National Institute for Research and Development of
Isotopic and Molecular Technologies
INCDTIM

Metal-coated microsphere arrays: versatile nanofabrication platforms for plasmon-enhanced optical spectroscopy

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Outline

Introduction: Plasmonics and plasmon-enhanced spectroscopy with metal nanostructures

Fabrication of plasmonic nanostructures based on microsphere arrays

Optical properties. Experiment and simulation

Plasmon-enhanced spectroscopy: fundamentals and applications

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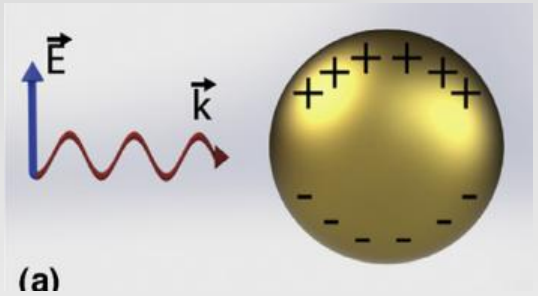
Introduction

surface plasmons

localized



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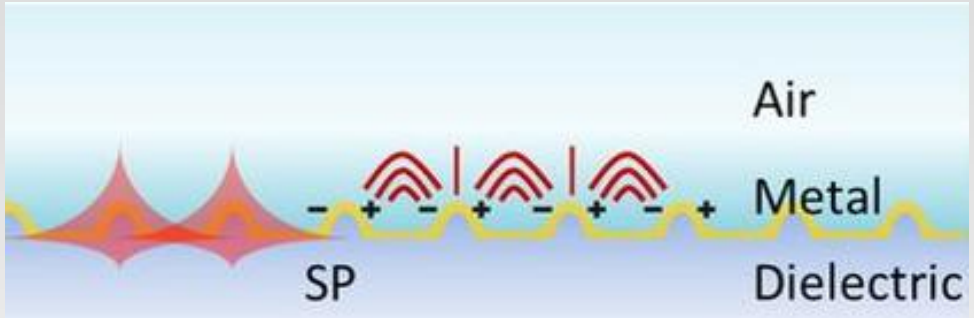

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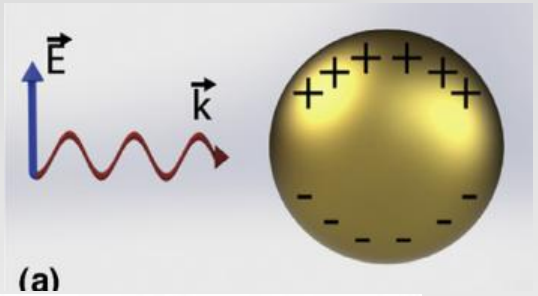

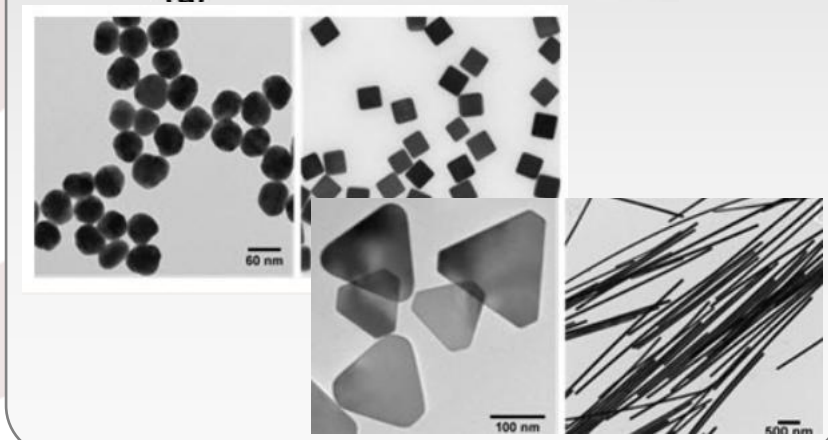

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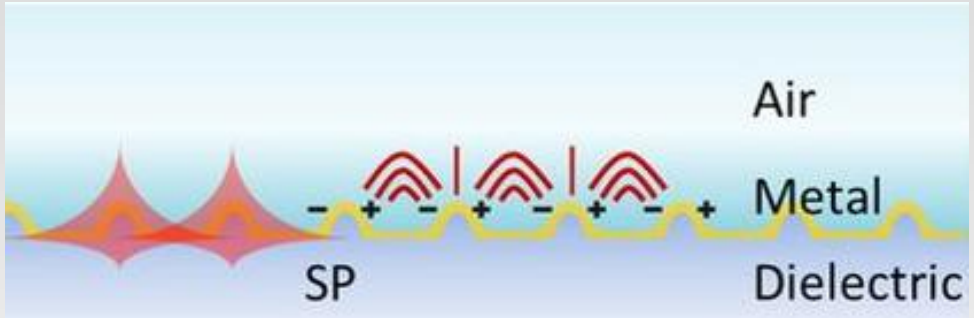

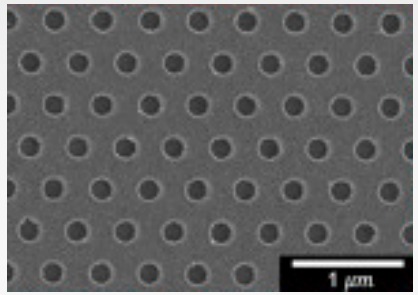

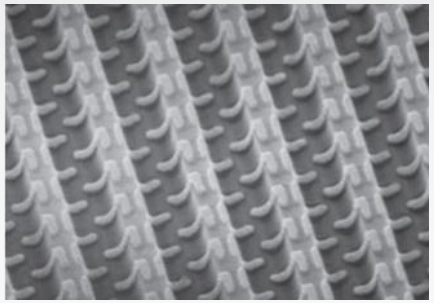

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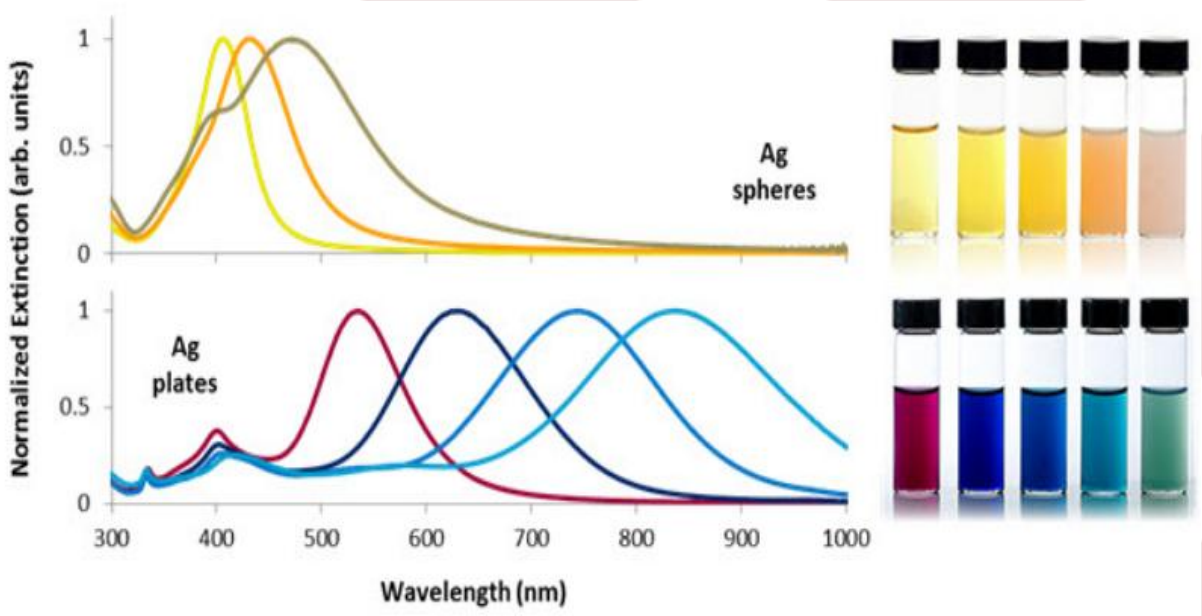
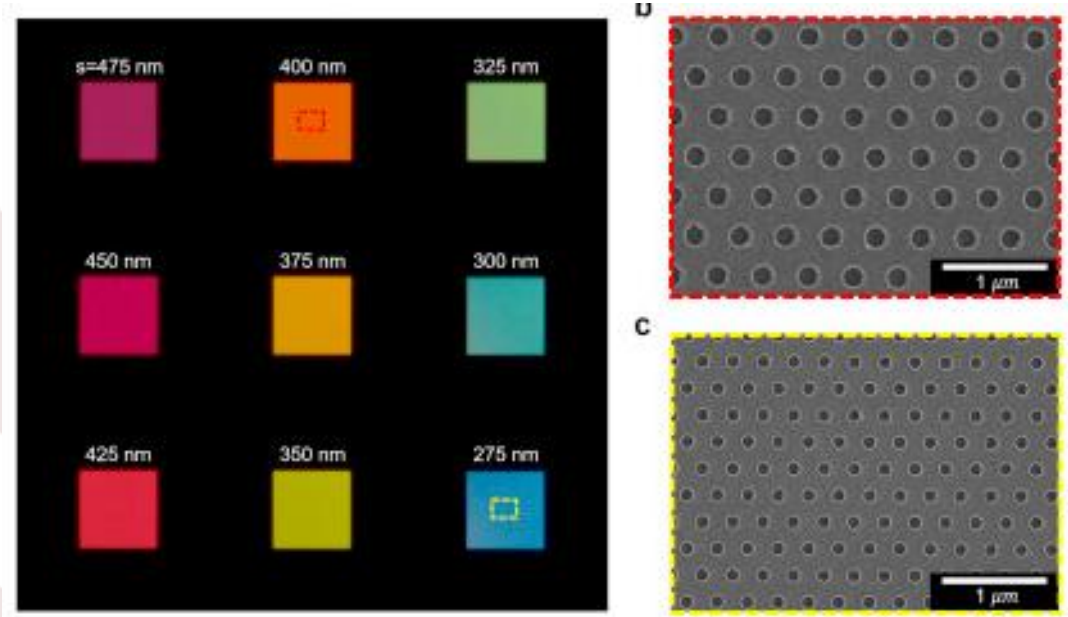
surface plasmons





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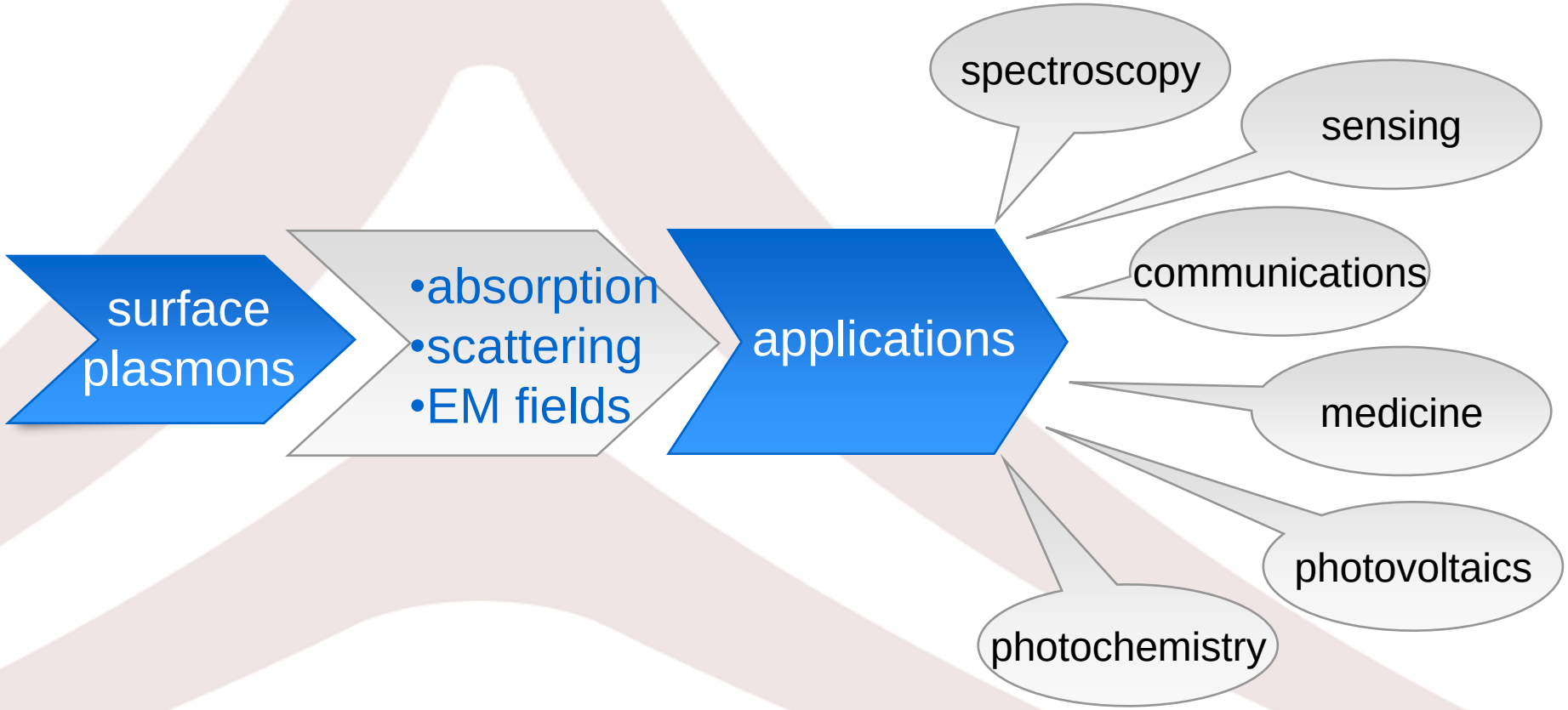

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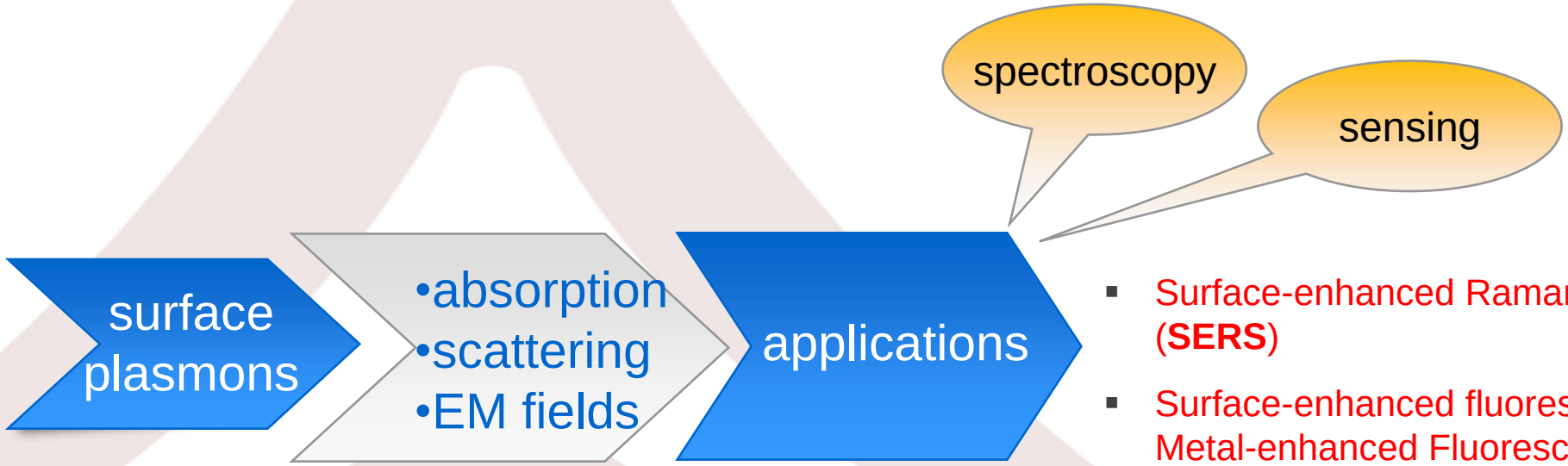

- Surface-enhanced Raman scattering (**SERS**)
- Surface-enhanced fluorescence (**SEF**) / Metal-enhanced Fluorescence (MEF)
- Surface-enhanced IR Absorption (**SEIRA**)
- Surface plasmon resonance (**SPR**) spectroscopy

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Fabrication of plasmonic nanostructures based on microsphere arrays

Optical properties. Experiment and simulation

Plasmon-enhanced spectroscopy: fundamentals and applications

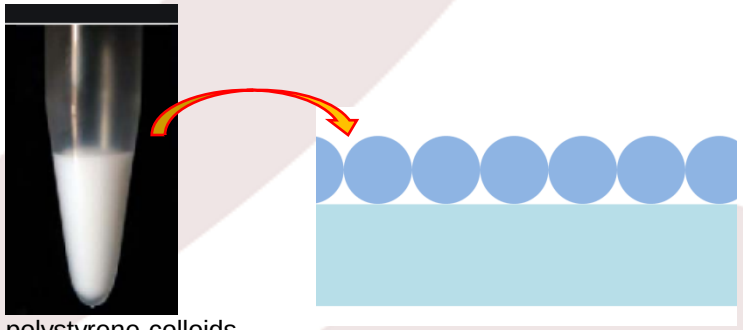
Nanofabrication

- Fabrication methods:
  - Electron beam lithography (EBL); nanoimprint lithography (NIL);
- Alternative fabrication methods:
  - Chemical synthesis
  - Colloidal self-assembly
  - Colloidal lithography

Nanofabrication

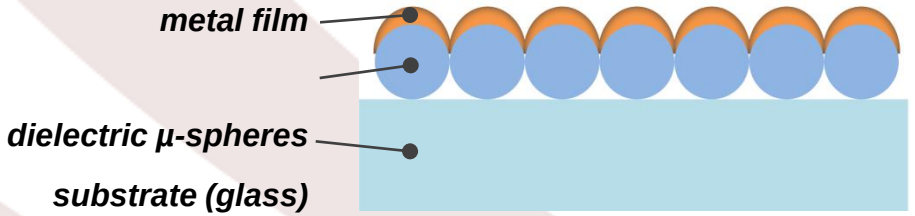
- Metal-coated microsphere arrays

colloidal self-assembly



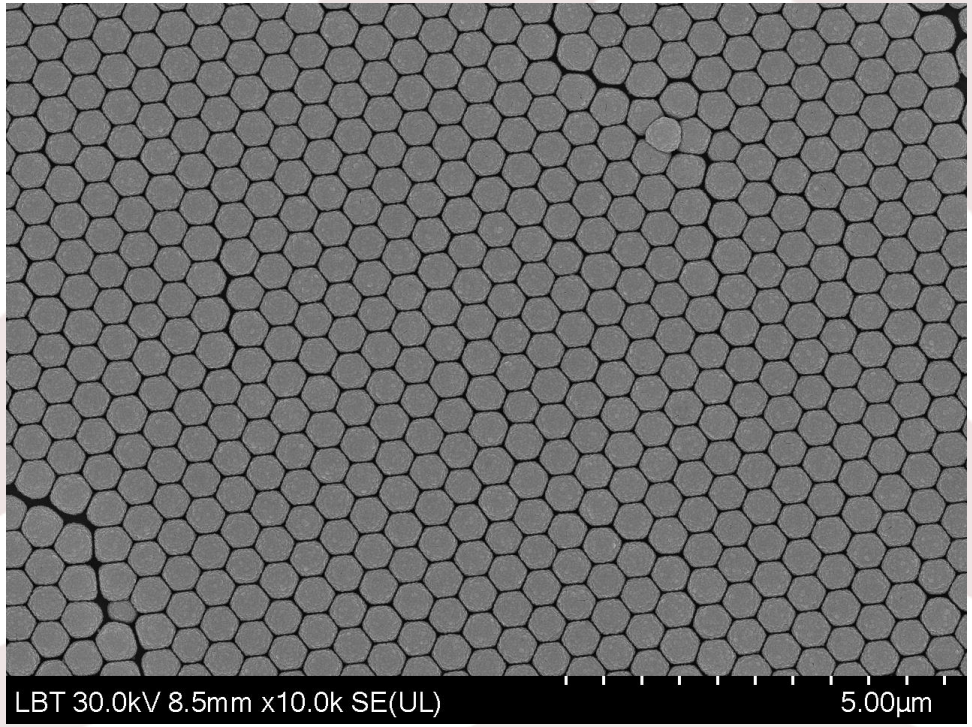
- polystyrene colloids in water;
- diameter 500 nm;
- 2% vol.;

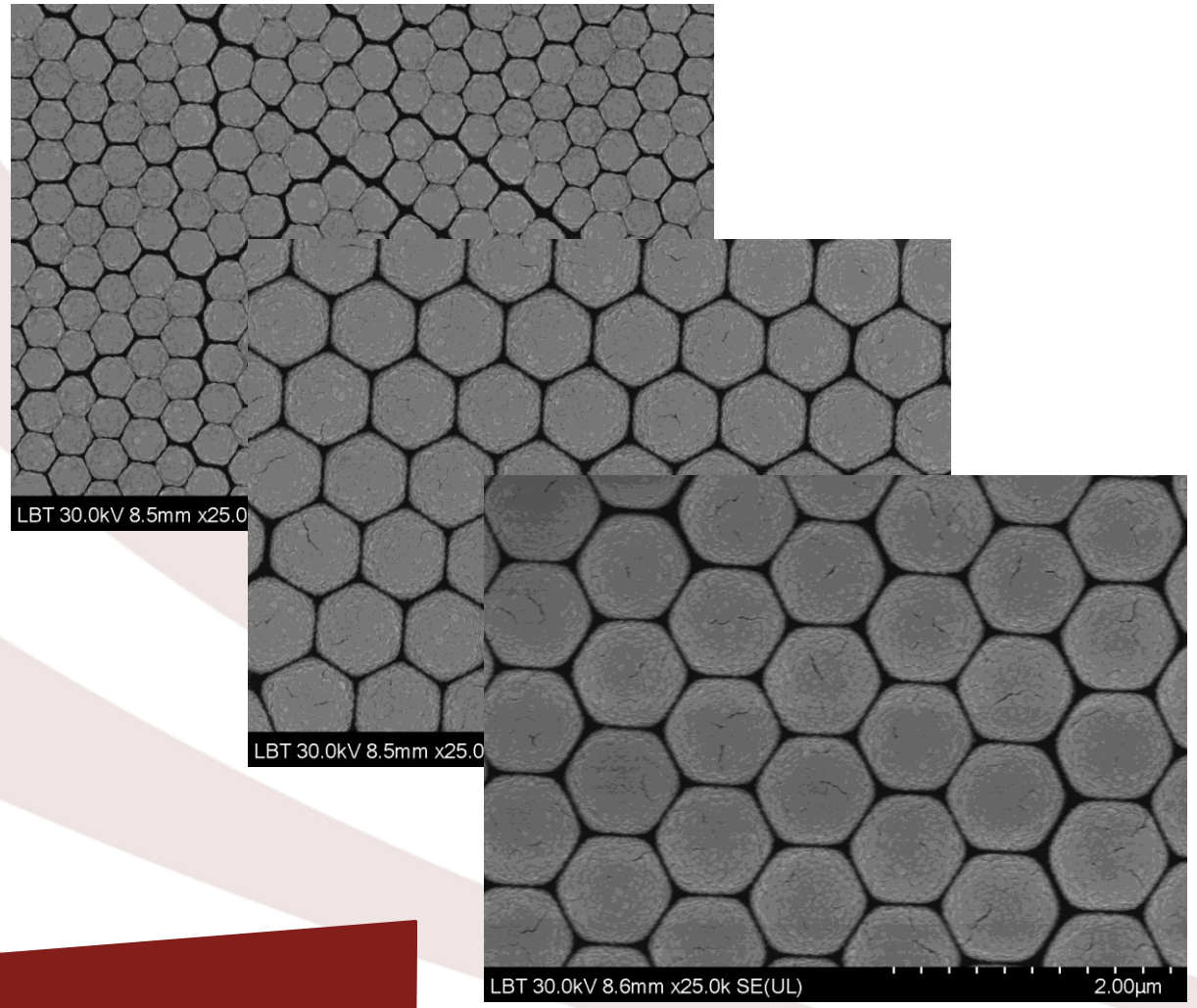
metal deposition by physical methods



Nanofabrication

- Metal-coated microsphere arrays

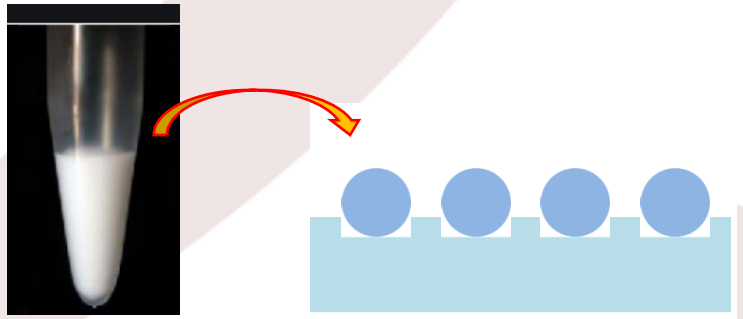




Nanofabrication

- Linear arrays of metal-coated microspheres

self-assembly on patterned substrates



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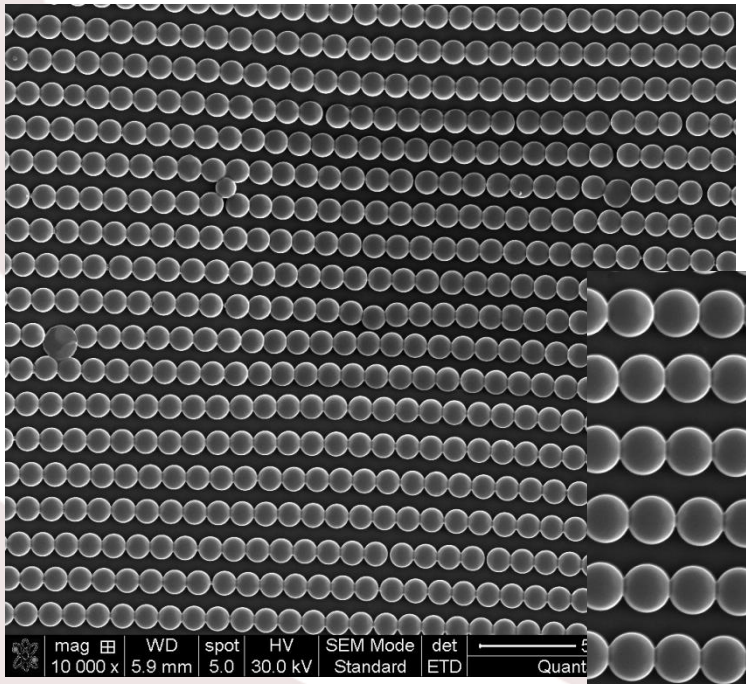
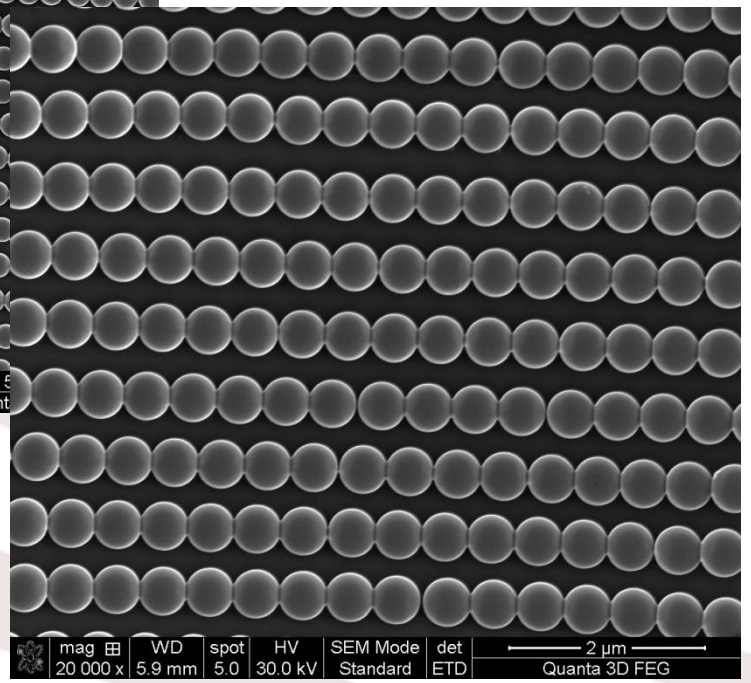
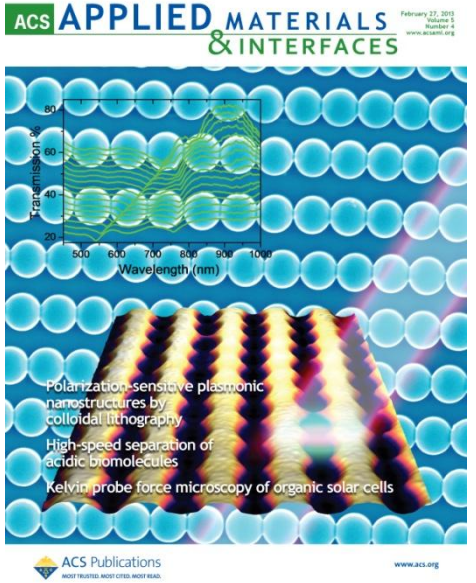




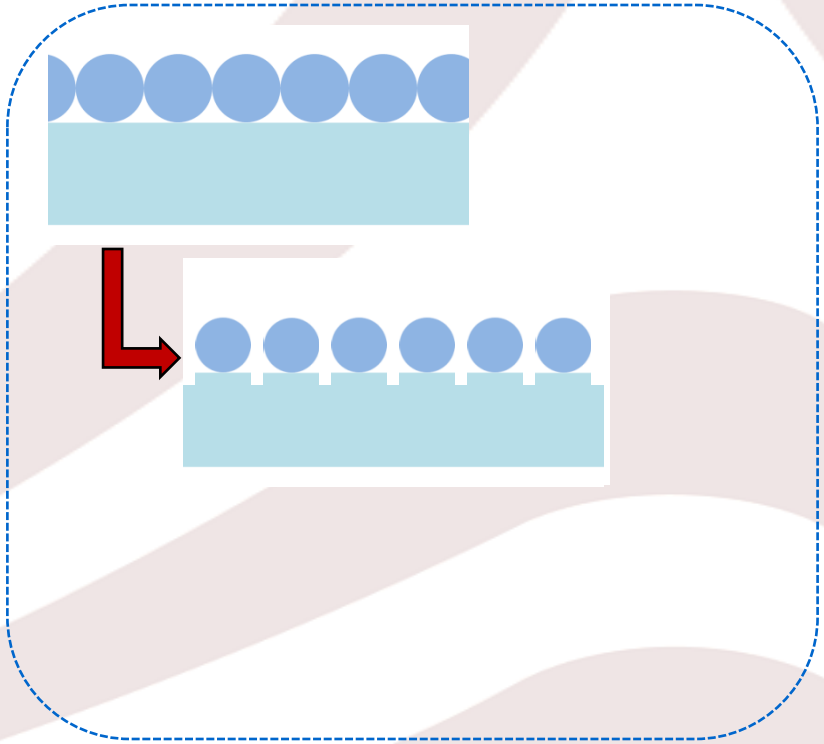


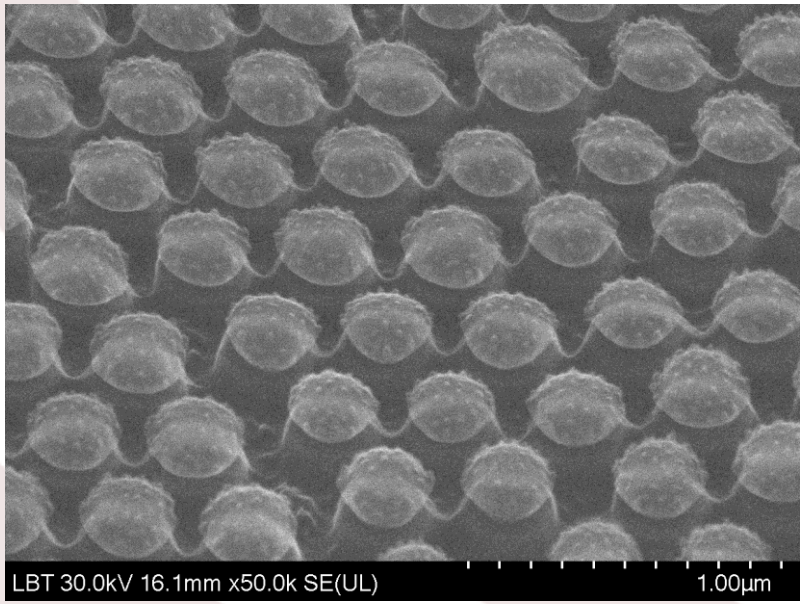
ACS Appl. Mat Interf **2013, *5*, 1362.**

Nanofabrication

- Microsphere arrays as lithographic masks

Plasma etching of microsphere arrays





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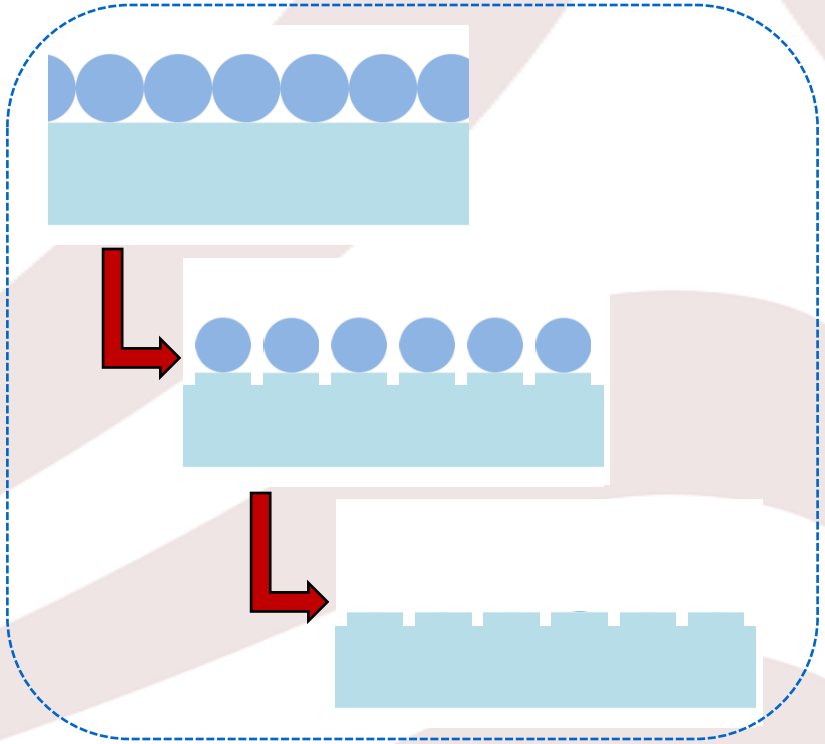

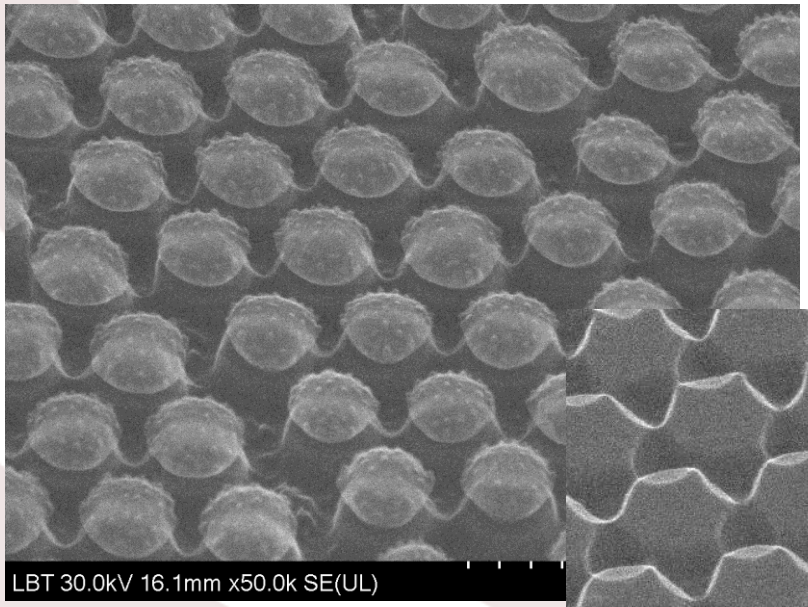

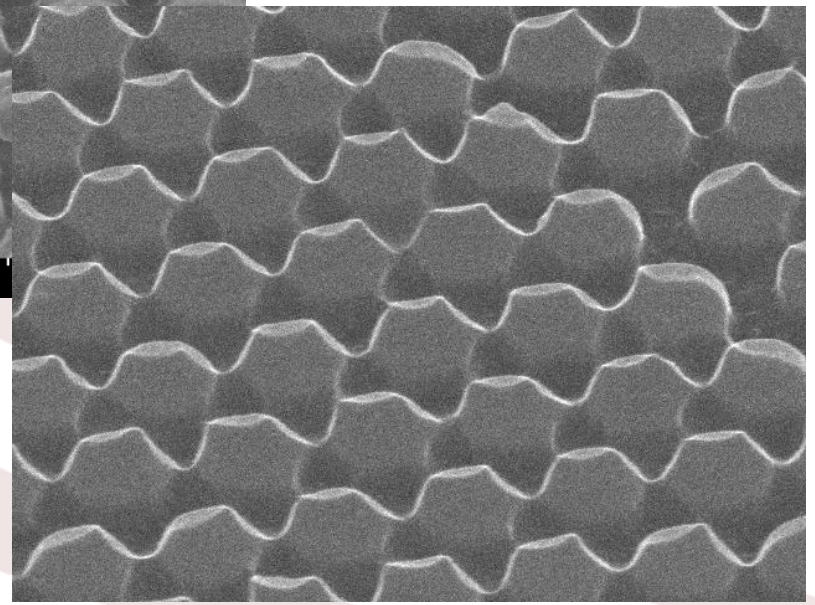

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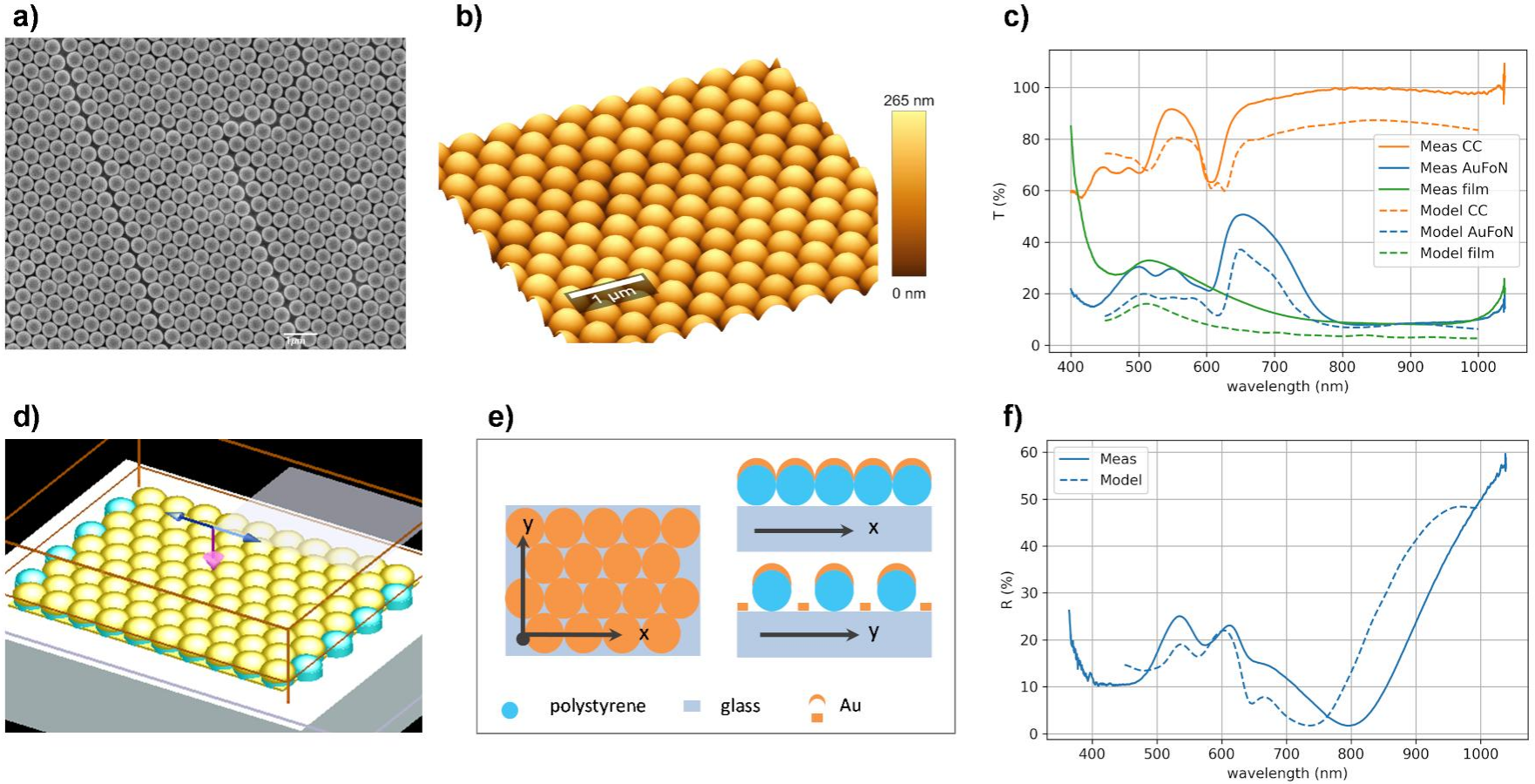
- Metal-coated microsphere arrays



Optical properties

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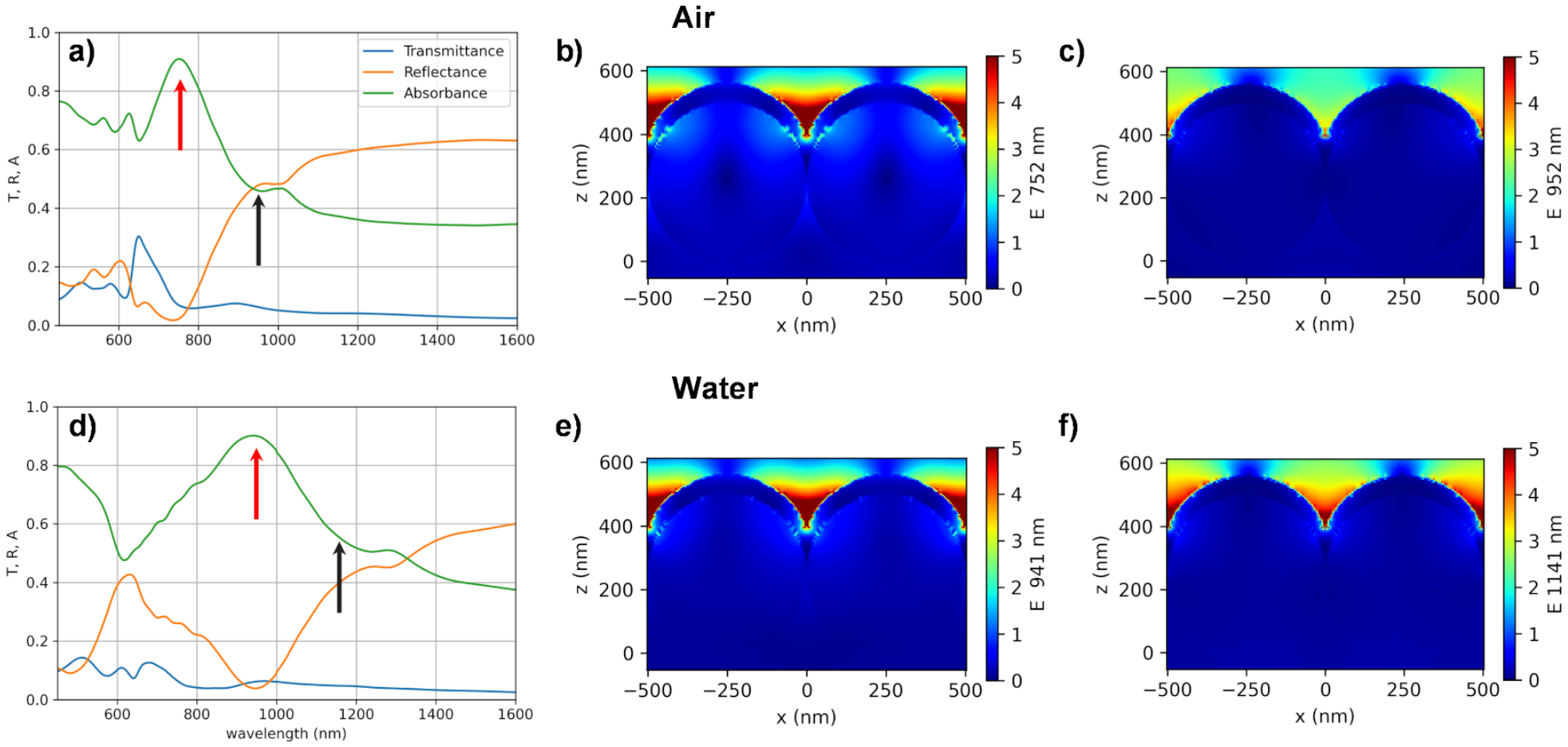
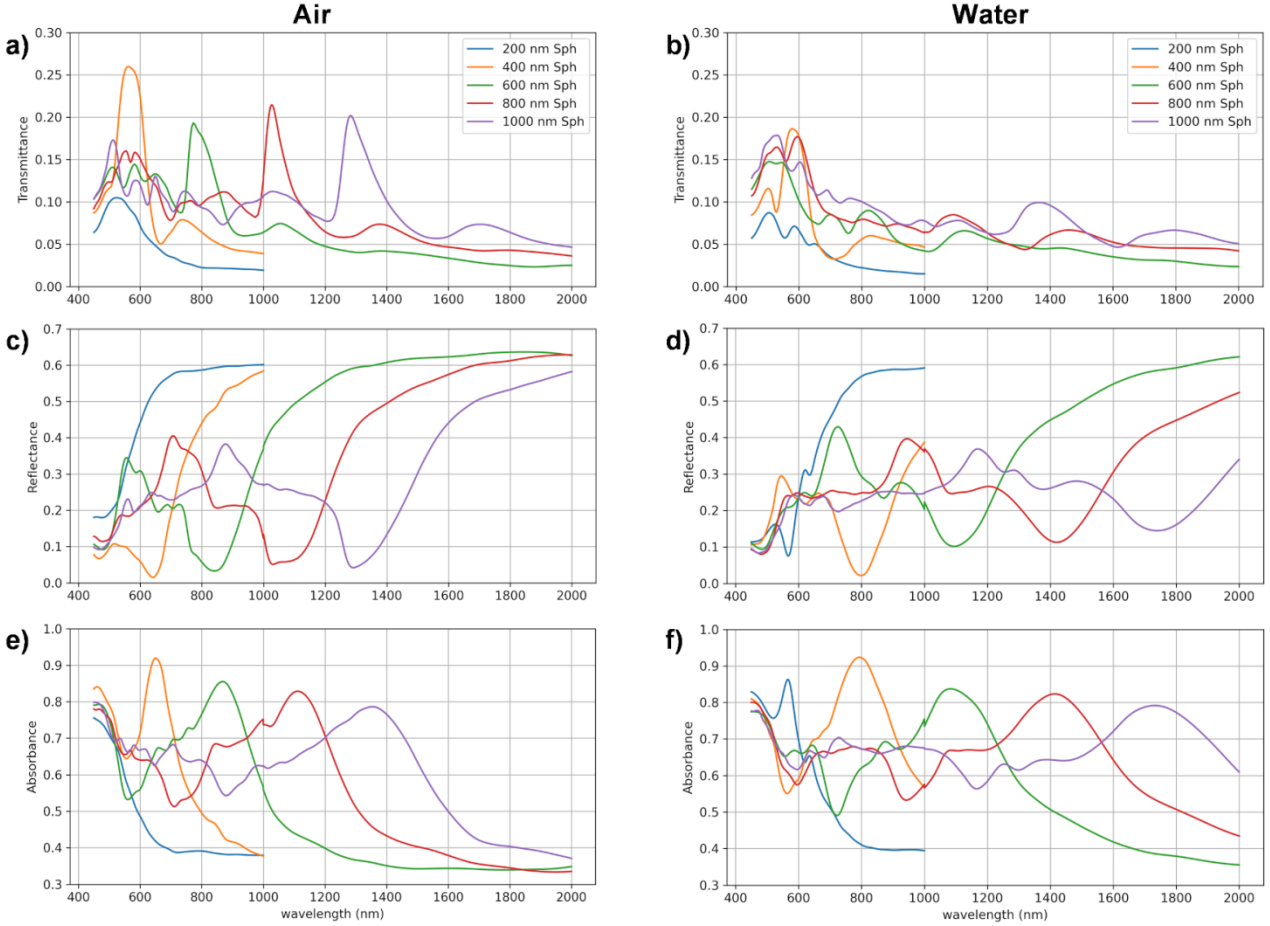
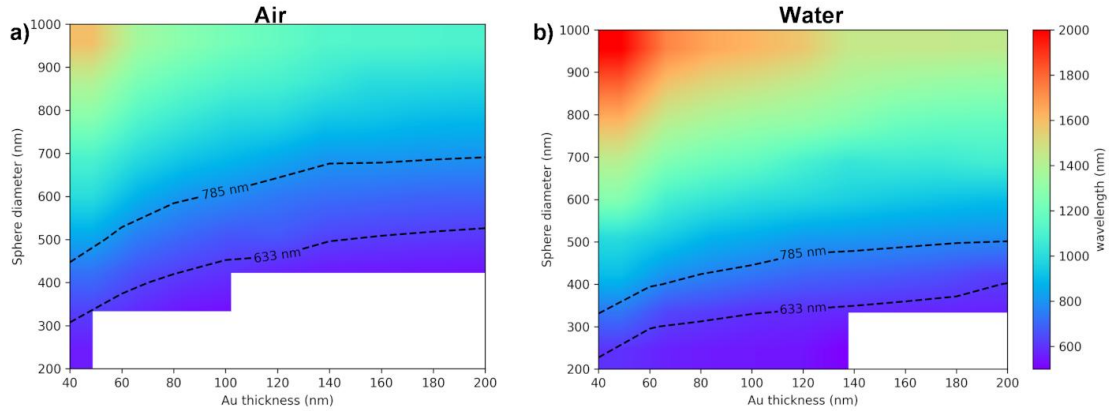


Opt. Express 2021, *29*, 42238.

Optical properties

- Metal-coated microsphere arrays

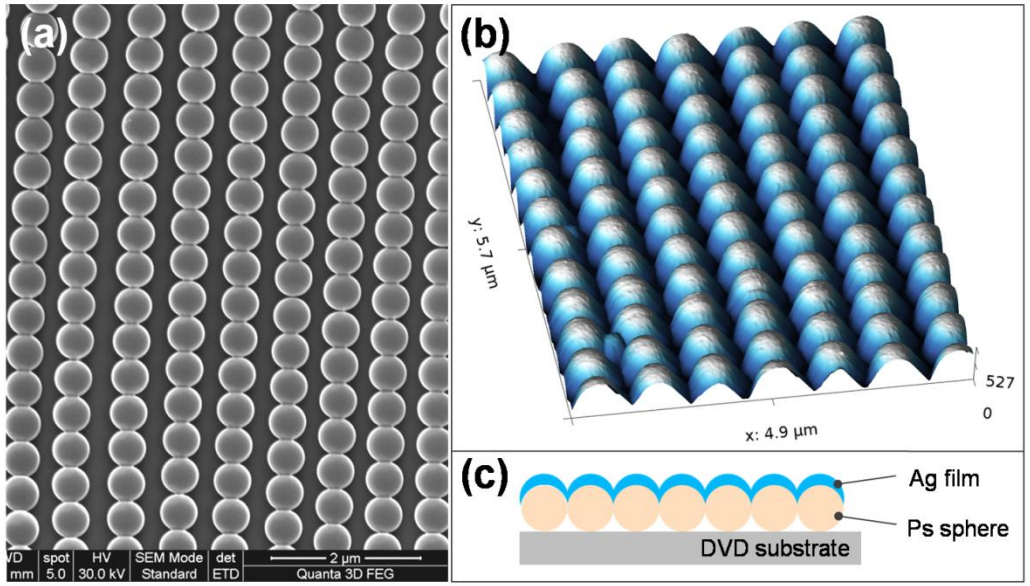


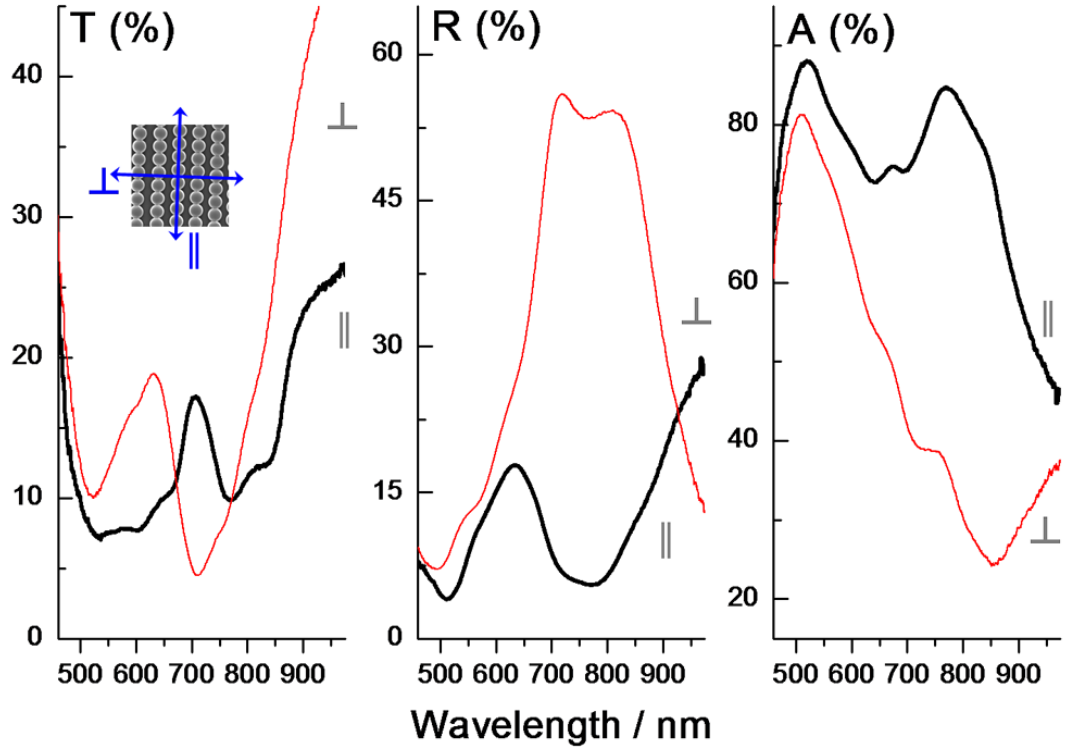


Opt. Express **2021, *29*, 42238.**

Optical properties

- Linear arrays of metal-coated microspheres





J Optics 2015, *17*, 114007.

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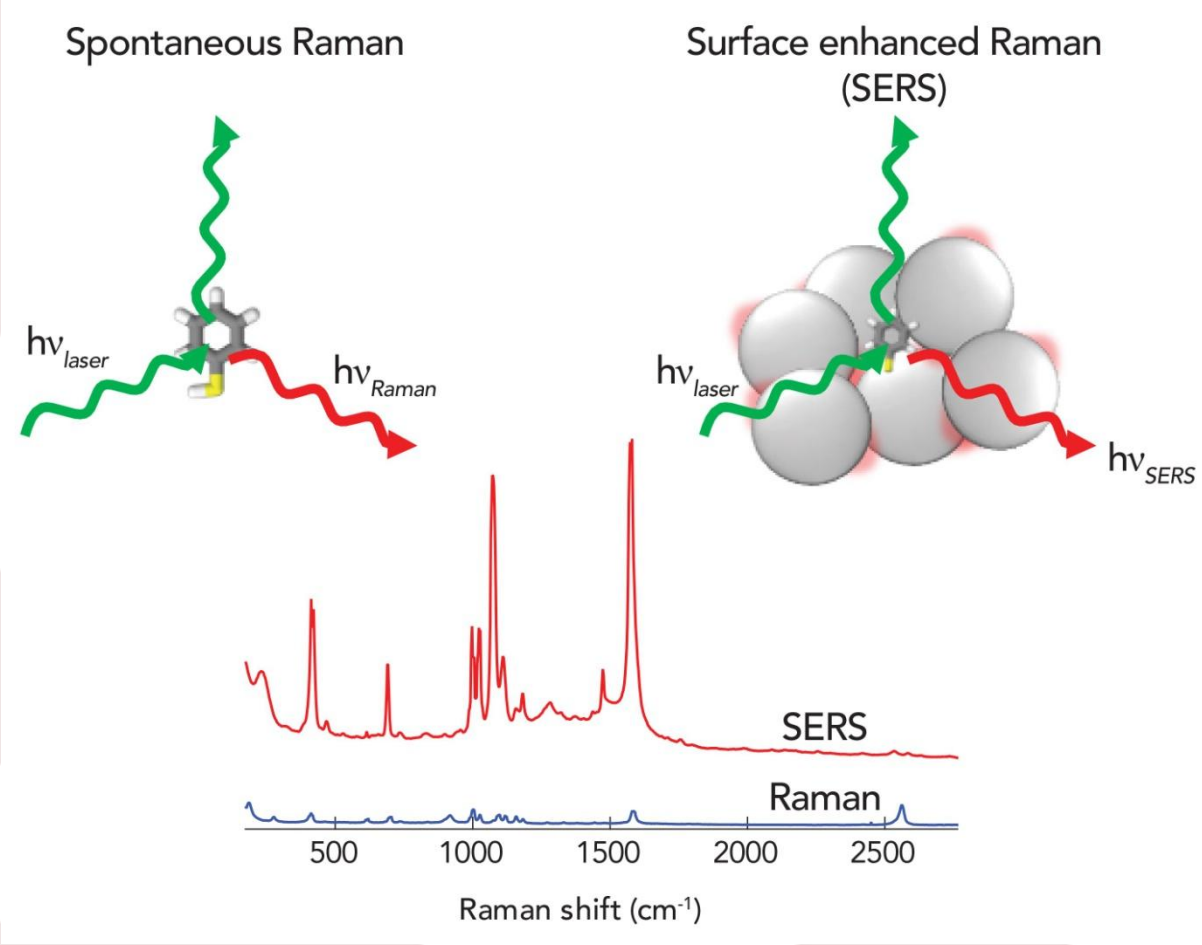
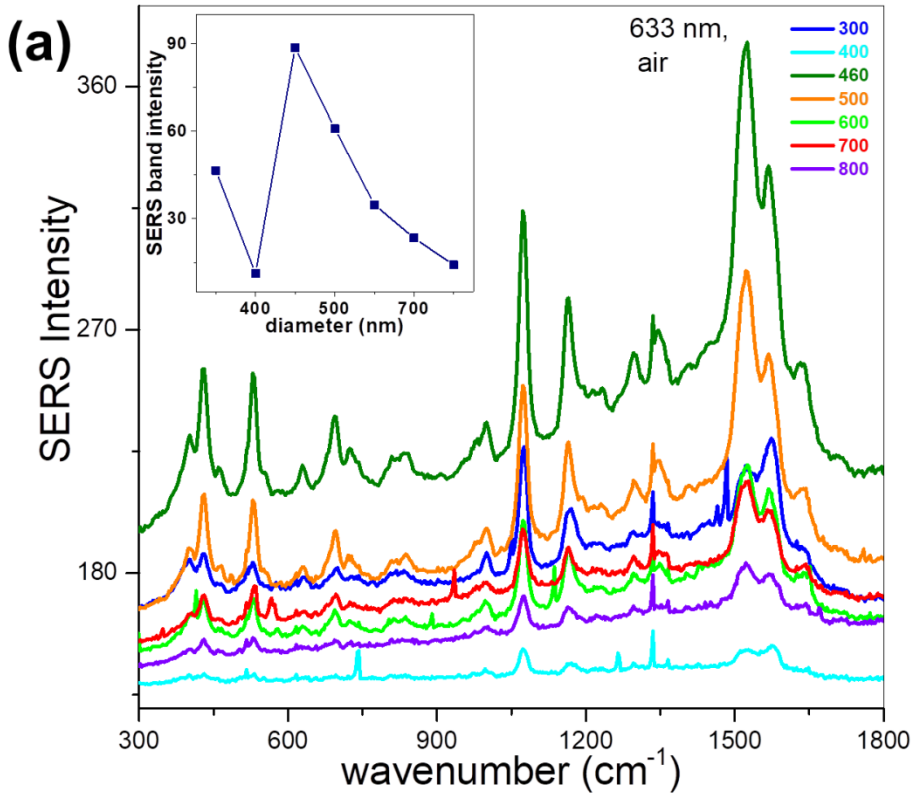
Surface-enhanced Raman scattering

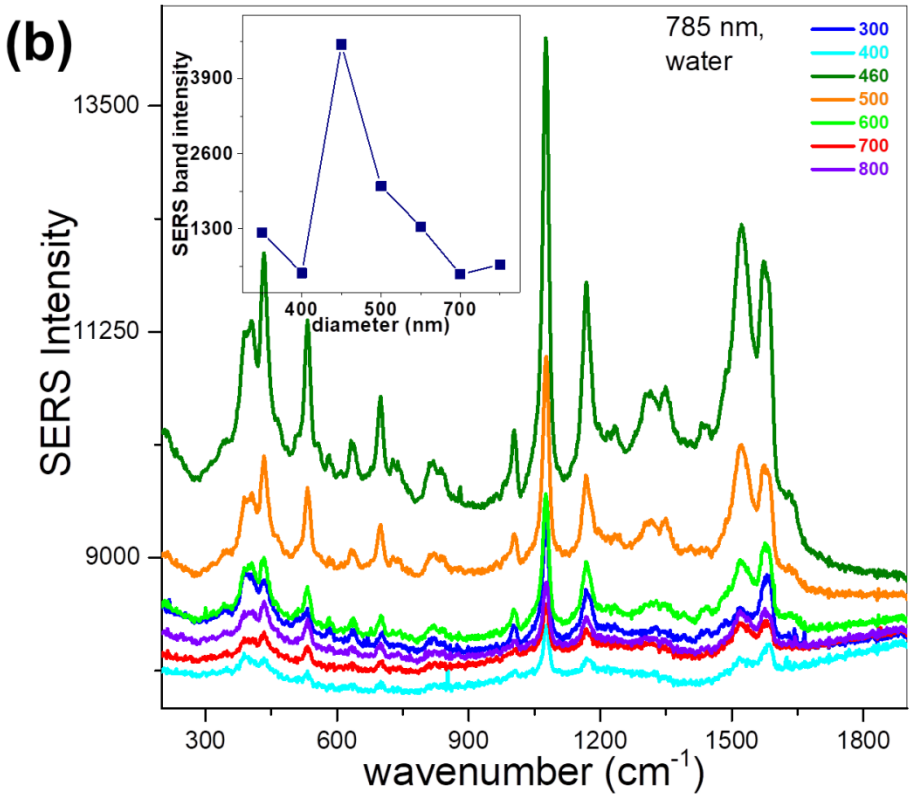


https://www.spectroscopyonline.com/view/sers-and-ters

Surface-enhanced Raman scattering

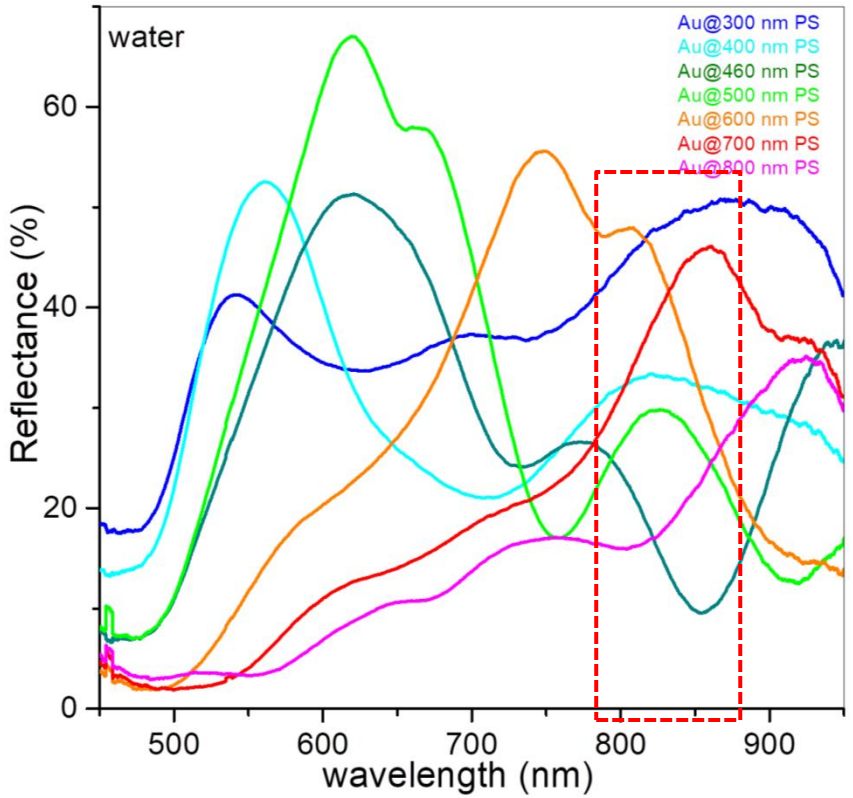
- Metal-coated microsphere arrays

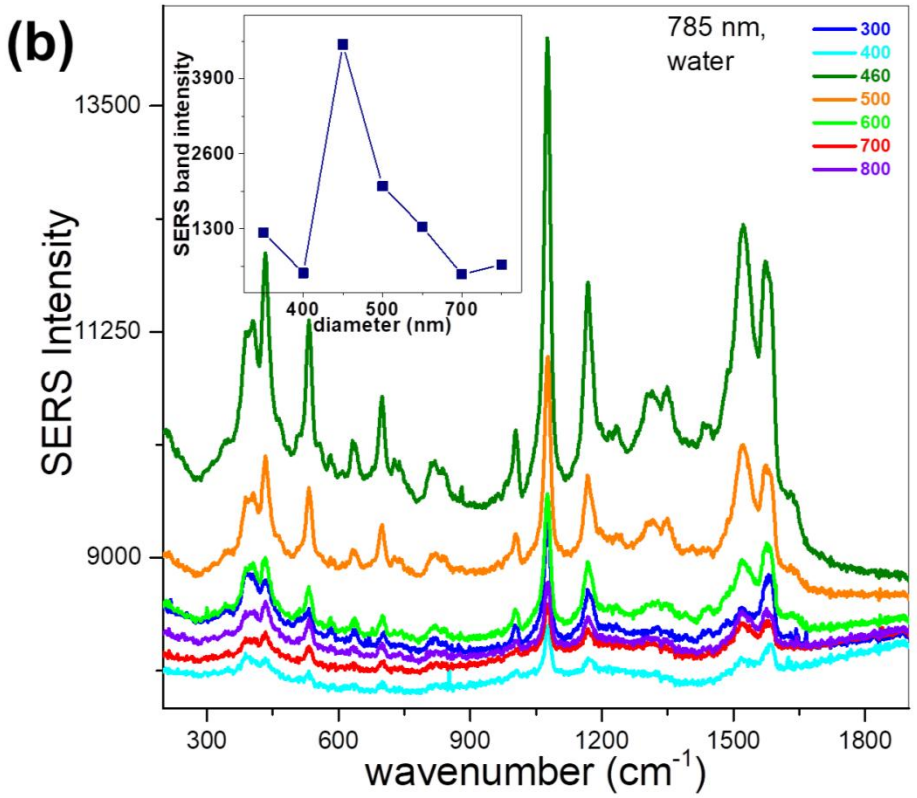




Surface-enhanced Raman scattering

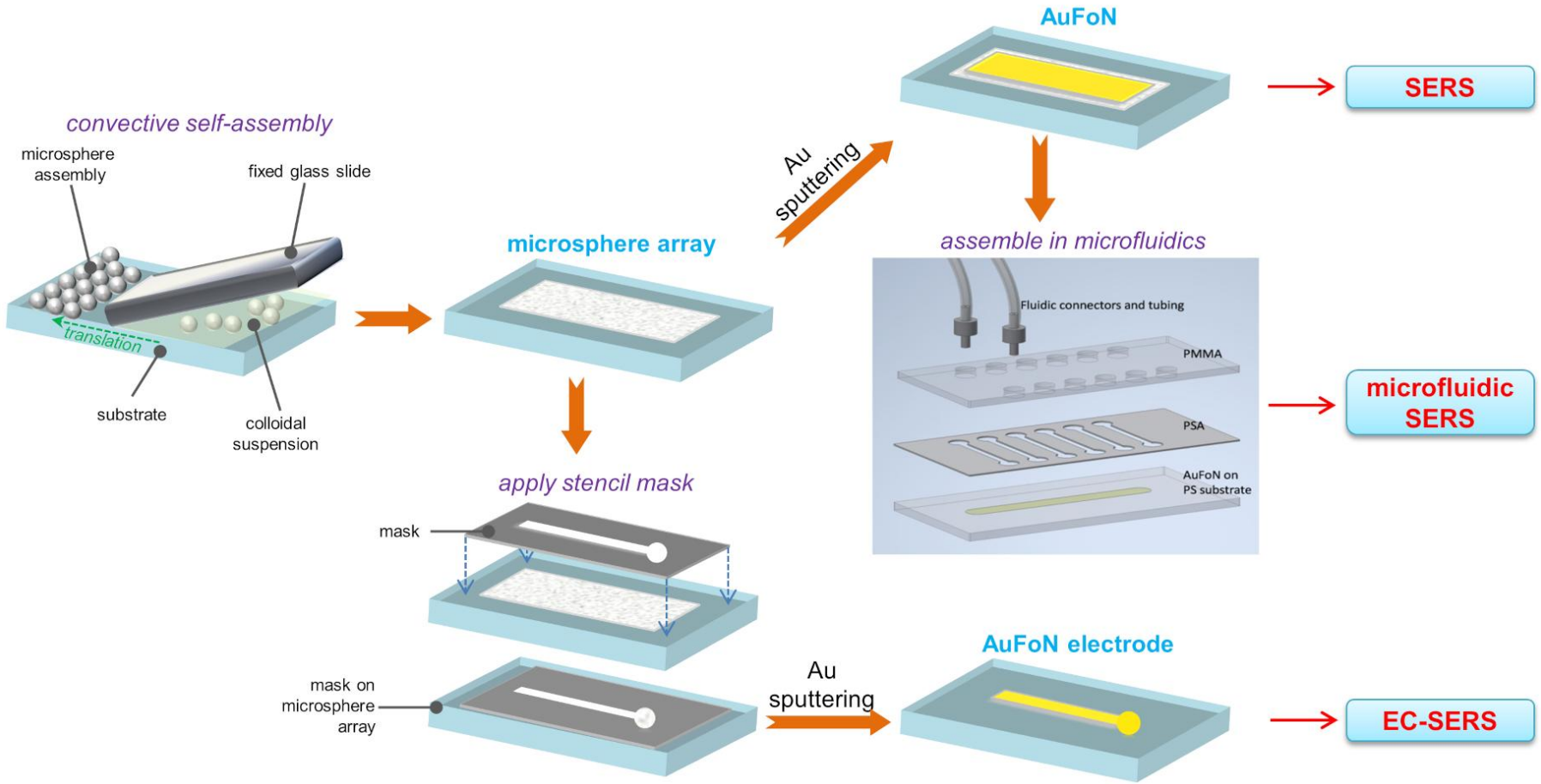
- Metal-coated microsphere arrays





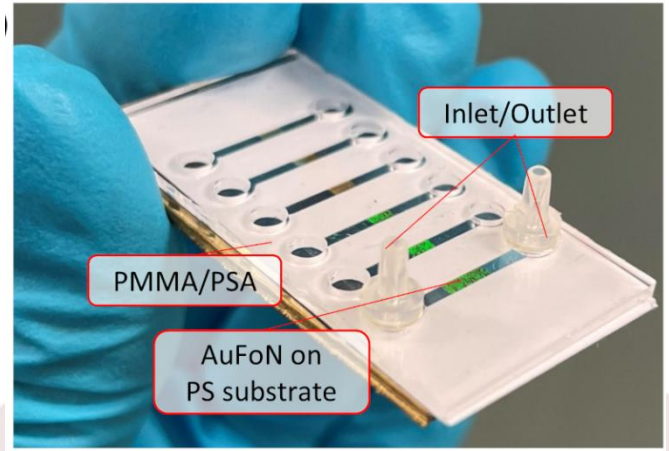
SERS applications

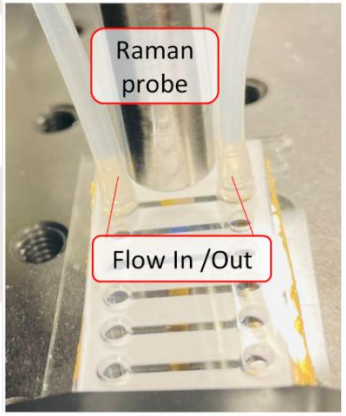
- Metal-coated microsphere arrays in SERS applications

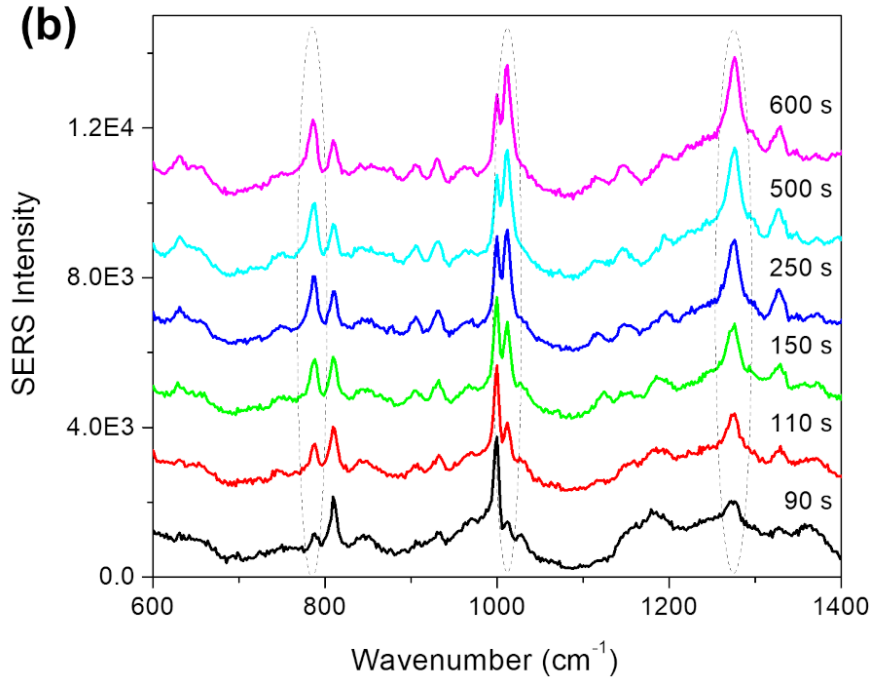


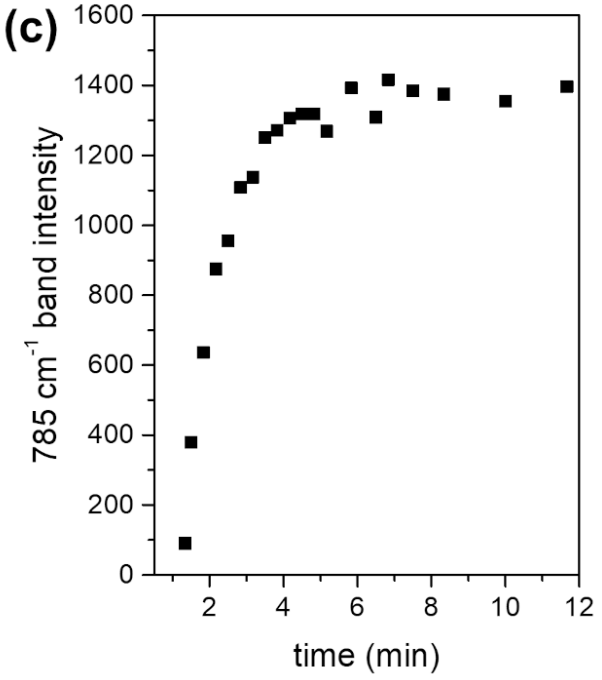
Microfluidic-SERS

- Metal-coated microsphere arrays in microfluidics



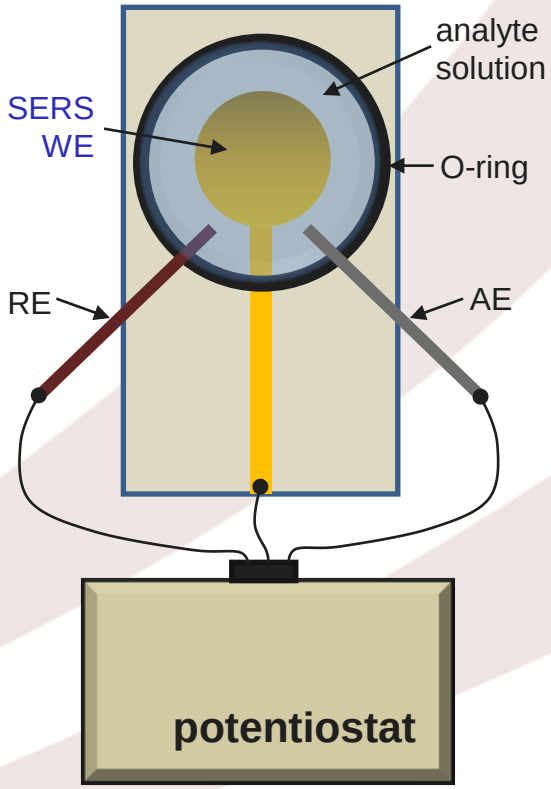


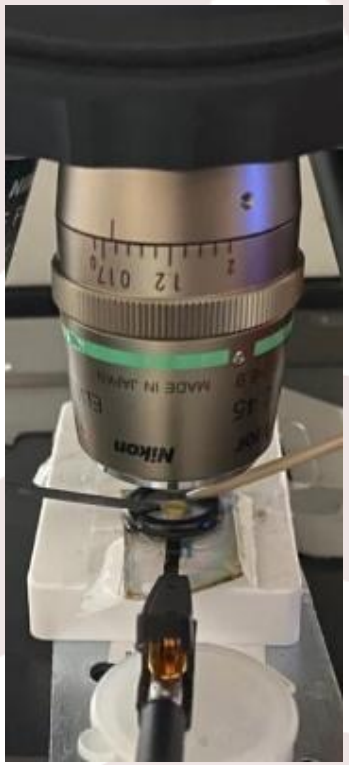


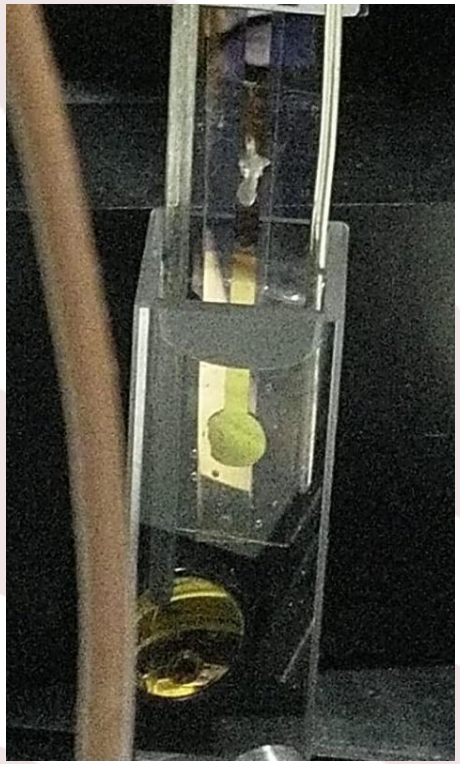


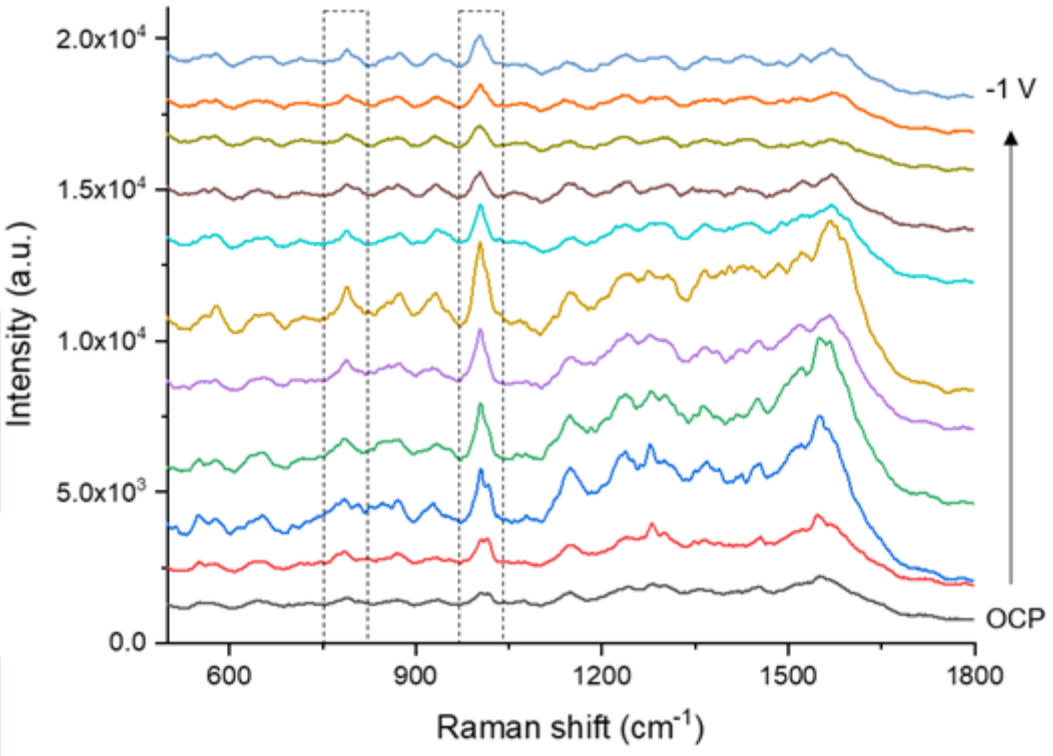
Electrochemical-SERS

- Metal-coated microsphere arrays as electrodes









Conclusions

- Self-assembled microsphere arrays are a versatile nanofabrication platform:
  - Metal-coated microsphere arrays;
  - Linear arrays of metal-coated microspheres;
  - Masks for plasma etching
- Optical properties of metal-coated microspheres:
  - Tunable across the visible range;
  - Similar behaviour in air and water;
  - Polarization-sensitive or insensitive;
- SERS application of metal-coated microsphere arrays:
  - Size-dependent, tunable SERS enhancement;
  - Can be integrated in microfluidics;
  - Coupled electrochemical-SERS assays can be developed.