# Chemistry And Biological Effects Of Germanium Oxide Nanoparticles

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*Under the supervision of*

**Thibaud Coradin**

# Nanomaterials And Biology

## FOOD INDUSTRY

Pesticides
Packaging
Silver nanoparticles (AgNPs)

## HEALTH CARE

Cosmetics
Disinfectant
Zinc oxide nanoparticles

## NANOMEDICINE

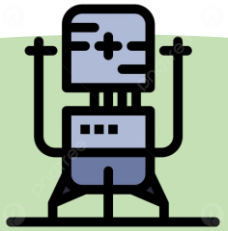
Diagnostic and drug delivery
Gold nanoparticles (AuNPs)

## BIOLOGICAL MODELS

Cell culture,
Animal and Tissues
Iron oxide nanoparticles

## ENVIRONMENT

Waste water treatment and sensing
Titanium dioxide nanoparticles

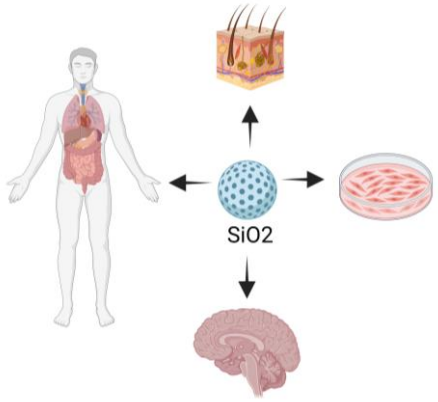


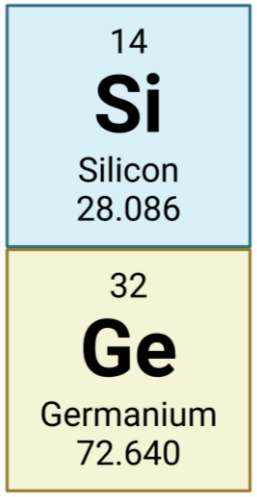
## ANALYSIS

Reporter cell
Organ on chip
Gold, silica, or polymeric NPs

Murphy et al. *ACS Cent Sci* (2015)

# Germanium Oxide vs. Silica

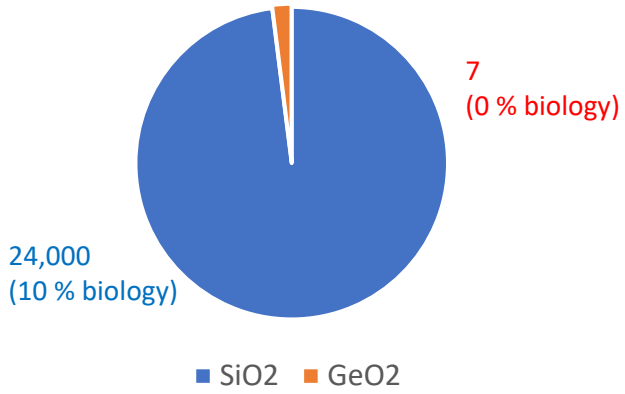



**Glass**

**Electronics**

No of articles on nanoparticles
(5 yrs source: WOS)



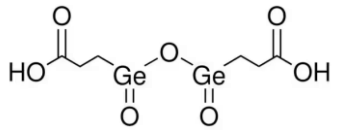

Bitar et al 10.1016/j.drudis.2012.06.014

## Ge in medicine

*scarcely studied*

in blood *ca.* **2 µM**
toxicity level **:** **$Ge(OH)_4$ unknow**

**nutritional additive:** (G-132)




Luo et al. *J Transl Med* (2023)

## Chemical Properties of Ge vs Si

Same electronegativity

pKa (Ge-OH) = pka (Si-OH)

**BUT...**

R(Ge) > R (Si)

- **Easier formation of coordination complexes**
- **More reactive metal alkoxides**
- **Crystalline vs amorphous nanoparticles at RT**

Pokrovski et al. *Geochim Cosmochim Acta* (1998)
Krishnan et al. *J Phys Chem B* (2007)

**Objective:** ***To study the interaction between $GeO_2$ nanoparticles and living system***

**Synthesis And Characterization Of GeO2 Nanoparticles**


**Techniques :**
*Size: SEM/TEM/DLS/AFM;*
*Structure: XRD;*
*Surface: Zeta potentiel, XPS*

**Surface Functionalization**
*Grafting of Aminosilanes, Grafting of sulfonates*

**Biological Studies**

**Further Studies**

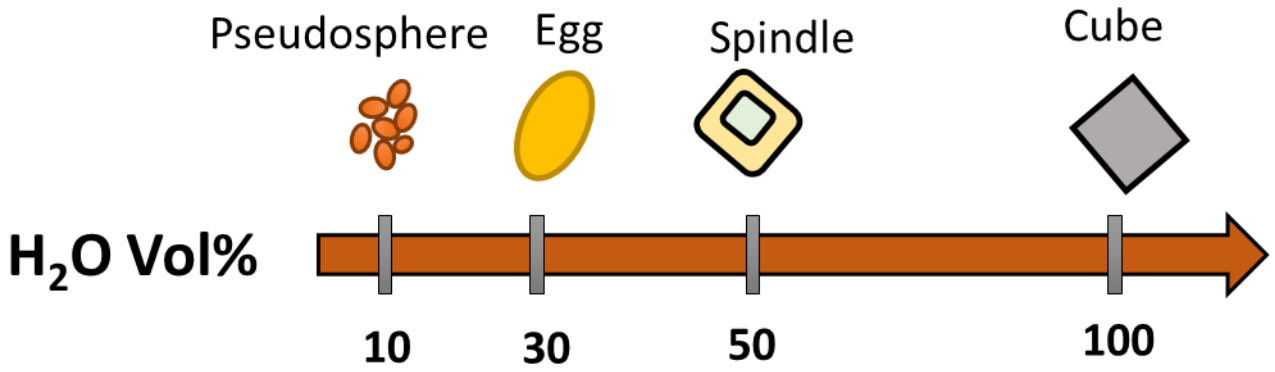
**(Based on Biological outcomes)**

01
02
03

Ji Y., Yang S. et al 10.3390/jfb14030154
Javadi M et al 10.1039/c4cc01490a
Chen D.G. et al 10.1016/0022-3093(94)90277-1.
Davis T.M.S. et al 10.1021/la702526c.

# EFFECT OF SOLVENT ON SHAPE OF $GeO_2$

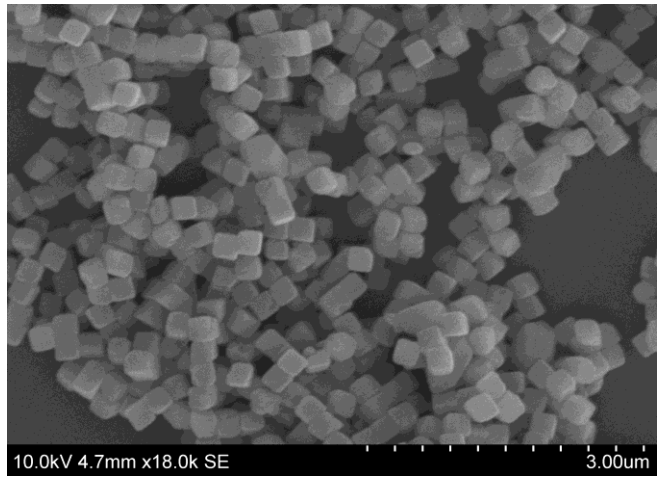
Different shapes of $GeO_2$ nanoparticles were obtained by varying the ethanol-to-water ratio

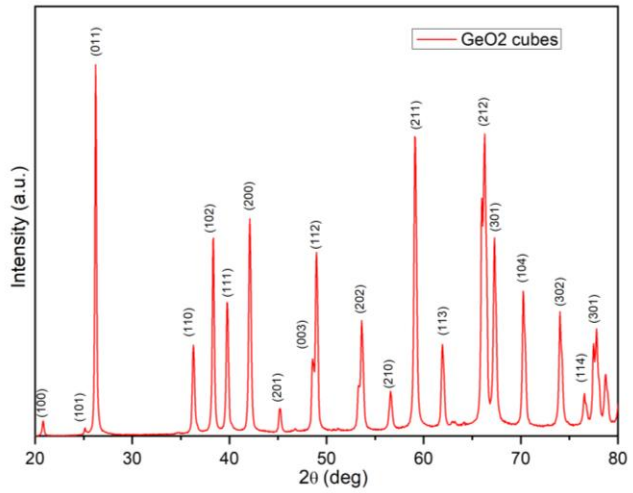



Javadi et al. (2014). *Chem. Commun.*, 50, 6101

| Water (%) | Ethanol (%) | Shape of $GeO_2$ Nanoparticles |
|---|---|---|
| 10 | 90 | Pseudo-spheres |
| 30 | 70 | Eggs |
| 50 | 50 | Spindles |
| 100 | 0 | Cubes |

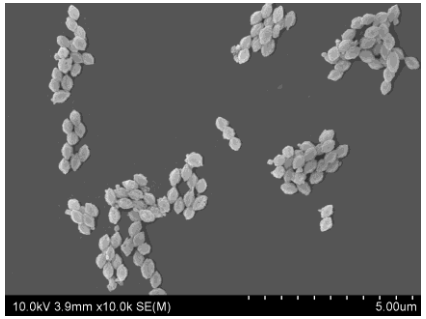
## $GeO_2$ Cubes

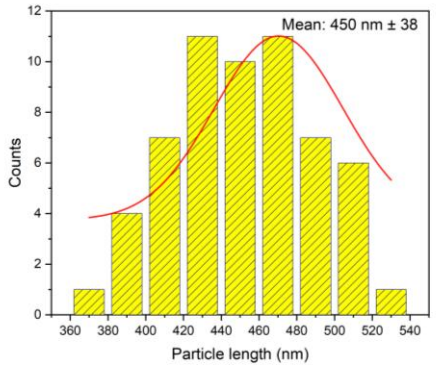


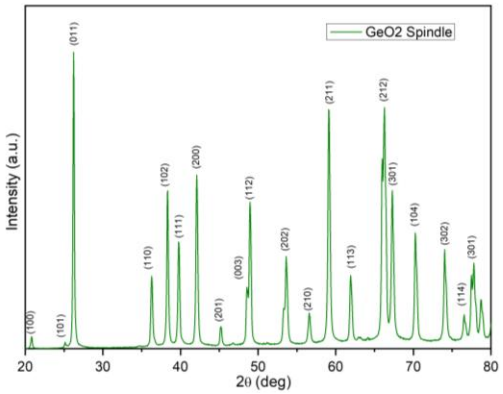




**crystallite size-Cubes: 35 nm**

## $GeO_2$ Spindles

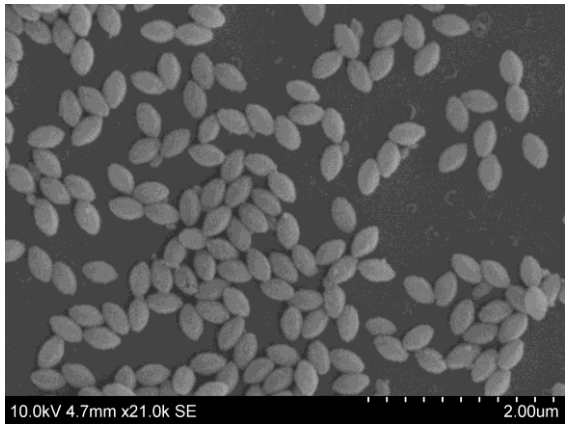


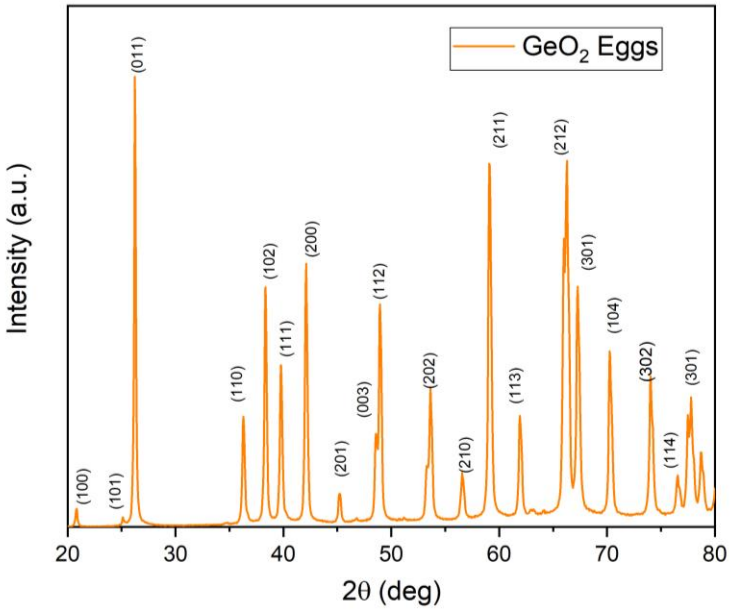




**crystallite size-Spindles: 42 nm**

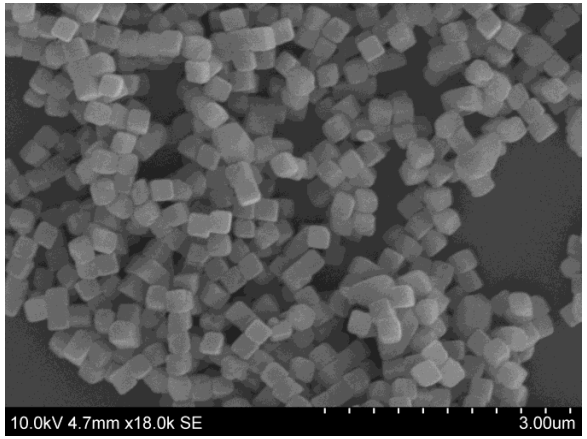
## $GeO_2$ Eggs

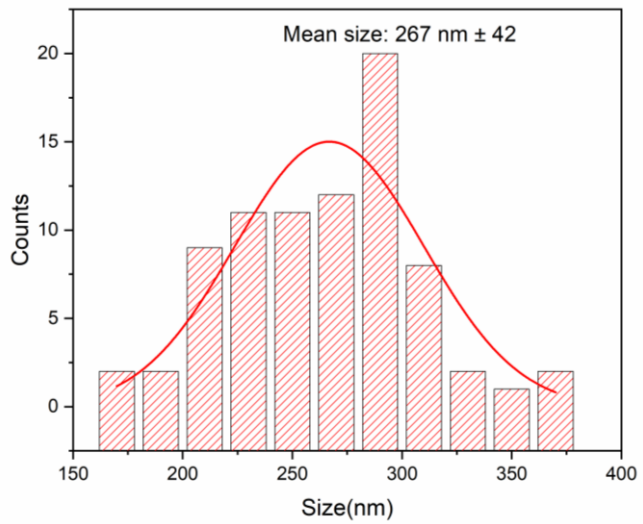


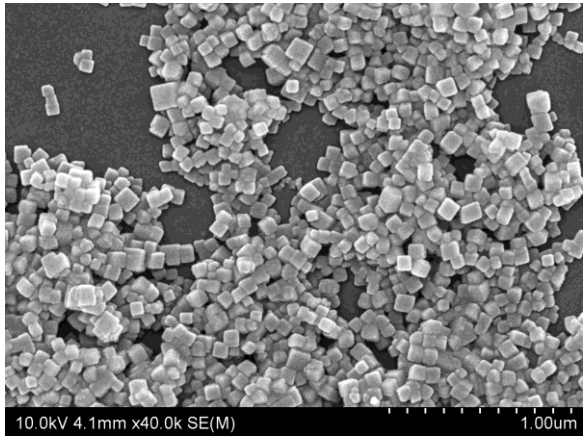

**crystallite size-Eggs: 38 nm**

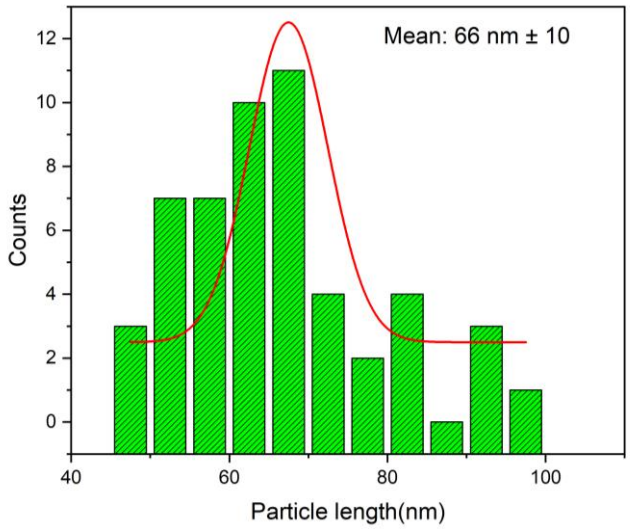
# Size comparison -Cubes



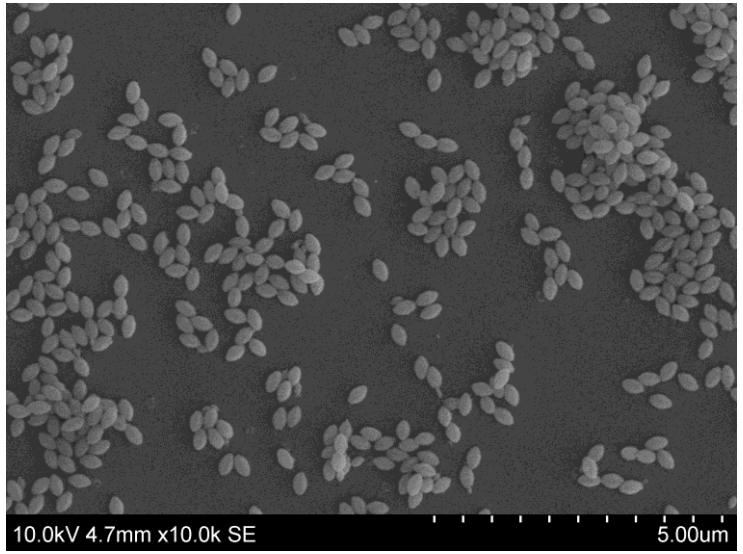

Cubes- Germanium Ethoxide

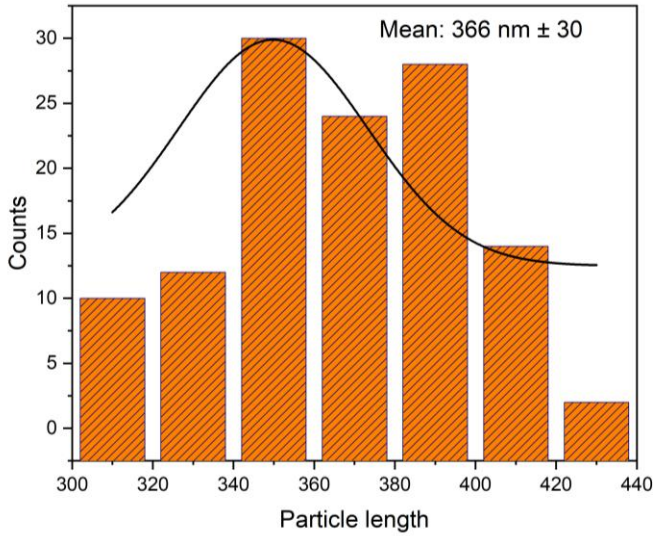


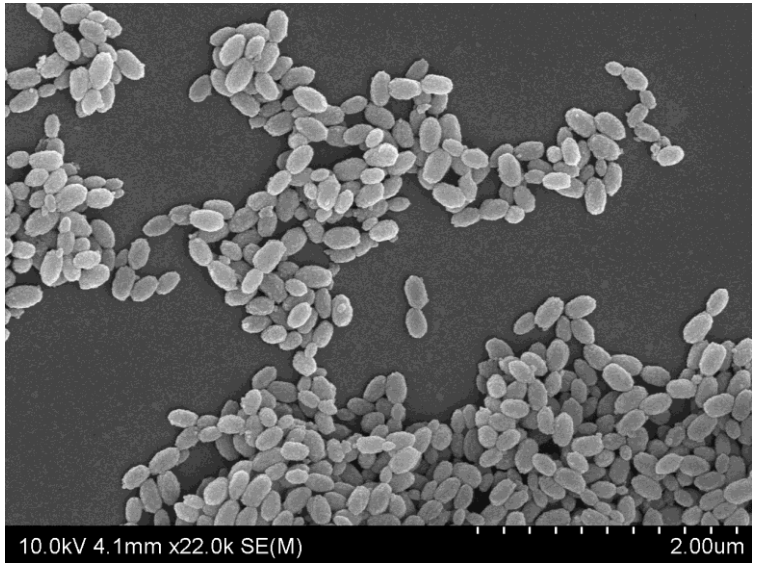

Cubes- Germanium isopropoxide

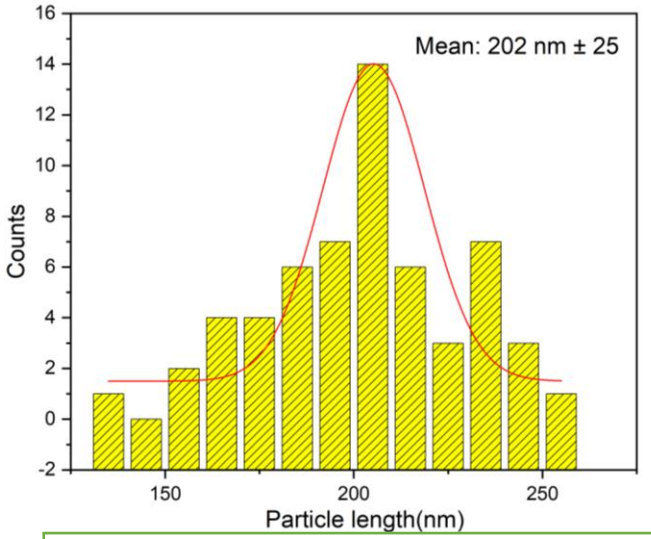
# Size comparison - Eggs



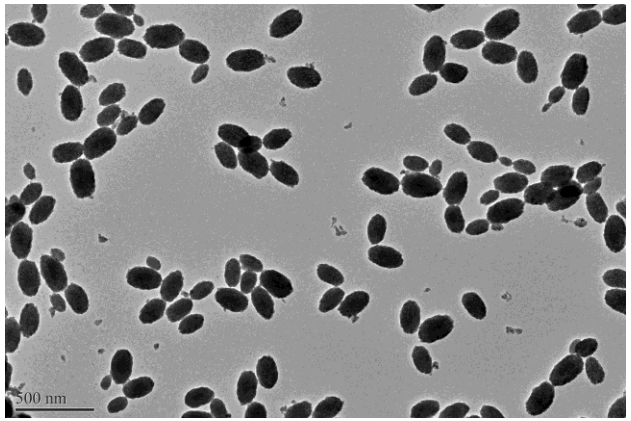

Eggs- Germanium Ethoxide

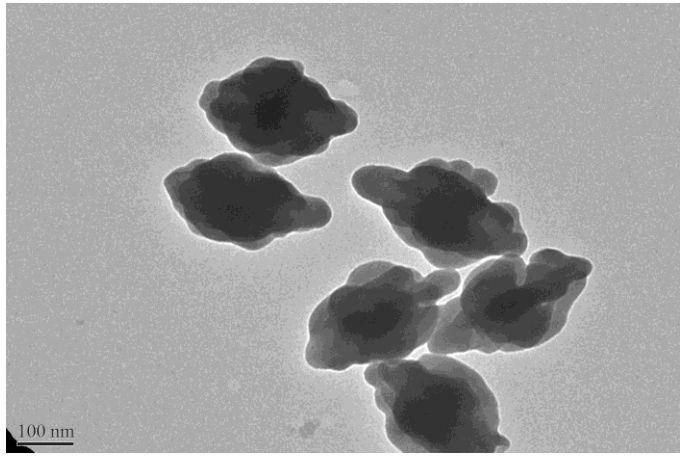


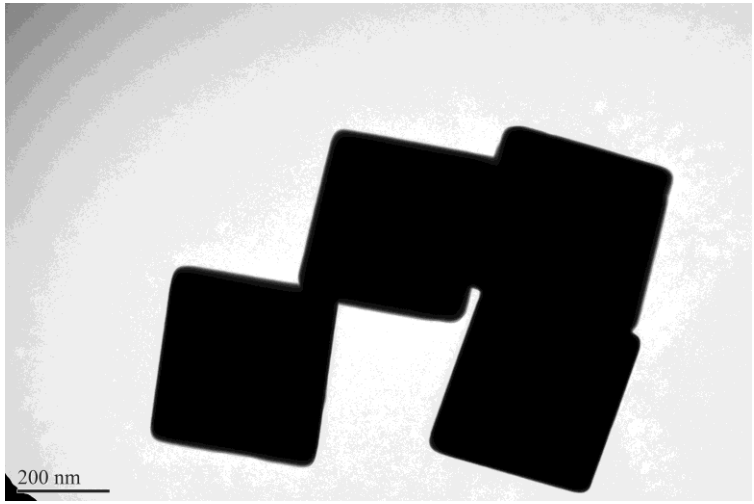



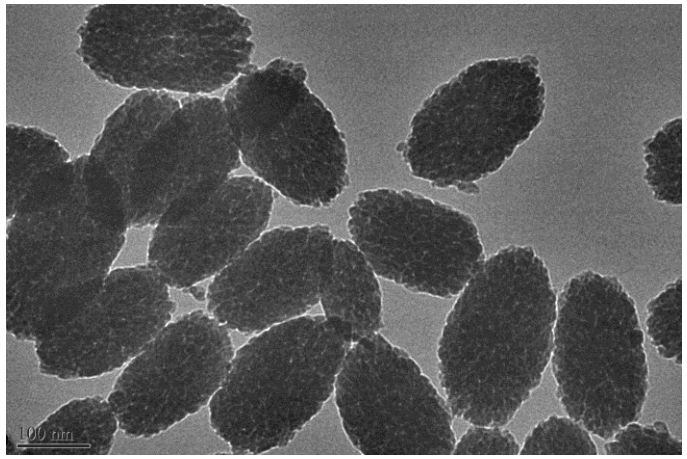

Eggs- Germanium isopropoxide

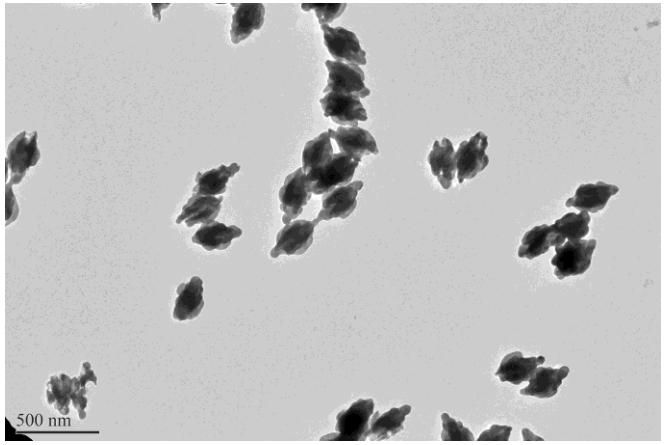
# TEM

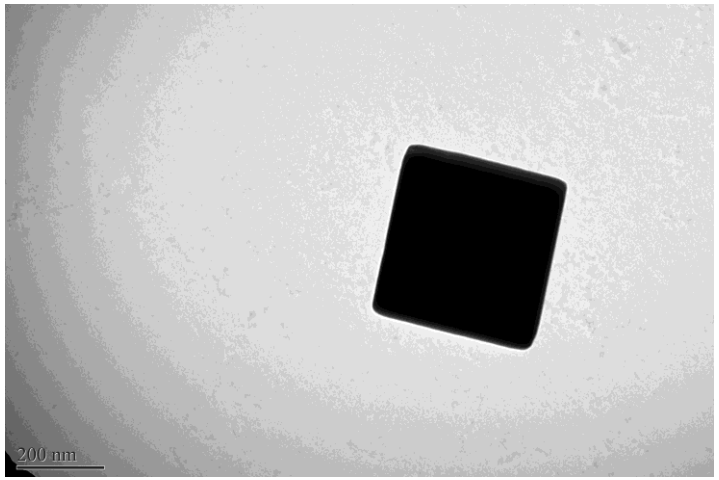


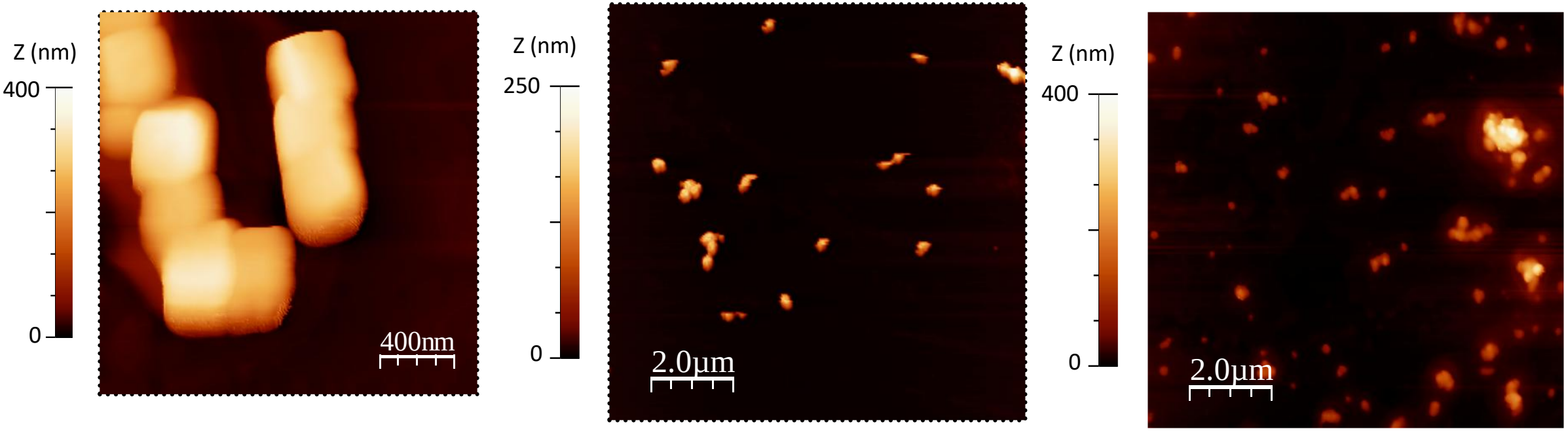



# ATOMIC FORCE MICROSCOPY (AFM)

Université Paris Cité
ITODYS
Nicolas Battaglini

Topography



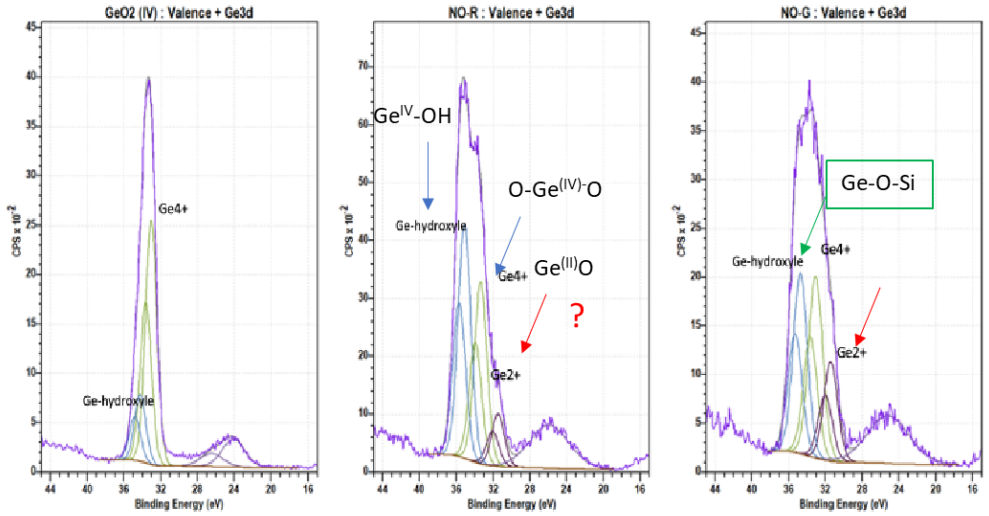

*Early AFM study Confirm the size distribution obtained in SEM and TEM*

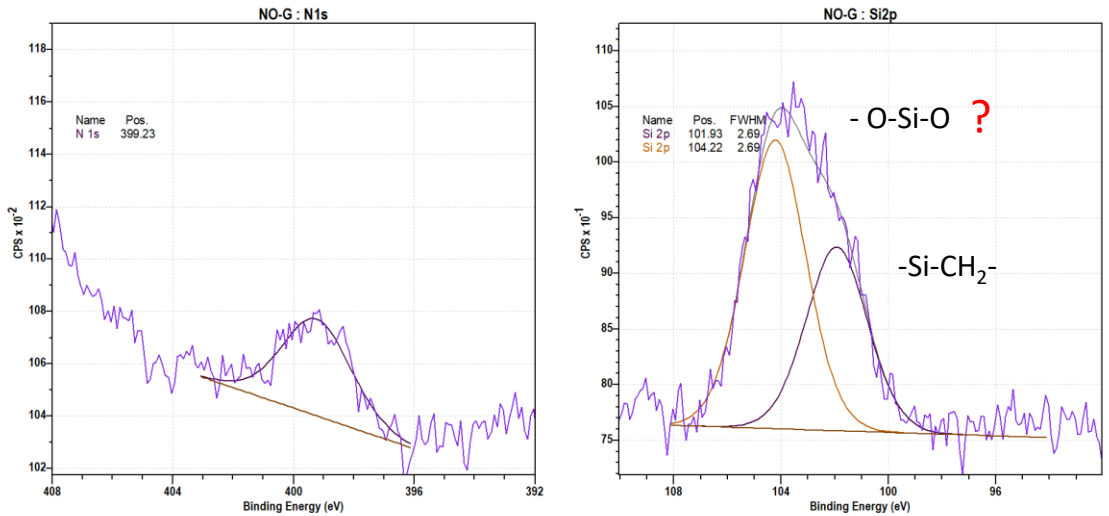
# X-RAY PHOTOELECTRON SPECTROSCOPY (XPS)

J. Allouche, P. Bargiela, D. Foix

## $Ge3d_{5/2,3/2}$ Spindles

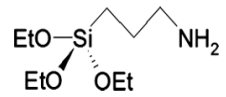
**Reference** **Spindle** **Grafted spindle**




- ✓ Presence of $Ge^{(II)}$ Oxidation state before grafting
- ✓ The intensity of $Ge^{(II)}$ increased after grafting.

| Sample/At Conc (%) | [C] totale | [O] totale | [Ge] totale | O-Si-CH | SiO2 (Si 4+) | [N] |
|---|---|---|---|---|---|---|
| GeO2(Ref) | 26.2 | 48.4 | 25.4 | x | x | x |
| Spindle | 4.9 | 60.2 | 34.9 | x | x | x |
| Grafted spindle | 14.5 | 53.7 | 26.7 | **1.3** | 2.1 | **1.7** |




$O\text{-}Si\text{-}(CH_2)_3\text{-}NH_2\text{--} \rightarrow \quad O\text{-}Si\text{-}O$

# Thank You

Vikraman Navibaskar