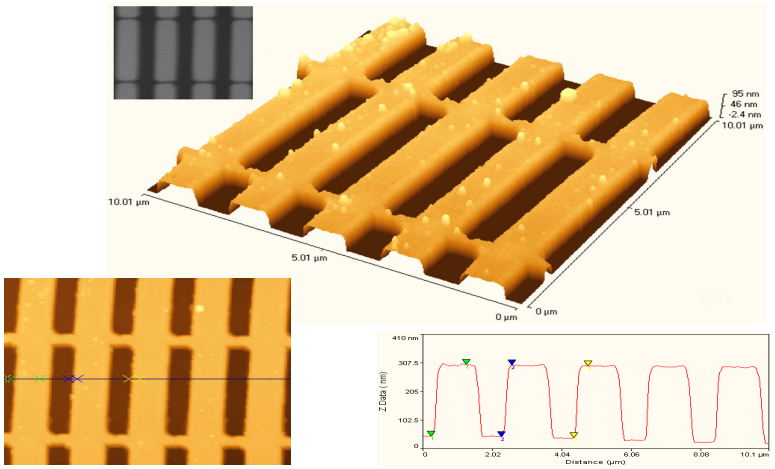


***Curbele de magnetizare** field-cooled (FC) si zero-field cooled (ZFC) pentru nanoparticulele core-shell Co/CoO*



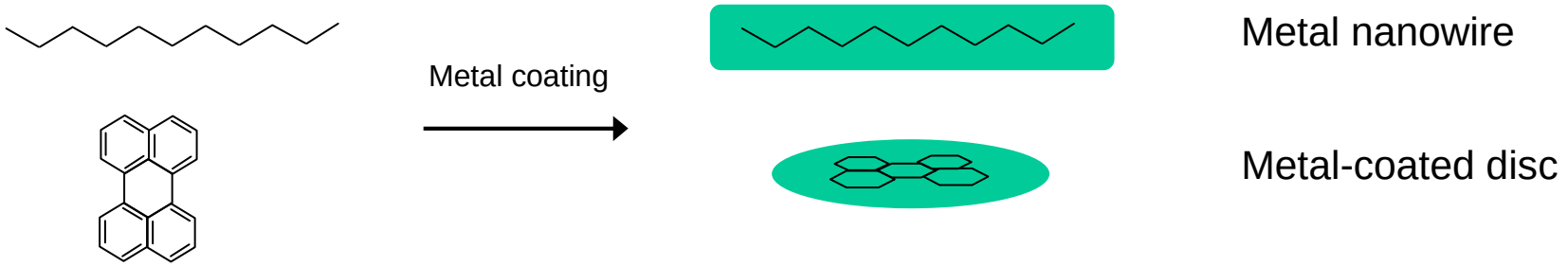
***Curbele de m**agnetizare pentru proba Co/CoO depusa in presiune de oxigen de 7×10^{-4} mbar, respectiv aceeasi proba tratata la 340ºC, 370ºC si 400ºC. In inset este prezentata evolutia campului de exchange-bias cu temperatura de tratament termic.*

Posibile aplicatii

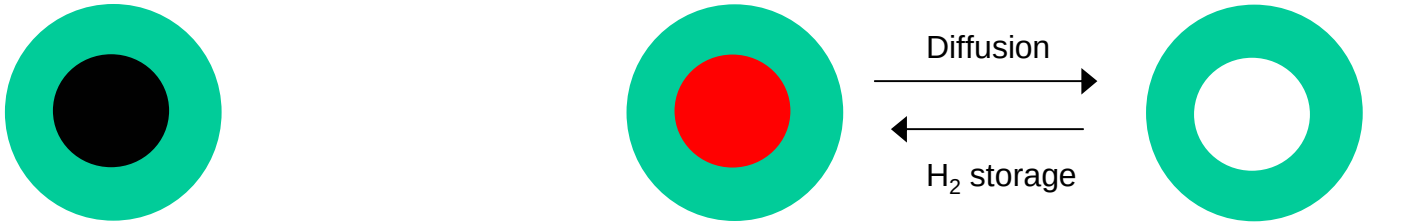


Pre-patterning

Template-assisted growth of shaped nanoparticles



Unusual cores



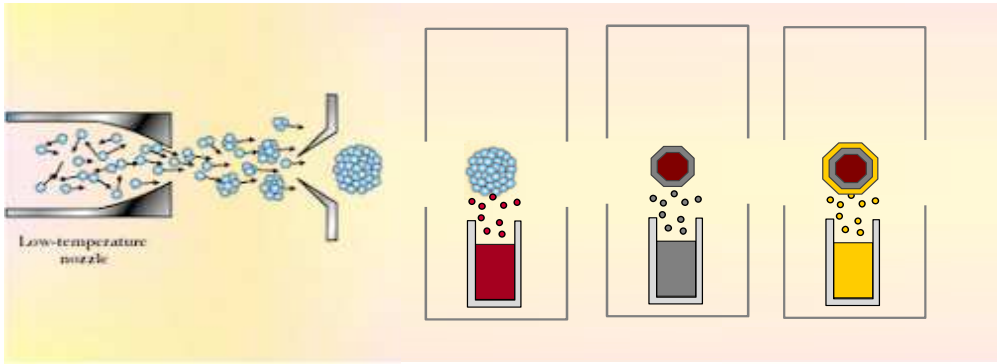
Liquid-filled (e.g. H_2O) core-shell nanoparticle

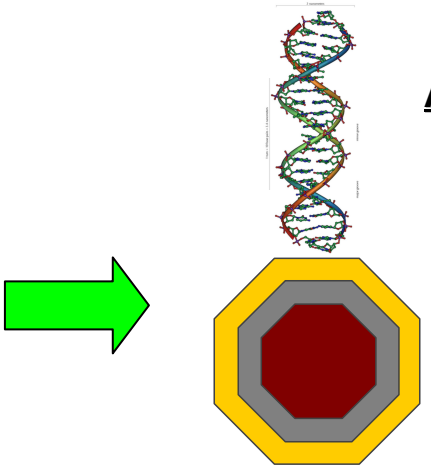
Solid shell, H_2 core

Hollow sphere

Functionalizare pentru aplicatii biomedicale

Multiple core-shell nanocluster





Aptamer

- **Functionalizare la suprafata cu anticorpi, acid folic, nucleotide**
- **Aptameri: proprietati de recunoastere moleculara**
- **Pot fi legati de o varietate de tinte moleculare: celule, tesuturi, etc.**
- **Aplicatii importante in terapia hipertermica (tratarea tumorilor prin incalzire localizata)**

Concluzii si output stiintific

- *Metoda de agregare in gaz / clusteri permite sinteza de nanoclusteri metalici de tip core-shell cu dimensiuni controlabile prin parametrii de sinteza*

- *Nanoclusterii de Fe si Fe / Fe oxid au fost sintetizati prin aceasta metoda si au fost caracterizati morfo-structural si magnetic*

- *Functionalizarea la suprafata, in decursul aceluiasi proces, prin atasarea de molecule variate pentru aplicatii in nanoelectronica si nanomedicina*

O. Crisan, K. von Haeften, A.M. Ellis, C. Binns, "Novel gas-stabilized iron clusters: synthesis, structure and magnetic behaviour", *Nanotechnology*, 19 (50) 505602 (2008)

O. Crisan, K. von Haeften, A.M. Ellis, C. Binns, "Structure and magnetic properties of Fe/Fe oxide clusters", *Journal of Nanoparticle Research* 10 (2008) 193-199

J. P. Andrés, J. A. González, J. A. De Toro, P. Muñiz, T. Muñoz, O. Crisan, C. Binns, J. M. Riveiro „Co-CoO Nanoparticles Prepared by Reactive Gas Phase Aggregation", *Journal of Nanoparticle Research* 11 (2009) 2105-2111

K. von Haeften, C. Binns, A. Brewer, O. Crisan, P.B. Howes, M.P. Lowe, C. Sibbley-Allen, S. Thornton, "A novel approach towards the production of luminescent silicon nanoparticles: Sputtering, gas aggregation and co-deposition with H_2O", *European Physical Journal D* , 52 (1-3) (2009) 11-14

Co-workers:

Chemistry, Univ. Leicester, UK

Dr. Andrew M. Ellis

Physics, Univ. Leicester, UK

Prof. Chris Binns
Dr Klaus von Haeften
Stuart Thornton

- Dr. M. Angelakeris and K. Simeonidis, Dept. of Physics, Aristotle University of Thessaloniki, Greece