



UNIVERSITÀ DEGLI STUDI DI NAPOLI  
FEDERICO II



Maria Alessandra Cutolo

Optoelectronic system for liquid phase  
biopsy based on fiber optic technology

Tutor: Prof. Giovanni Breglio

Cycle: 36°

Year:2021/2022

# My background

- **M.Sc. in Electronic Engineering – 12th July 2019**

Thesis title: "Lab-on-Fiber" thermo-plasmonic platforms for the localized release of drugs.

Tutors: Prof. Giovanni Breglio, Prof. Andrea Cusano (University of Sannio, BN).

- **Research contract by Cerict (BN) – July 2019 to July 2021:**

- Development of thermo-plasmonic platforms with a view to the localized release of drugs through microgel.
- Design of a needle as an ultrasound probe for selective and localized destruction of cancer cells.
- Design and development of a barcode and QRcodes for a low cost wireless sensor for structural, medical and environmental monitoring.
- Design of an innovative in-line control system for soft tissue and bone drilling.

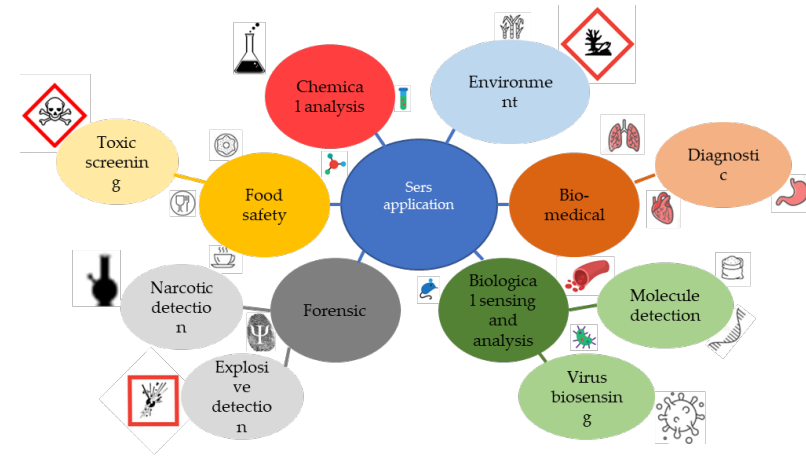
- **Ph.D. started in Nov 2020 (XXXVI cycle):**

Title: Optoelectronic system for liquid phase biopsy based on fiber optic technology

Tutors: Prof. Giovanni Breglio

# Objective

*Development of SERS-active substrates highly sensitive, uniform and cost-effective*

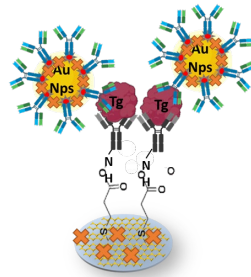
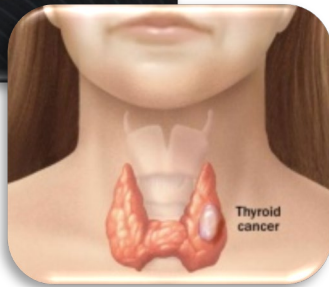


*Surface enhanced Raman spectroscopy (SERS) is a powerful analytical technique based on inelastic scattering of photons interacting with matter that can be used for material identification and analysis*

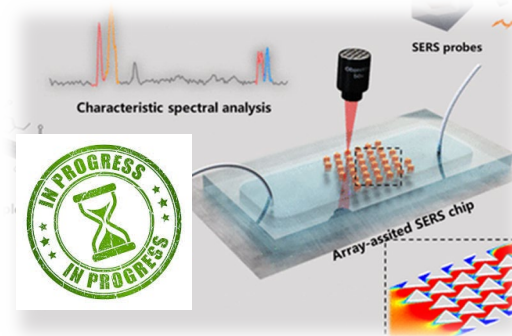
# Motivations



*Liquid biopsy in a smart needle*

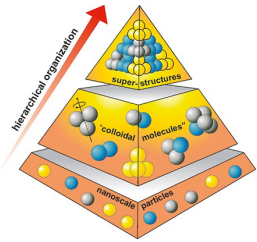


*Point of Care (POC) diagnostic devices*

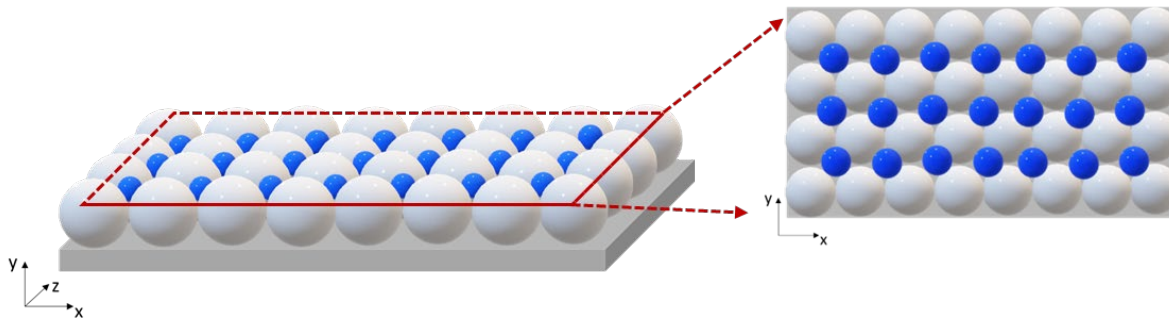


# Proposed Substrate

## Hierarchical binary structure:

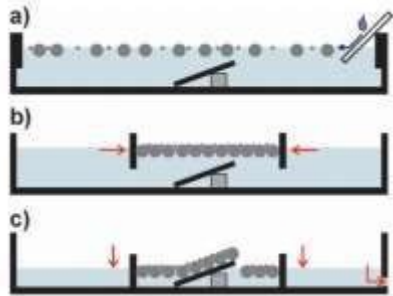
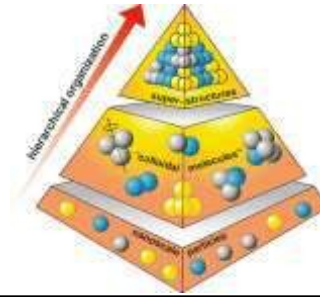
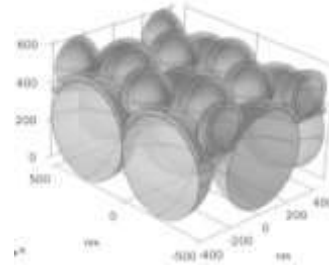


- layer of big spheres periodically patterned on the surface of which there is a second layer of spheres, proportionally reduced in size (Polystyrene).
- Coated with 30nm of gold film .



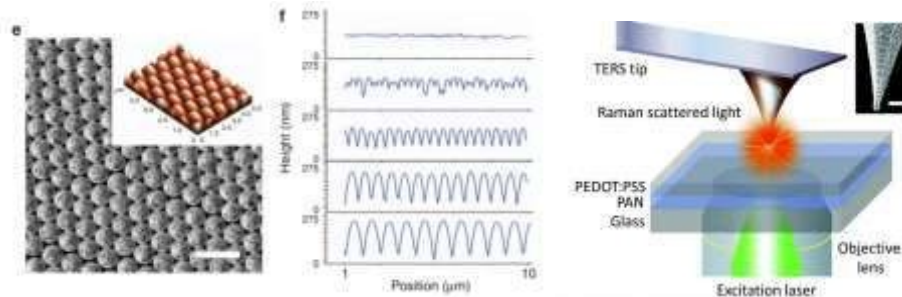
# Methodologies:

Design of SERS substrate in *Comsol Multiphysics*



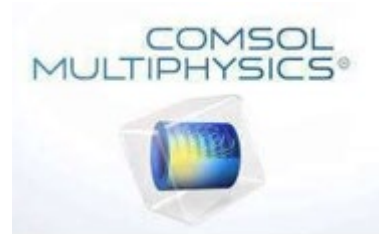
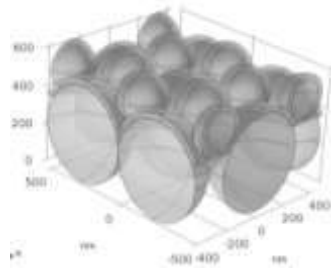
Fabrication through *self-assembly* methodology

Characterization with *AFM, SERS* and spectral acquisition



# Results:

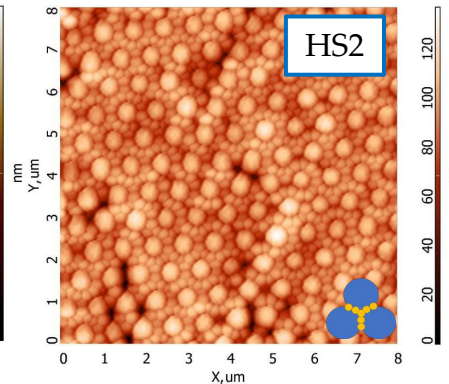
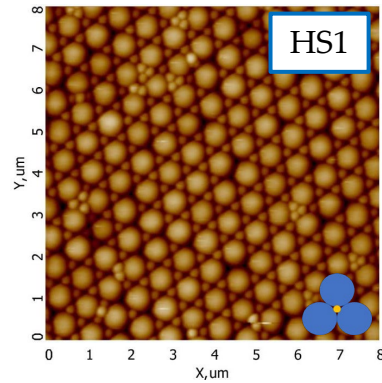
Numerical  
Analysis



**Best performance  
for radius ratio  
equal to 0.40**

Fabrication

Morphological  
Analysis



**Ordered structure  
obtained only for  
radius ratio equal  
to 0.2**

Characterization

Performance  
Analysis

	Peak Intensity		Enhancement Factor	
Substrates:	785 nm	633nm	785 nm	633nm
CPA	3222.3	1098.7	$2.16 \cdot 10^5$	$0.09 \cdot 10^5$
HS1	3297.6	2872.6	$2.43 \cdot 10^5$	$0.26 \cdot 10^5$
HS2	2073.7	3682.6	$3.10 \cdot 10^5$	$0.70 \cdot 10^5$

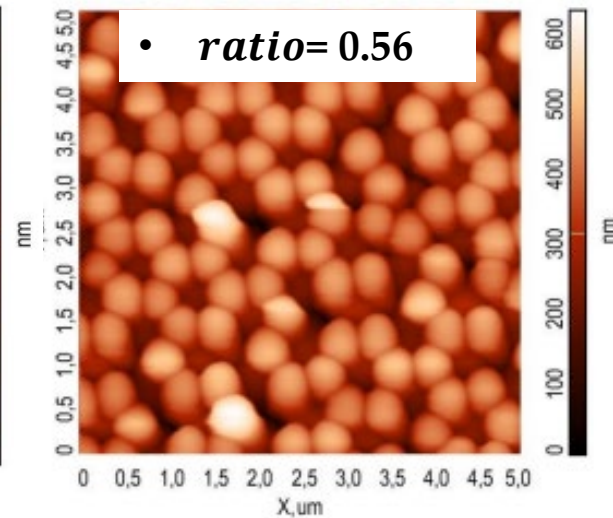
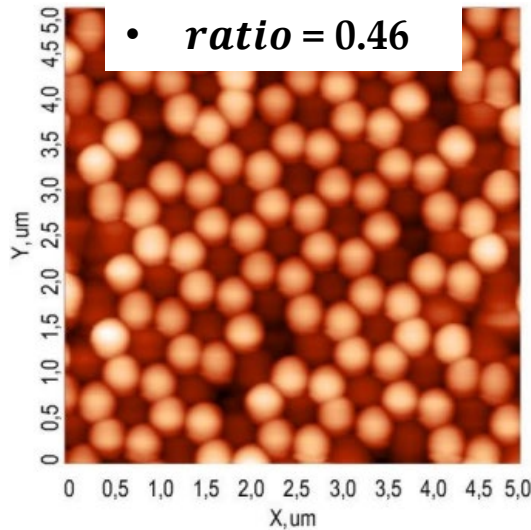
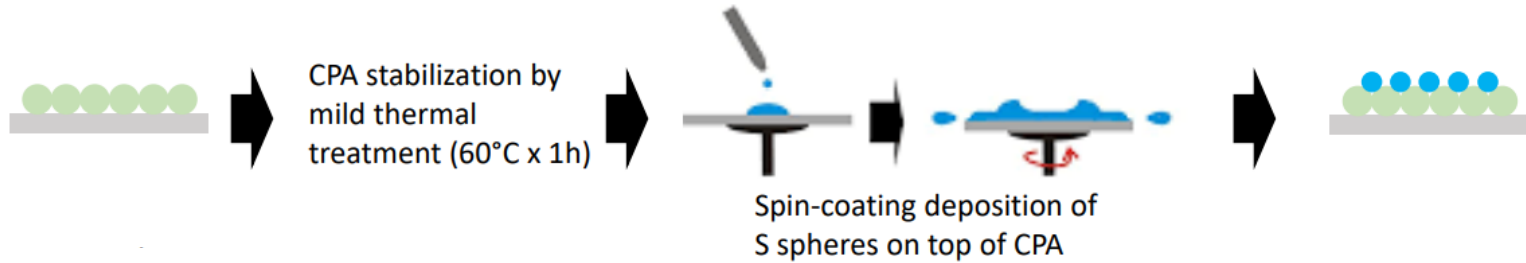
**Slight performance  
improvement  
respect CPA**

# Outcomes

**Problem:** Ordered structure only for ratio 0.2 (low performance)



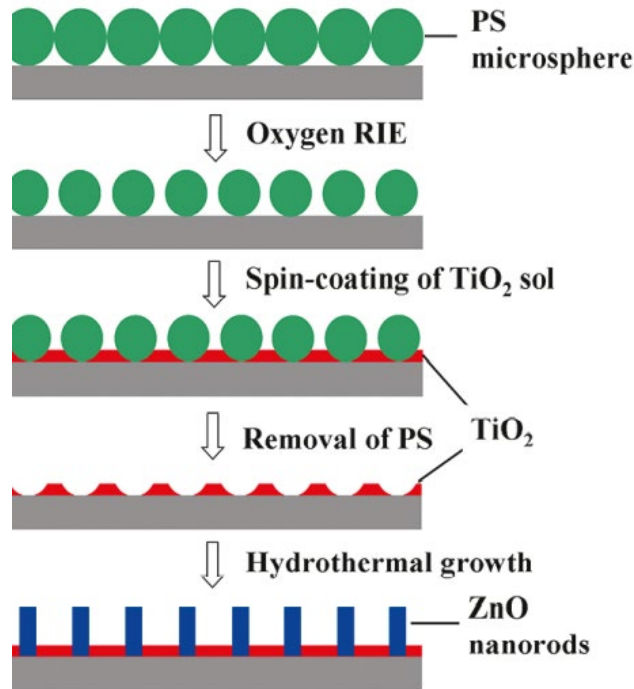
**Solution:** Realize structure with ratio 0.4 (best performance) using a *two-step process*



# On going activity:

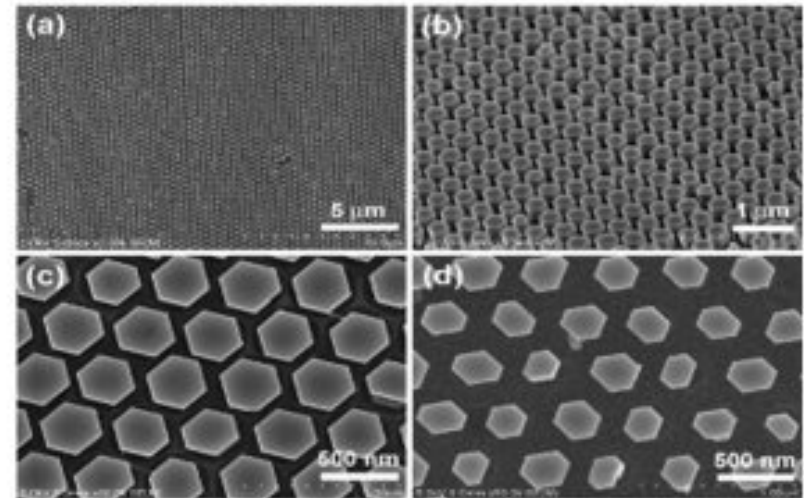
1. Identify the best geometry configuration for the SERS substrate:  
*Double layer of spheres*  **Nanopillar**

2. Fabrication by *seed assisted growth*:



3. Characterization:

- Morphological
- Spectral
- Sers/Raman





# Summary of study activities:

	Courses	Seminars	Research	Tutorship	Total
Bimonth1	0	0.8	7	0	7.8
Bimonth2	0	0	8	0	8
Bimonth3	2	0.3	7	0	9.3
Bimonth4	8	2.7	4	0	14.7
Bimonth5	0	0	10	0	10
Bimonth6	4	0	9	0	13
<b>Total</b>	14	3.8	45	0	63
<b>Expected</b>	30 - 70	10 - 30	80 - 140	0 - 4.8	

## Courses

- Imprenditorialità accademica
- Matrix Analysis for signal processing with matlab examples
- CI-LAM Summer School
- IV Scuola Nazionale Biosensori Ottici e Biofotonica
- SIE phd school

## Conferences

1. AIV XXV [*Oral Presentation*]
2. ICOP [*Poster Presentation*]
3. SIE [*Poster Presentation*]

# Products

## Journal contributions

[P1]	Authors: MariaAlessandra Cutolo, GiovanniBreglio Title: Interferometric Fabry-Perot sensors for ultrasound detection on the tip of an optical fiber, Results in Optics, ISSN 2666-9501, <a href="https://doi.org/10.1016/j.rio.2021.100209">https://doi.org/10.1016/j.rio.2021.100209</a> .
[P2]	Authors: Maria Alessandra Cutolo, Carlo Cafiero, Luigi Califano, Martino Giaquinto, Andrea Cusano, Antonello Cutolo Title: Feasibility analysis of an ultrasound on line diagnostic approach for oral and bone surgery. Sci Rep 12, 905 (2022). <a href="https://doi.org/10.1038/s41598-022-04857-0">https://doi.org/10.1038/s41598-022-04857-0</a> .
[P3]	Authors: Antonello Cutolo, Angelo Rosario Carotenuto, Maria Alessandra Cutolo, Arsenio Cutolo, Martino Giaquinto, Stefania Palumbo, Andrea Cusano, Massimiliano Fraldi. Title: Ultrasound waves in tumors via needle irradiation for precise medicine. Sci Rep 12, 6513 (2022). <a href="https://doi.org/10.1038/s41598-022-10407-5">https://doi.org/10.1038/s41598-022-10407-5</a>

## Conference contributions

[C1]	<b>AIV XXV</b> Conference Materials, Interfaces, Processes in Industrial and Basic Research Applications 2022. Hierarchical binary structures as SERS-active substrates. Authors: M. A. Cutolo, G. Quero, V. Calcagno,S. Spaziani,F. Galeotti, M. Pisco, A. Irace, G. Breglio, A. Cusano. <b>[Oral Presentation]</b>
[C2]	<b>ICOP</b> Italian Conference on Optics and Photonics 2022. Hierarchical binary structures as SERS-active substrates. Authors: M. A. Cutolo, G. Quero, V. Calcagno,S. Spaziani,F. Galeotti, M. Pisco, A. Irace, G. Breglio, A. Cusano. <b>[Poster Presentation]</b>
[C3]	<b>SIE</b> Riunione Annuale dell'Associazione Società Italiana di Elettronica SIE 2022 . Hierarchical binary structures as SERS-active substrates. Authors: M. A. Cutolo, G. Quero, V. Calcagno,S. Spaziani,F. Galeotti, M. Pisco, A. Irace, G. Breglio, A. Cusano. <b>[Poster Presentation]</b>