

Nanorings, Nanocones and Nanocubes: Designing Nanotextured Surfaces with Unique Properties

Rings



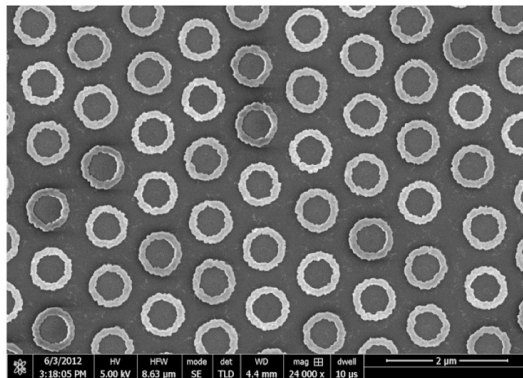
Cones



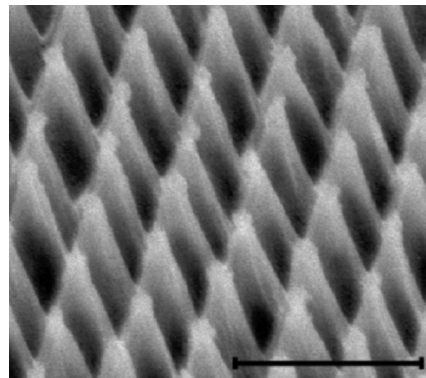
Cubes



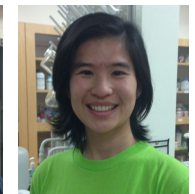
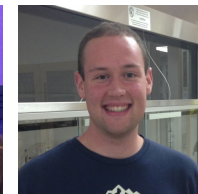
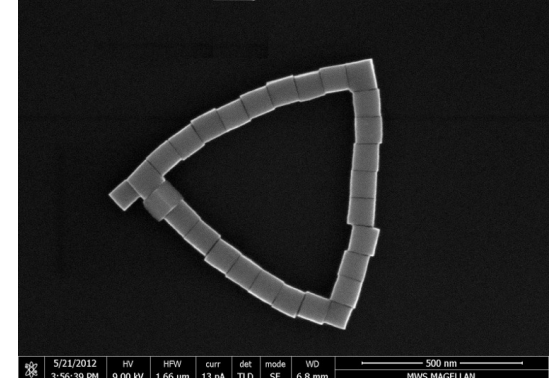
Nanorings



Nanocones



Nanocubes



Prof. Robert Corn

UCI Departments of Chemistry & Biomedical Engineering



UCIrvine
University of California, Irvine



Structural Coloration - Diffraction - Iridescence



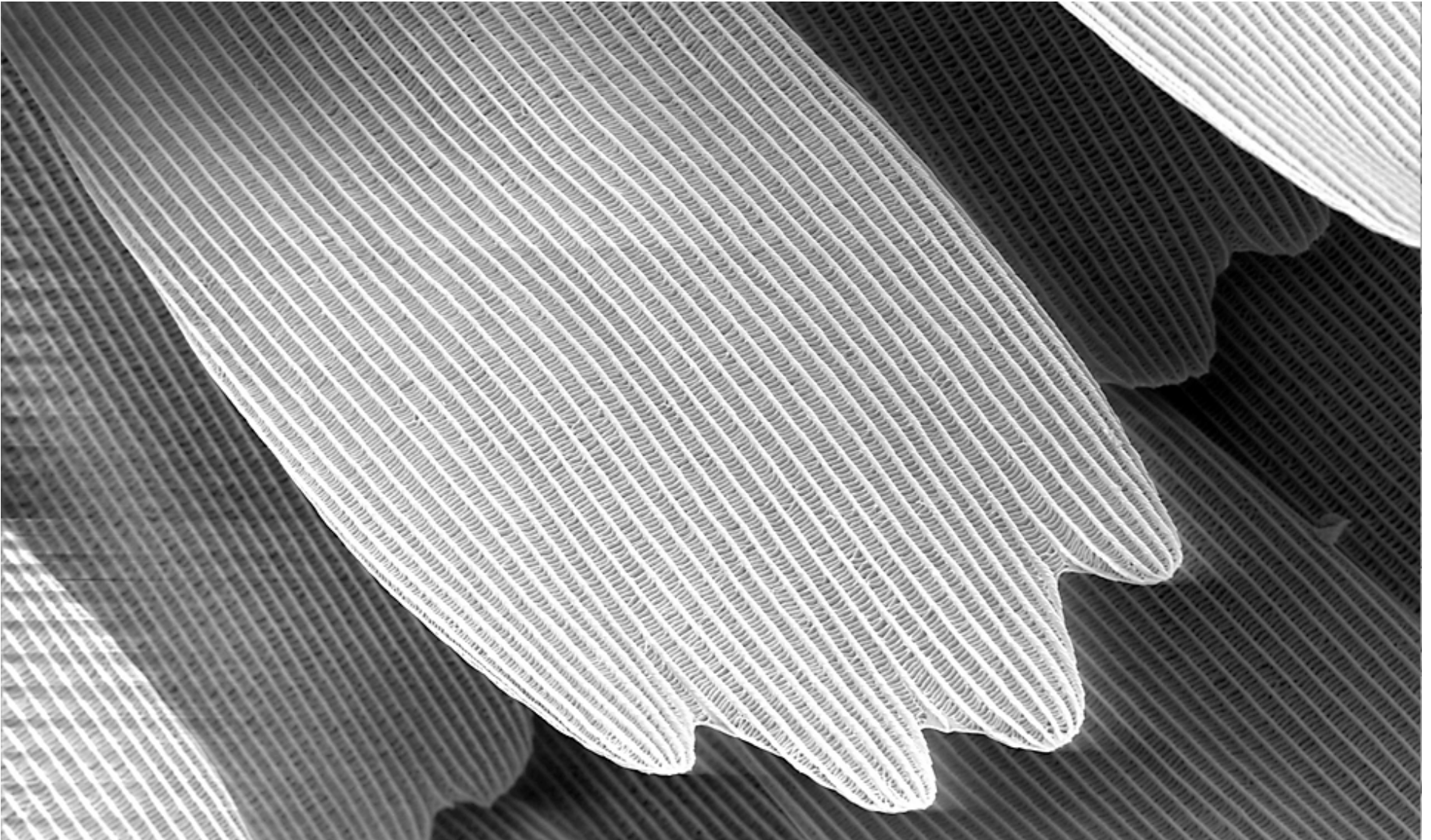
Structural Coloration - Diffraction - Iridescence



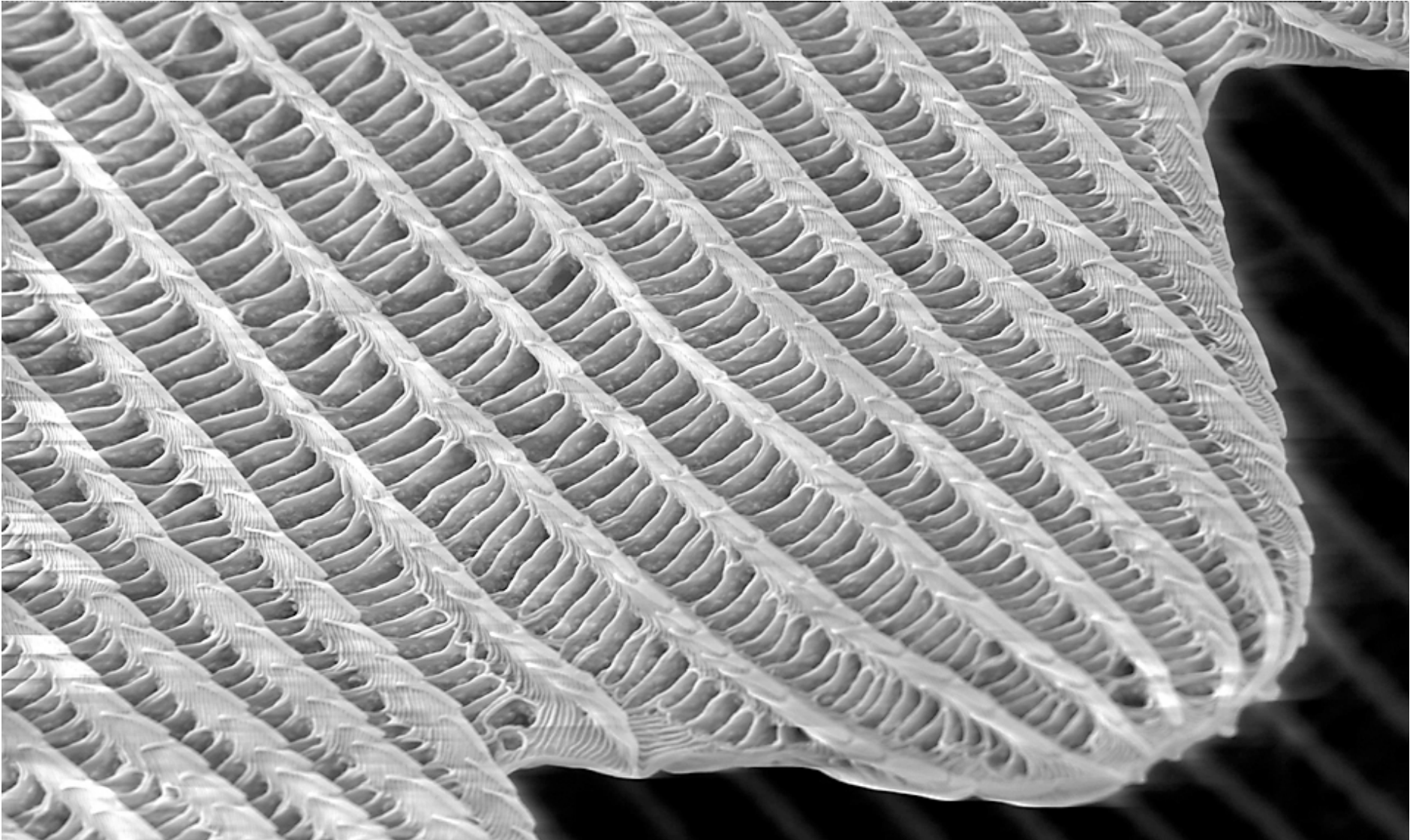
Structural Coloration - Diffraction - Iridescence



Structural Coloration - Diffraction - Iridescence



Structural Coloration - Diffraction - Iridescence



Peacock Butterfly Wing - <http://en.wikipedia.org/wiki/Butterfly>

Structural Coloration - Diffraction - Iridescence

Structural Coloration occurs because:

- i) light behaves like an ocean wave.*
- ii) the distance between waves determines the color.*

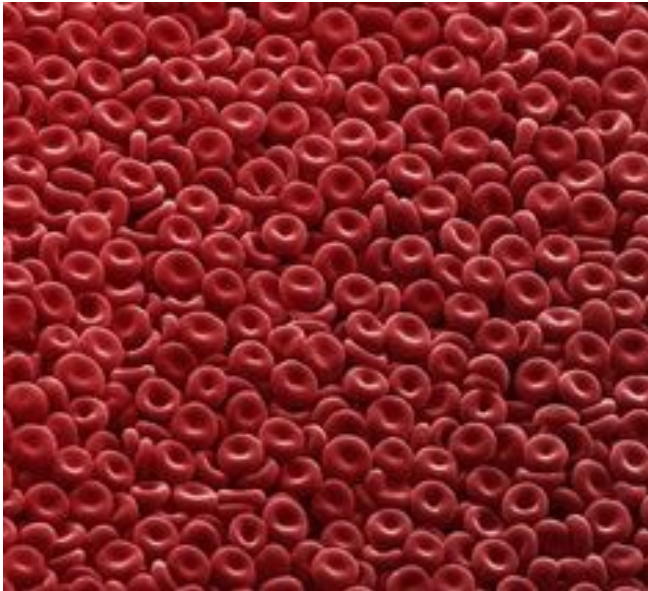


Structural Coloration - Diffraction - Iridescence

Structural Coloration occurs because:

- i) light behaves like an ocean wave.
- ii) the distance between waves determines the color.

For **red** light, that distance is about 600 nanometers.



Diameter of a red blood cell:

0.006 millimeters

6 microns

6000 nanometers

We can't see 60 nm objects!

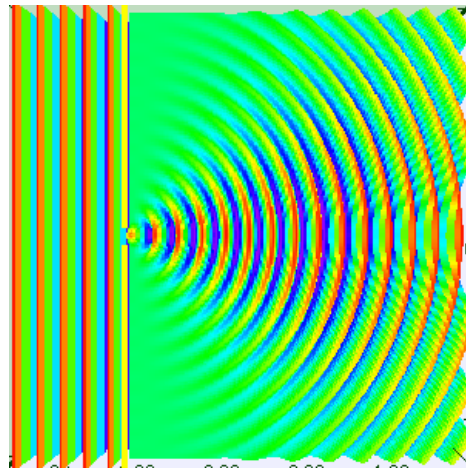


Structural Coloration - Diffraction - Iridescence

Structural Coloration occurs because:

- i) light behaves like an ocean wave.*
- ii) the distance between waves determines the color.*

Diffraction bends and breaks up both ocean and light waves

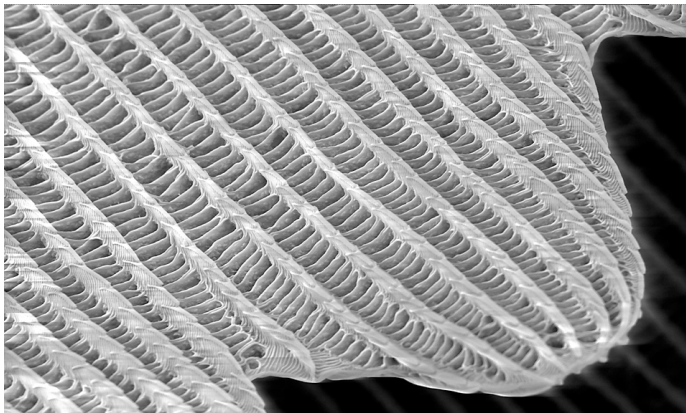


Structural Coloration - Diffraction - Iridescence

Structural Coloration occurs because:

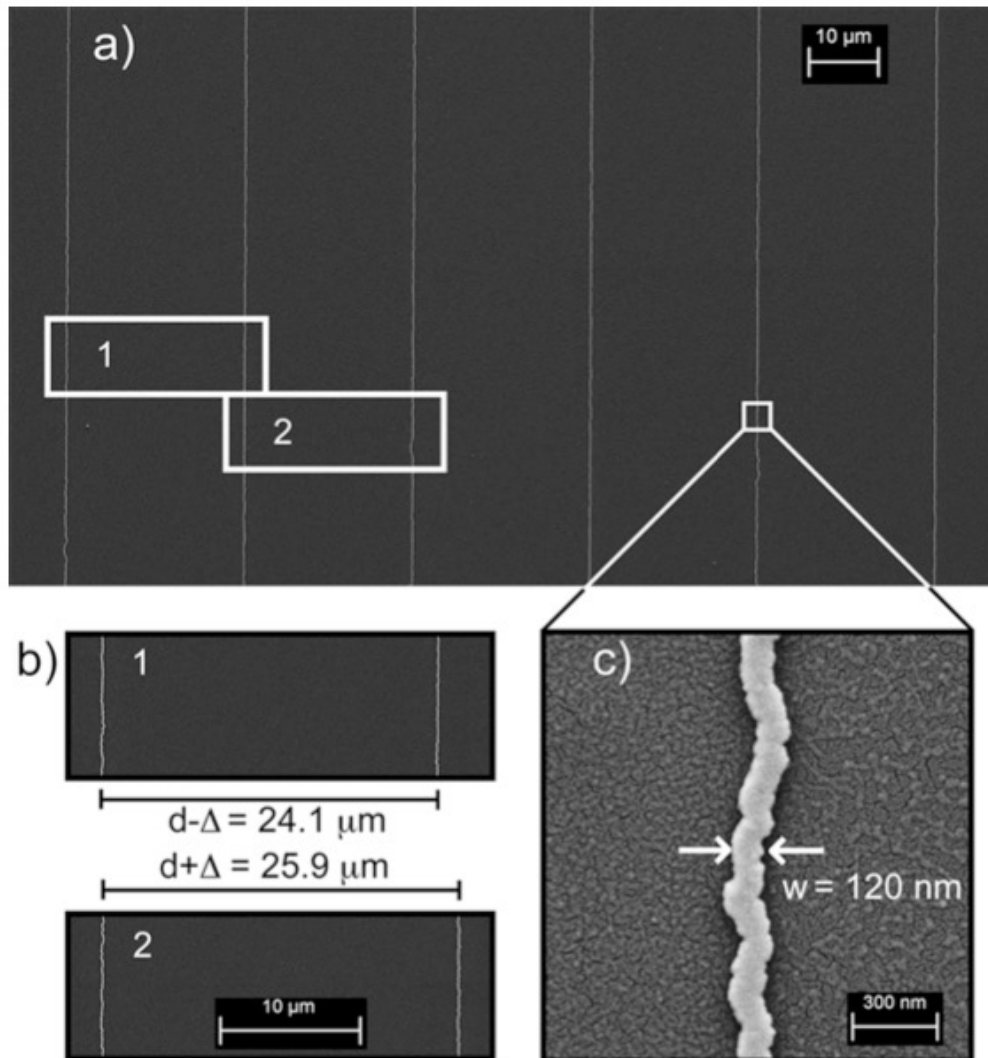
- i) light behaves like an ocean wave.
- ii) the distance between waves determines the color.

Diffraction from nanometer-spaced arrays leads to iridescence



Optical Diffraction from Nanowire Arrays

Lithographically Patterned Nanowire Electrodeposition (LPNE)



Aaron Halpern

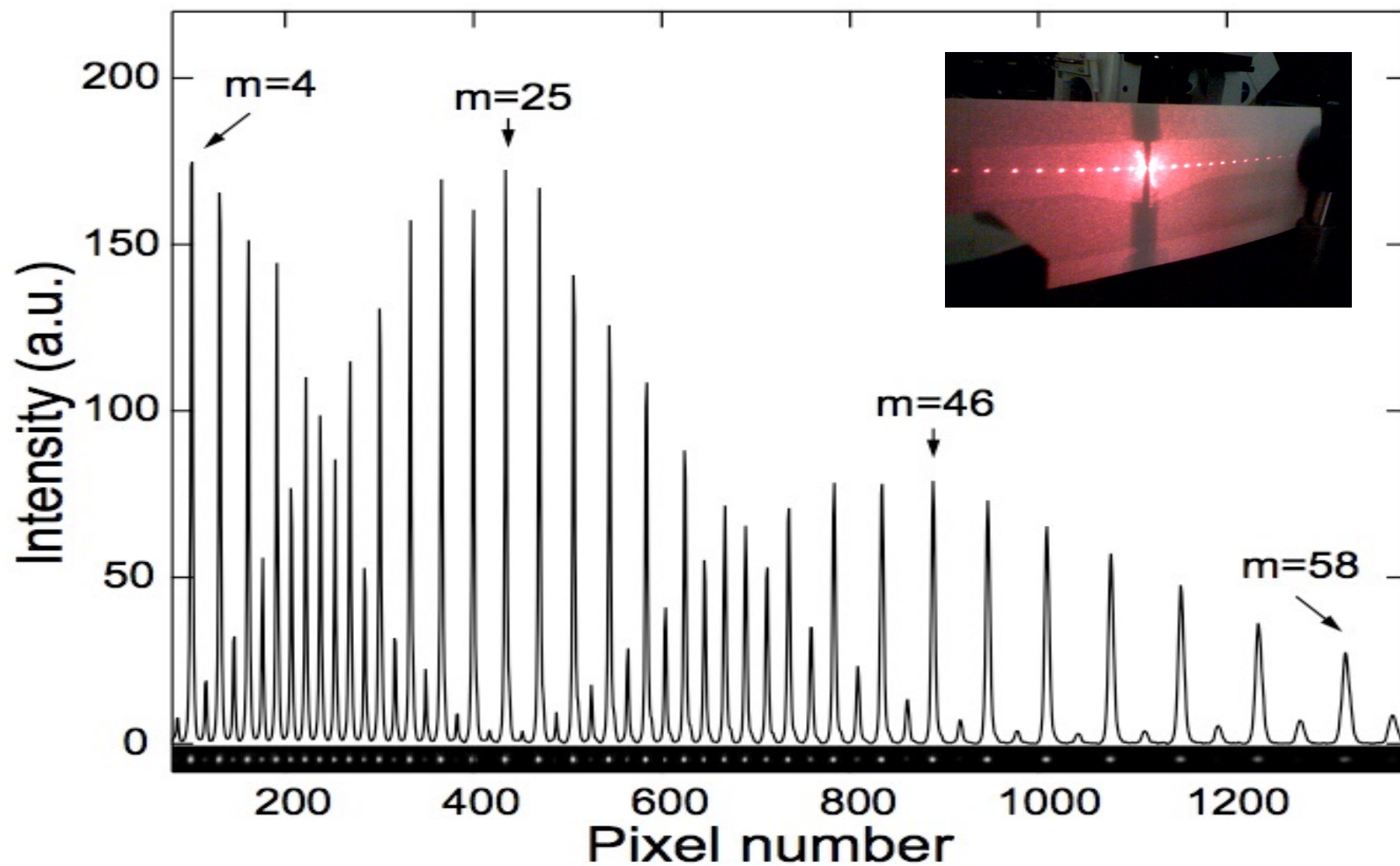
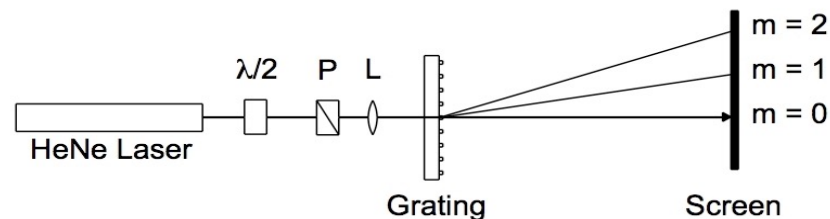


Prof. Reg Penner

A. Halpern et al., *Analytical Chem.*, **81**, 5585-5592 (2009).



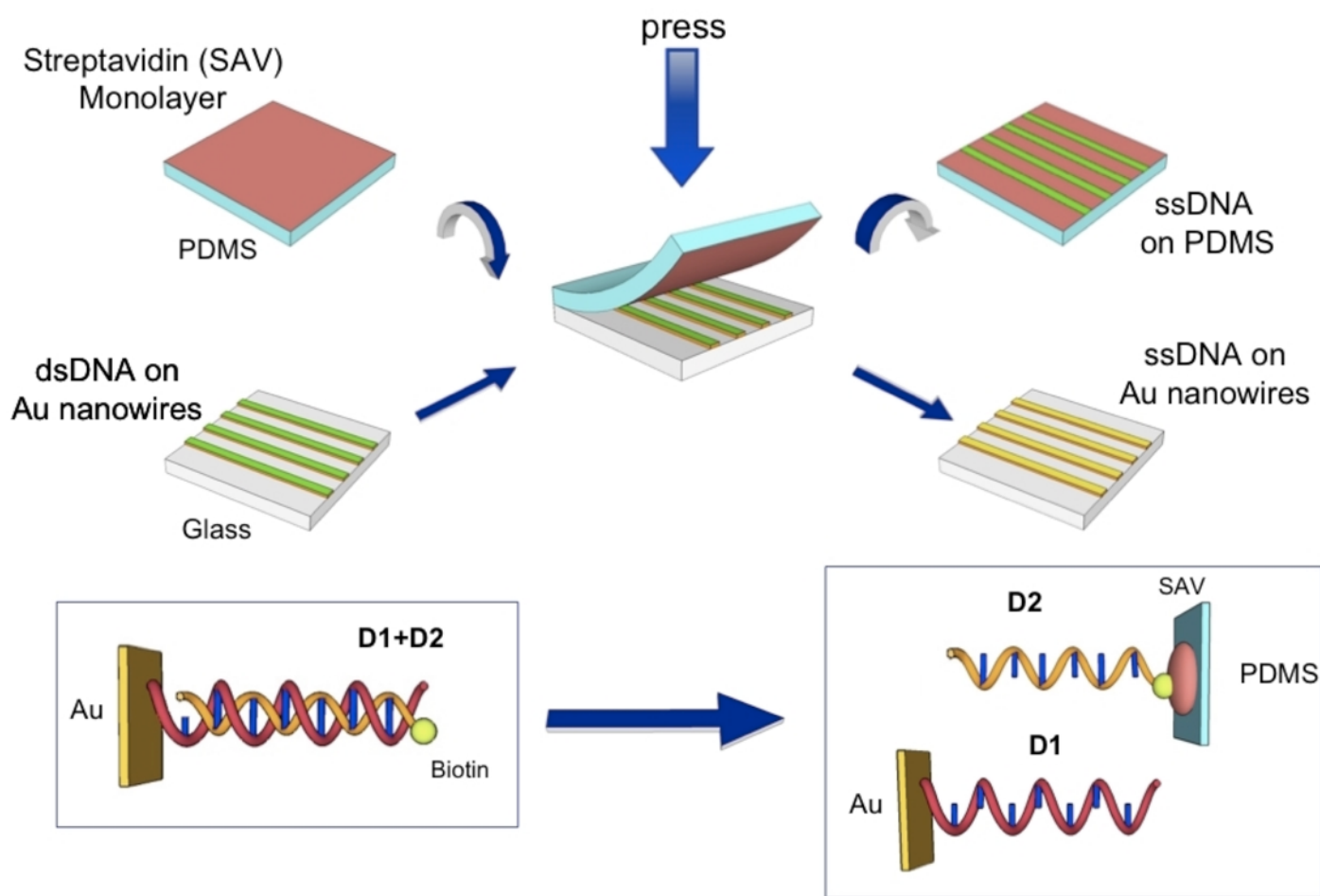
Nanowire Diffraction Gratings



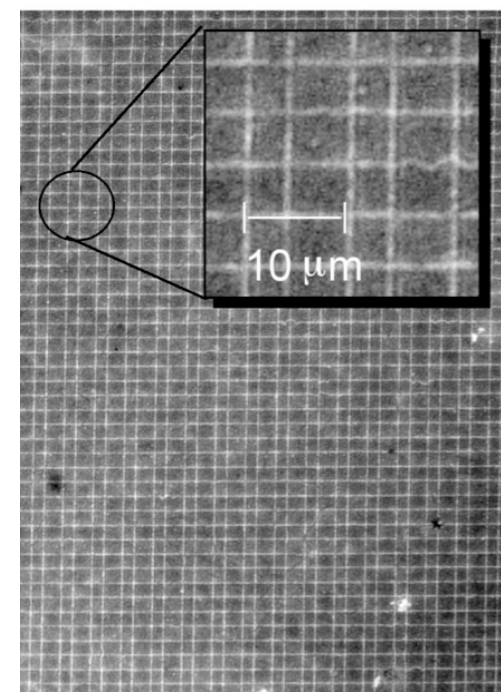
A. Halpern et al., *Analytical Chem.*, **81**, 5585-5592 (2009).



DNA Nanoline Gratings on PDMS

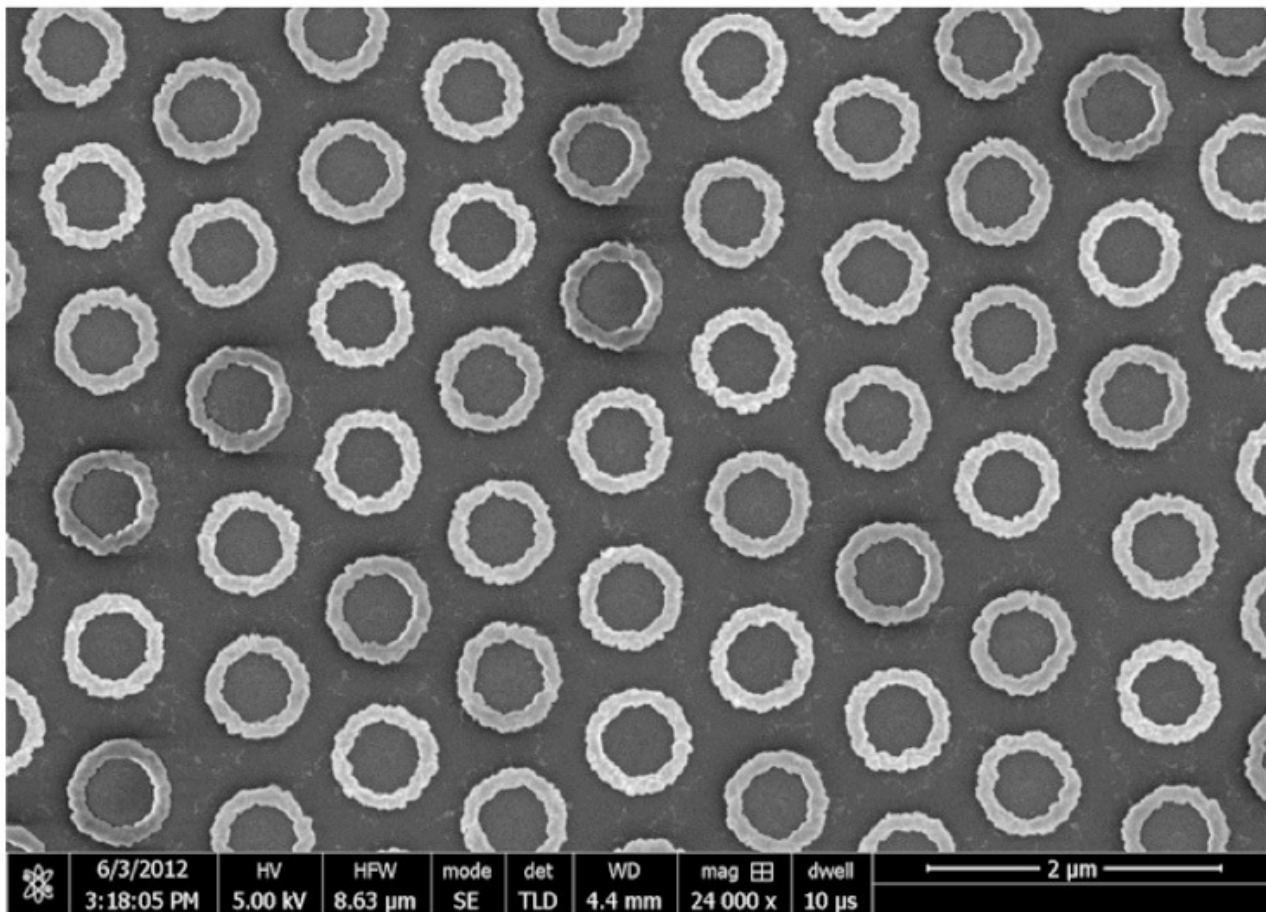


Dr. Yulin Chen



Y. Chen et al., *Analytical Chem.*, **82** 3365-3370 (2010).

Electrodeposited Nanoring Arrays (Au, Ag, Ni, CdTe)



Colloidal Lithography & Lithographically Patterned Nanoscale Electrodeposition (LPNE)

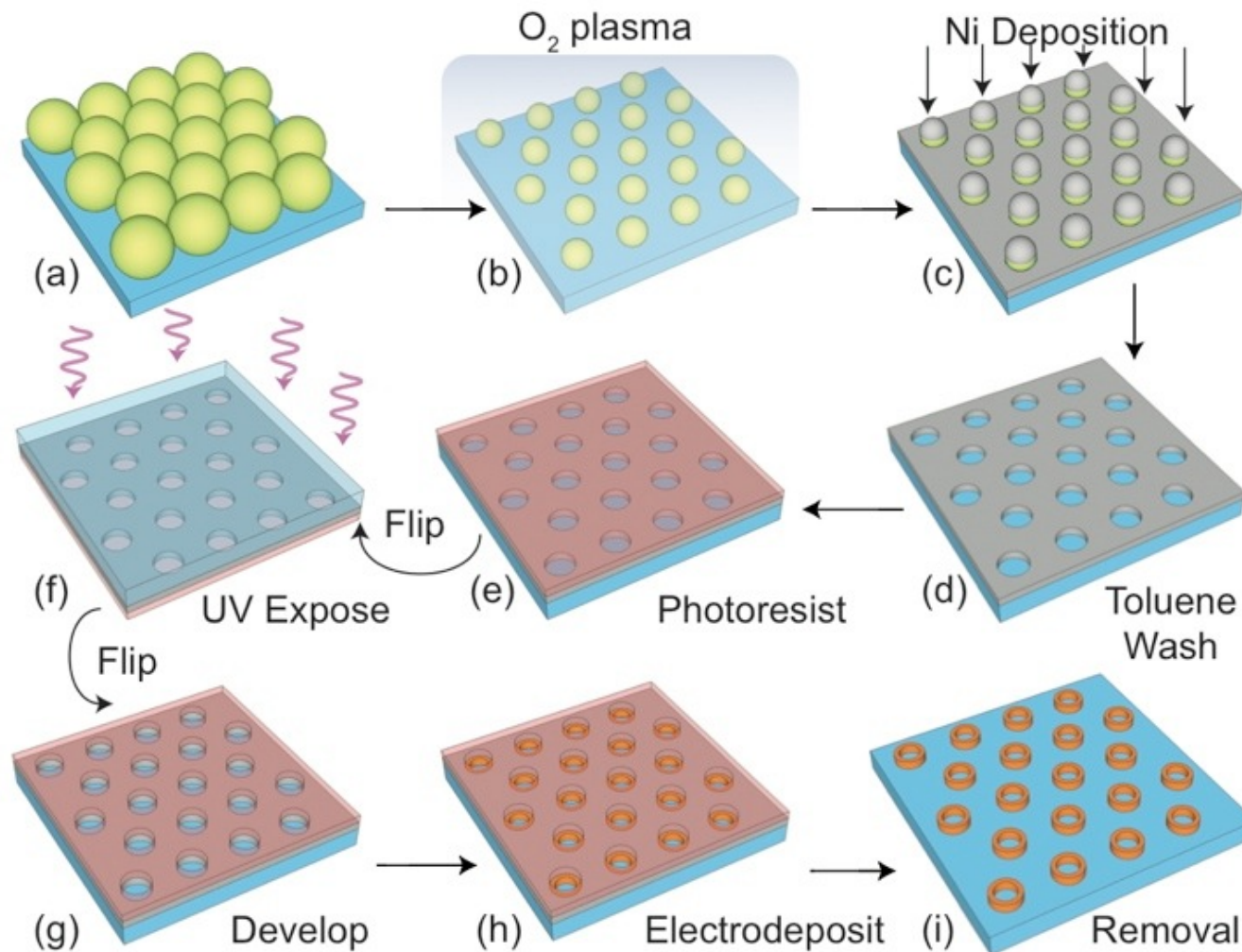
Dr. Aaron Halpern



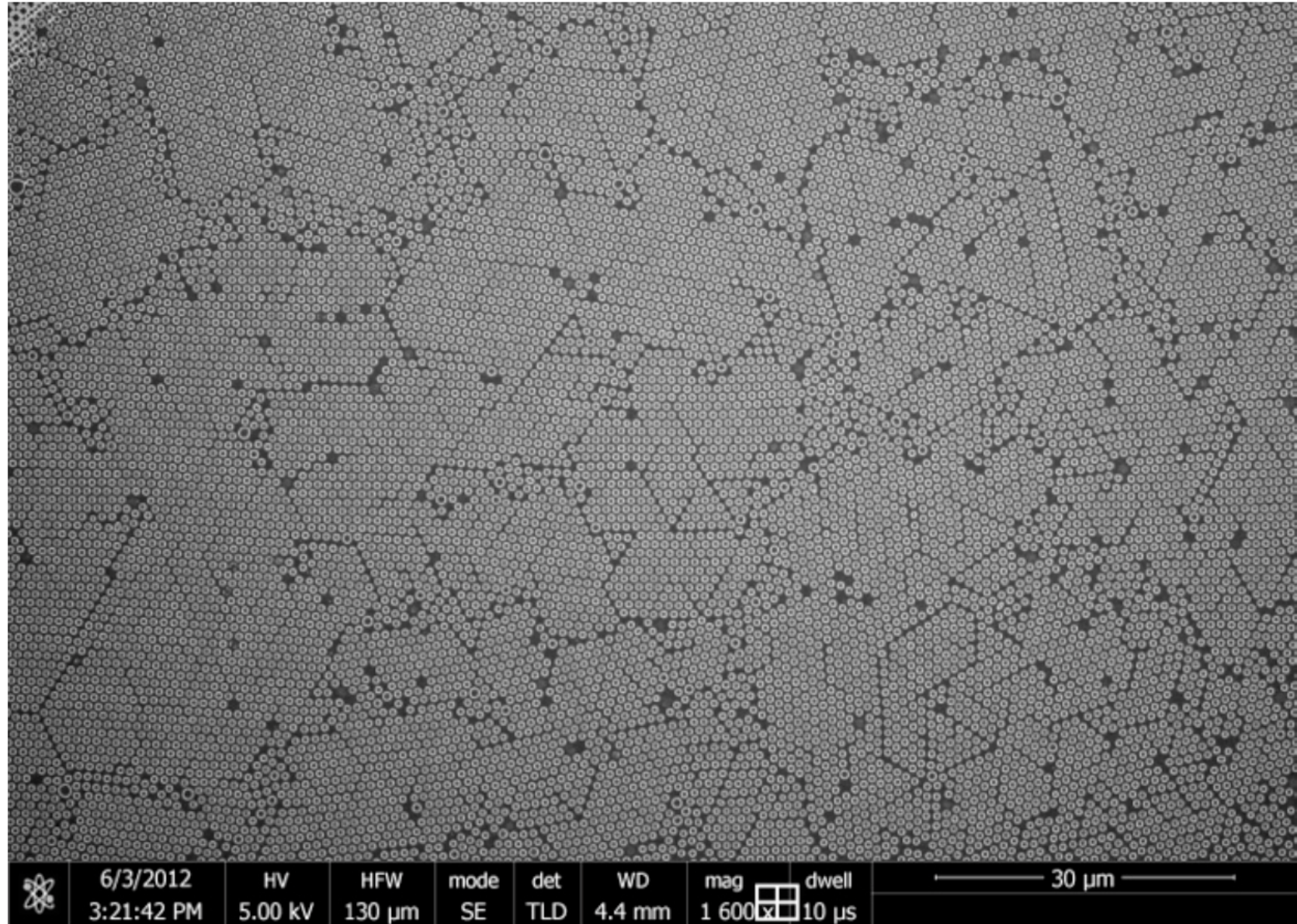
A. R. Halpern and R. M. Corn, *ACS Nano*, **7** 1755-1762 (2013).

Electrodeposited Nanoring Arrays

A Combination of Colloidal Lithography and Lithographically Patterned Nanoscale Electrodeposition (LPNE)



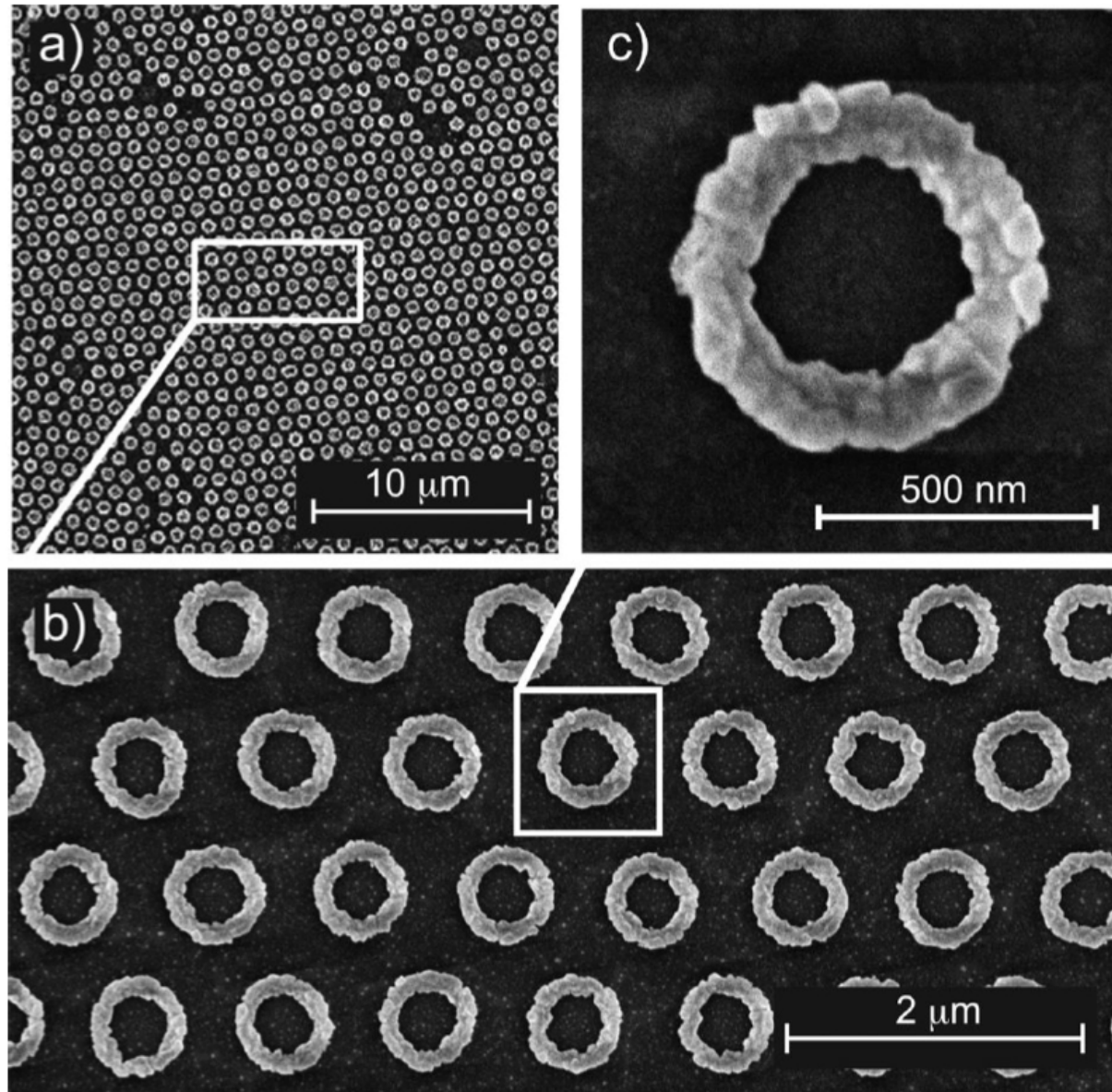
Electrodeposited Nanoring Arrays



Gold Nanoring Arrays

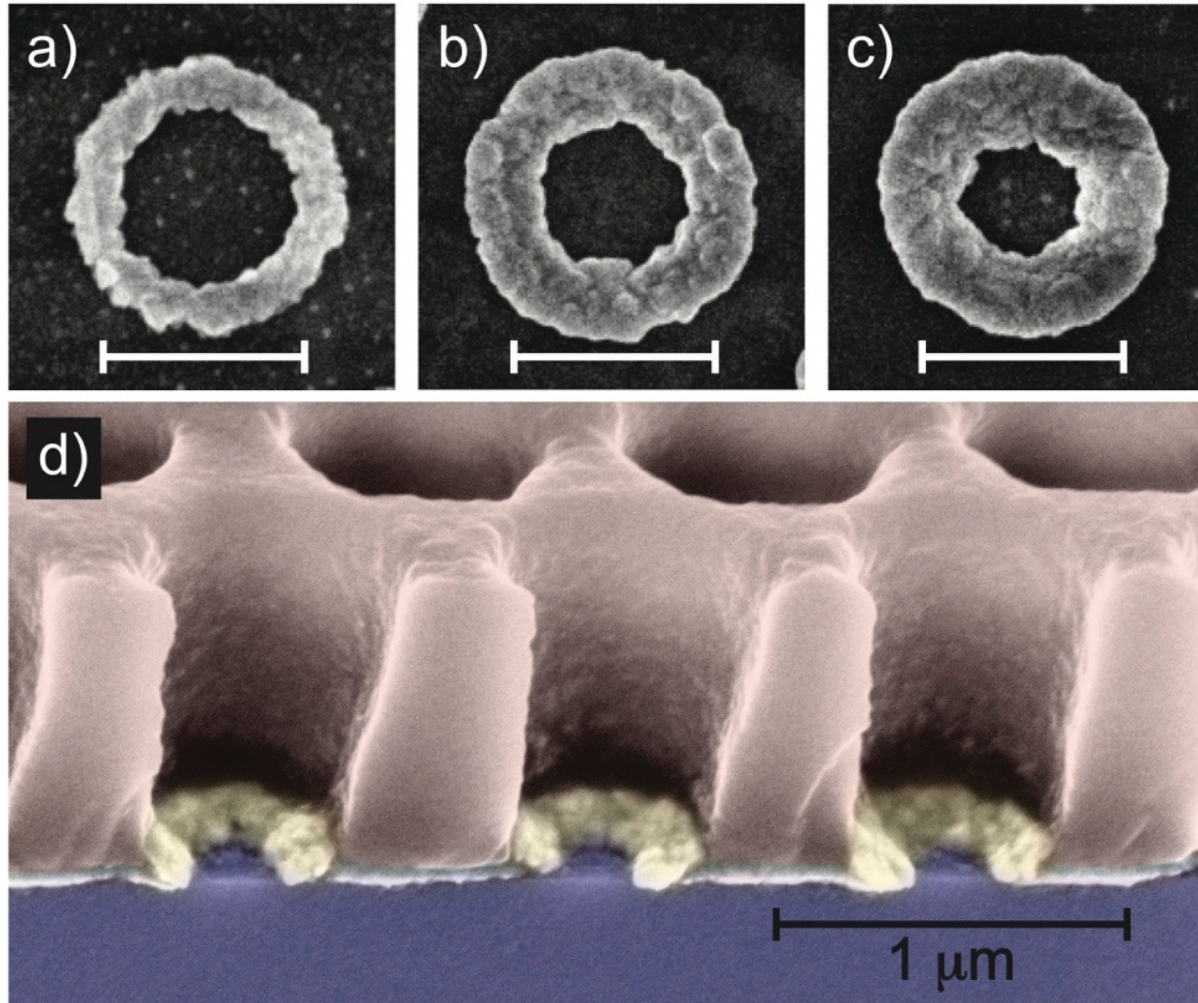


Electrodeposited Nanoring Arrays



Gold Nanoring Arrays

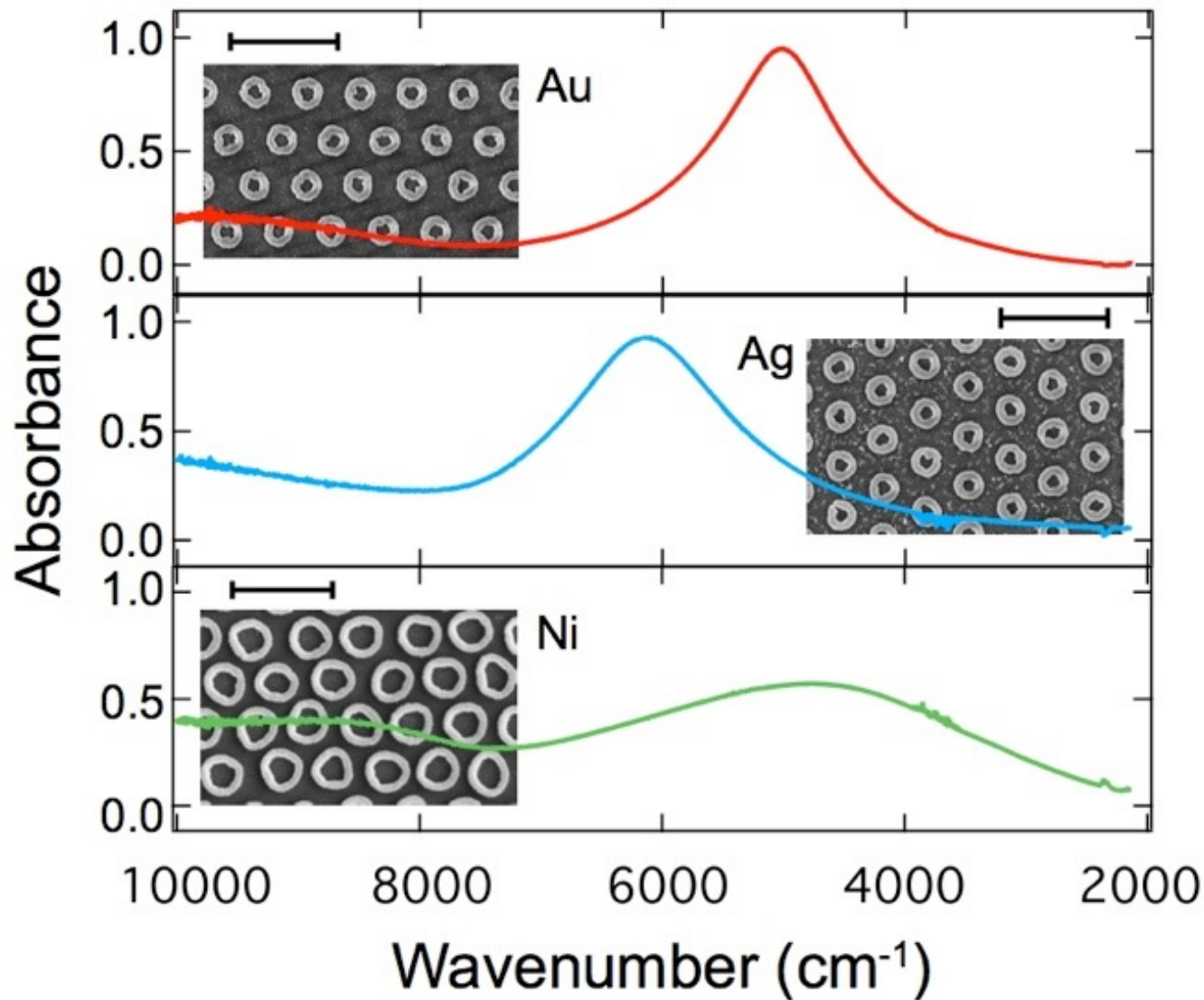
Electrodeposited Nanoring Arrays



*Electrodeposition
time controls ring
width*

Electrodeposited Nanoring Arrays

*NIR: Near Infrared
(0.75 to 3 microns)*



*NIR Plasmonic
Resonances
for Gold (Au), Silver
(Ag) and Nickel
(Ni) Nanorings*

*5000 wavenumbers
corresponds to:
2 microns
2000 nanometers*



Electrodeposited Nanoring Arrays

What's a Plasmonic Resonance?

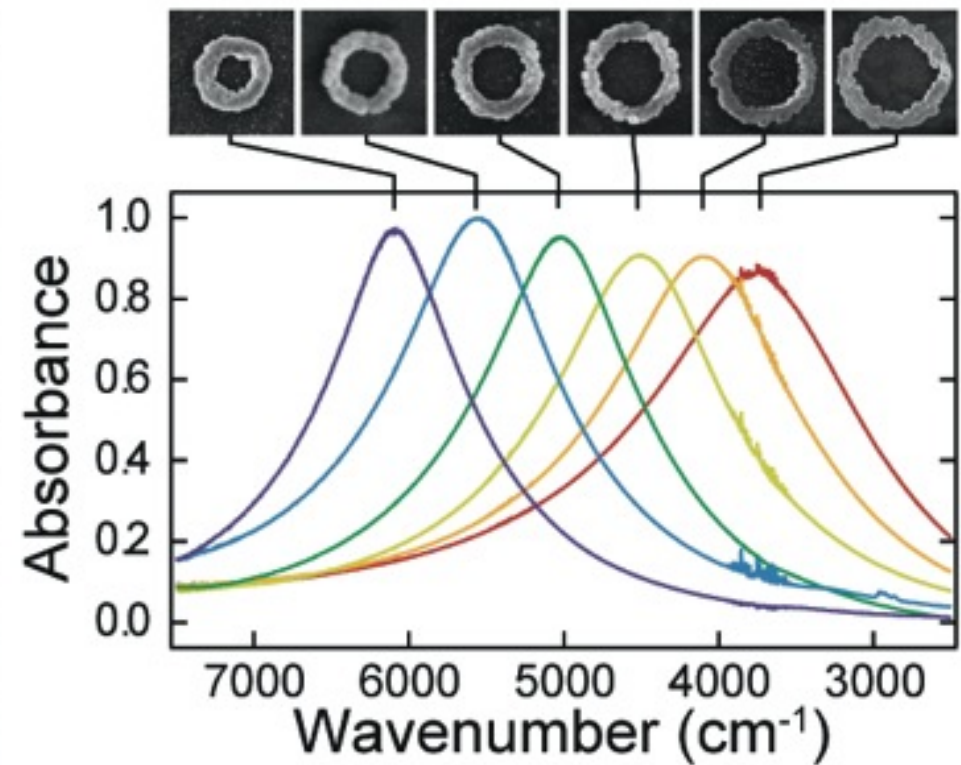
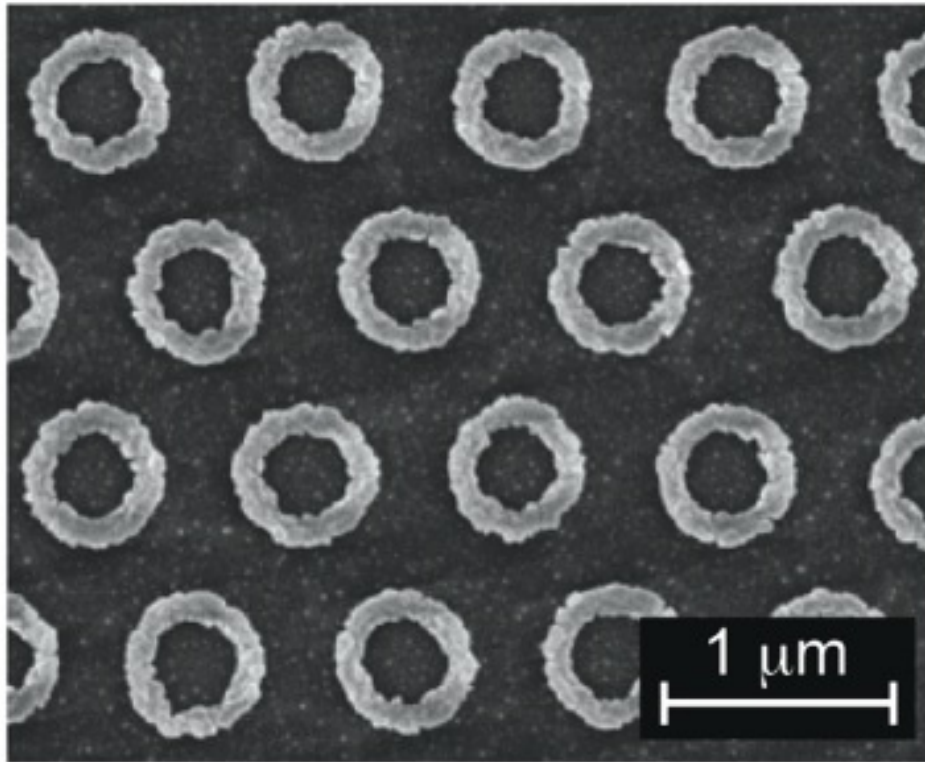
Surface Plasmons (SPs)

Surface Plasmon Resonance (SPR)

Localized Surface Plasmon Resonance (LSPR)



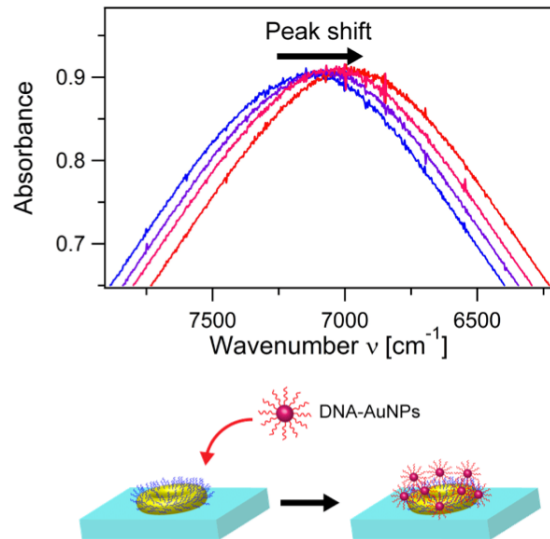
Electrodeposited Nanoring Arrays



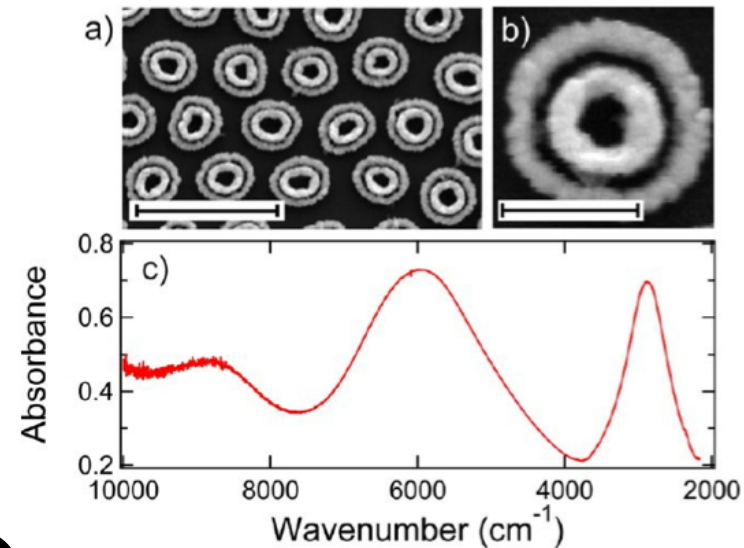
Gold Nanoring Arrays
Tunable NIR Plasmonic Resonance (1 to 3 microns)

Application and Extensions of Nanoring Arrays

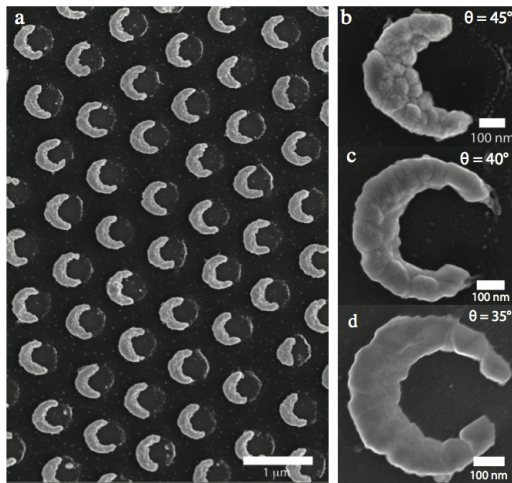
NIR LSPR Biosensing



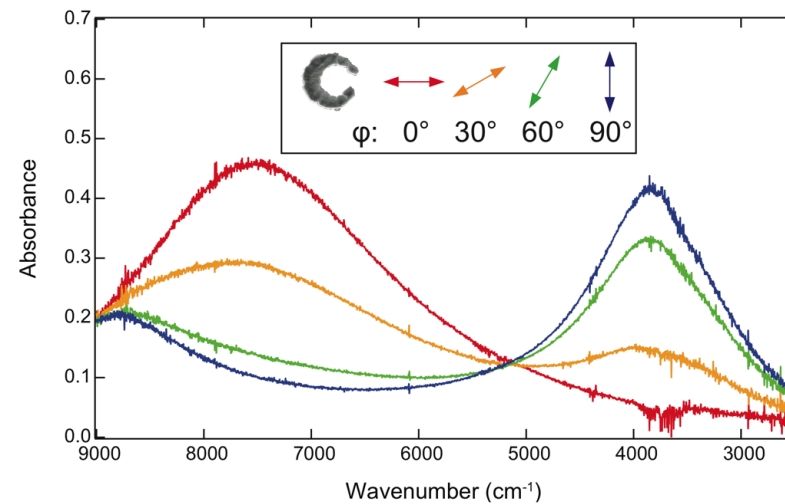
Double Nanoring Arrays



Split Nanoring Arrays

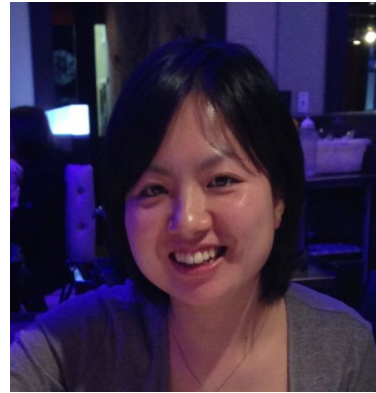
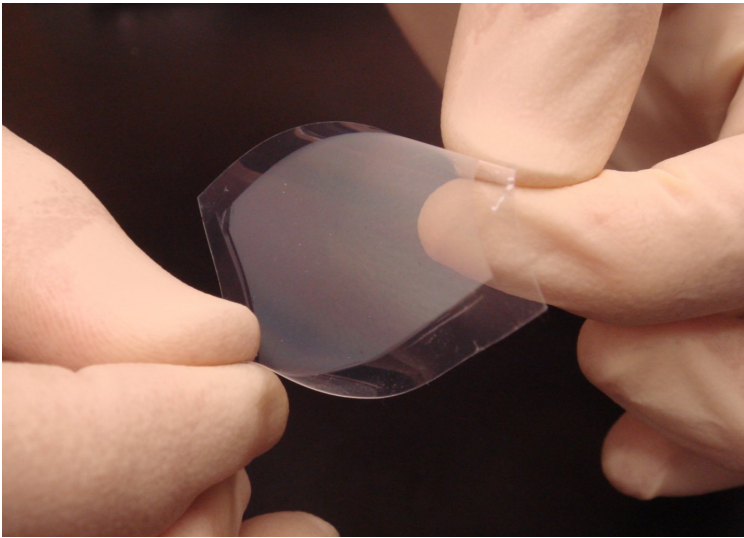


Dichroic Filters

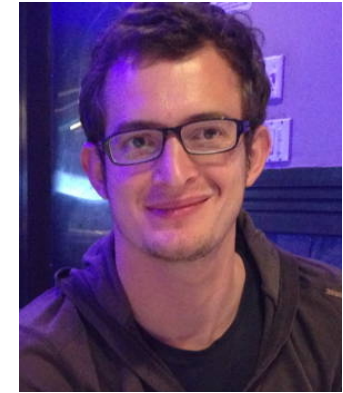


K. Cho, G. Loget and R. M. Corn, *J. Phys. Chem. C*, 118 28993-29000 (2014).

Anti-Reflective Nanocone Arrays: Serendipity in Science



Dr. Mana Toma



Dr. Gabriel Loget



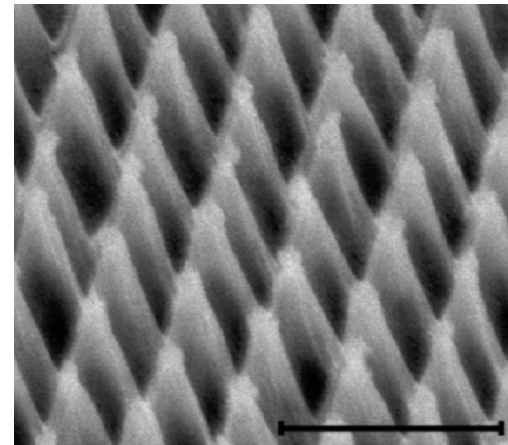
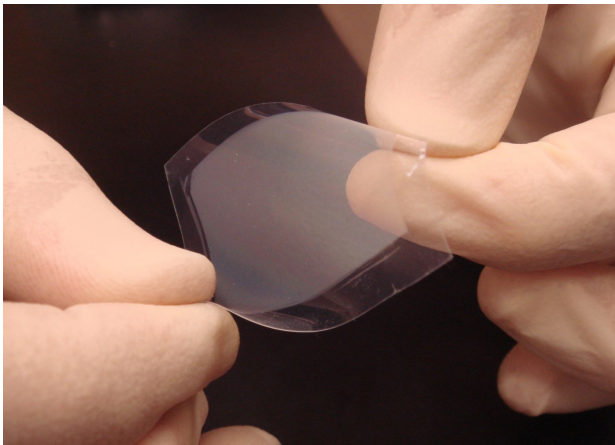
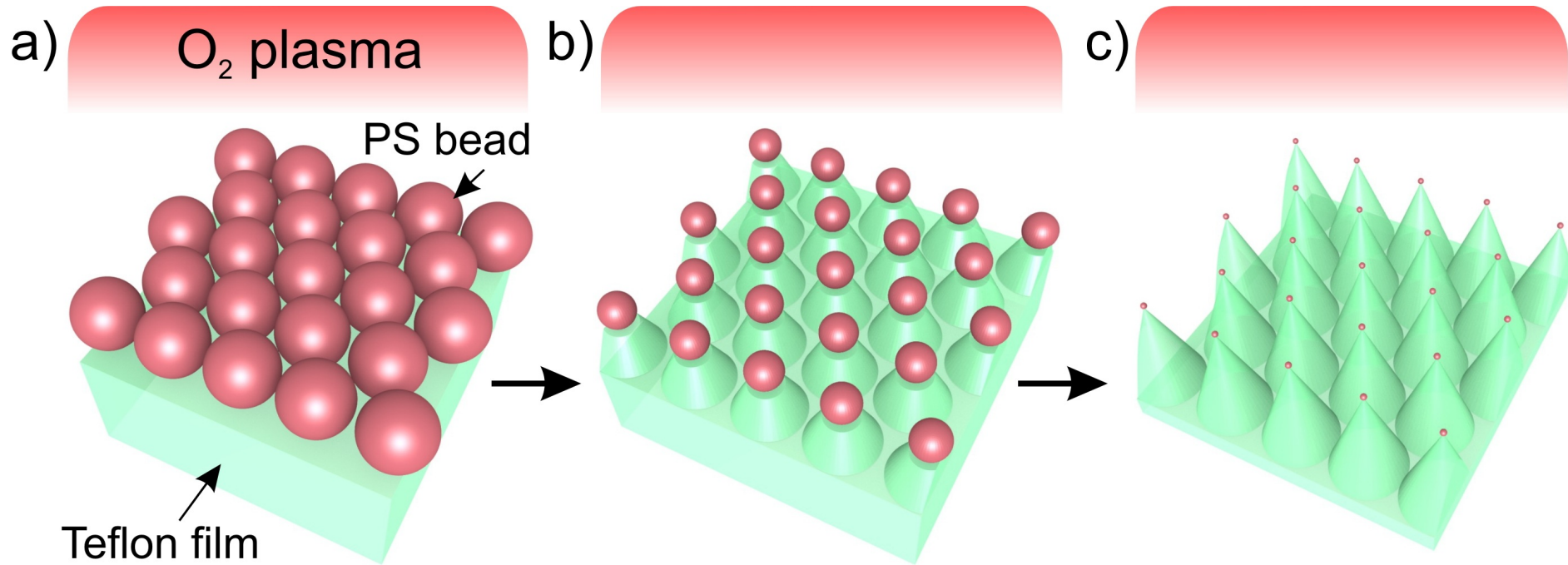
Why did this film turn jet black?

*“Chance favors only the prepared mind”
- Louis Pasteur*



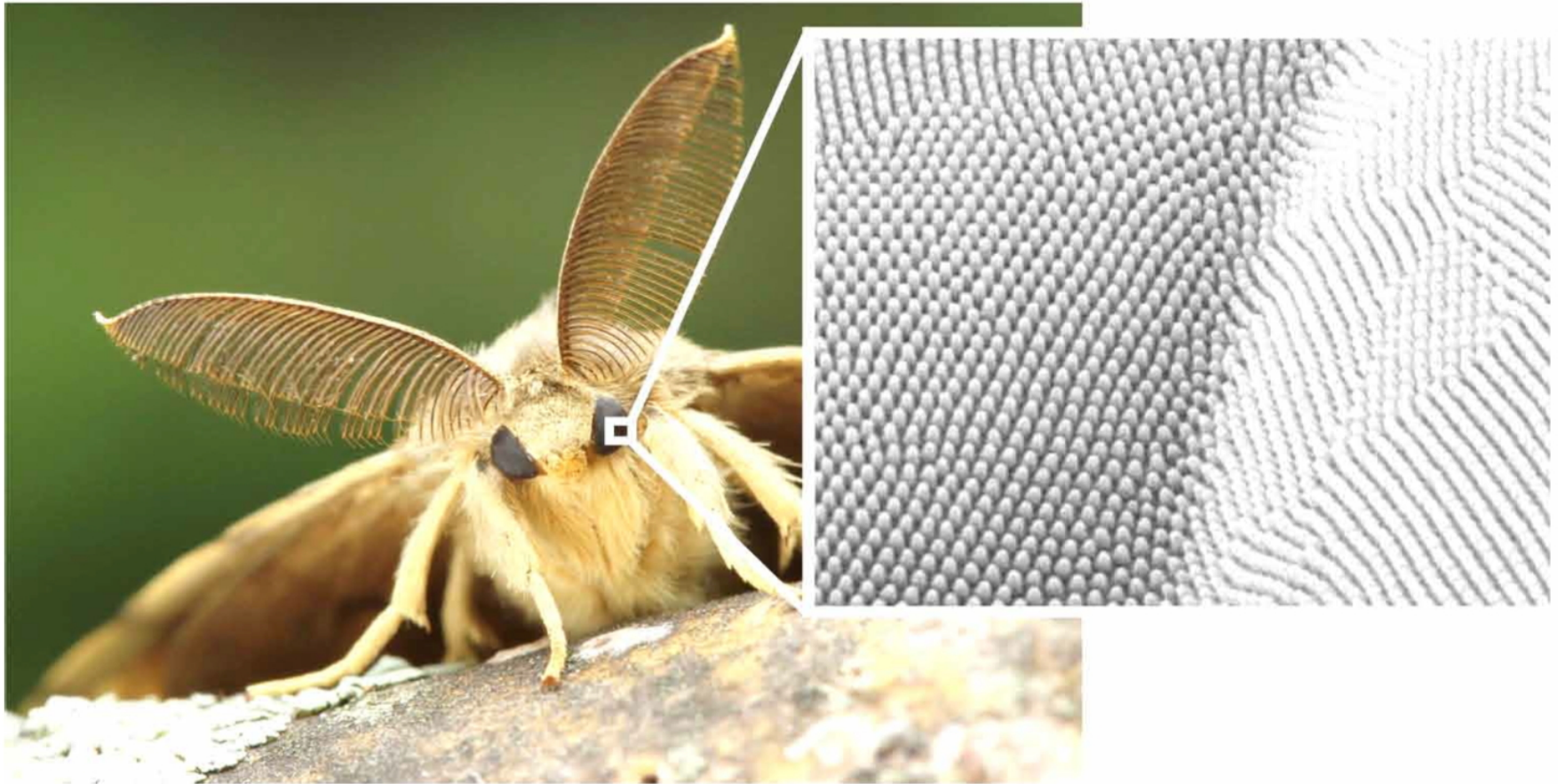
Nanocone Arrays: A new biomimetic surface

Formed by the differential etching of polystyrene beads and Teflon

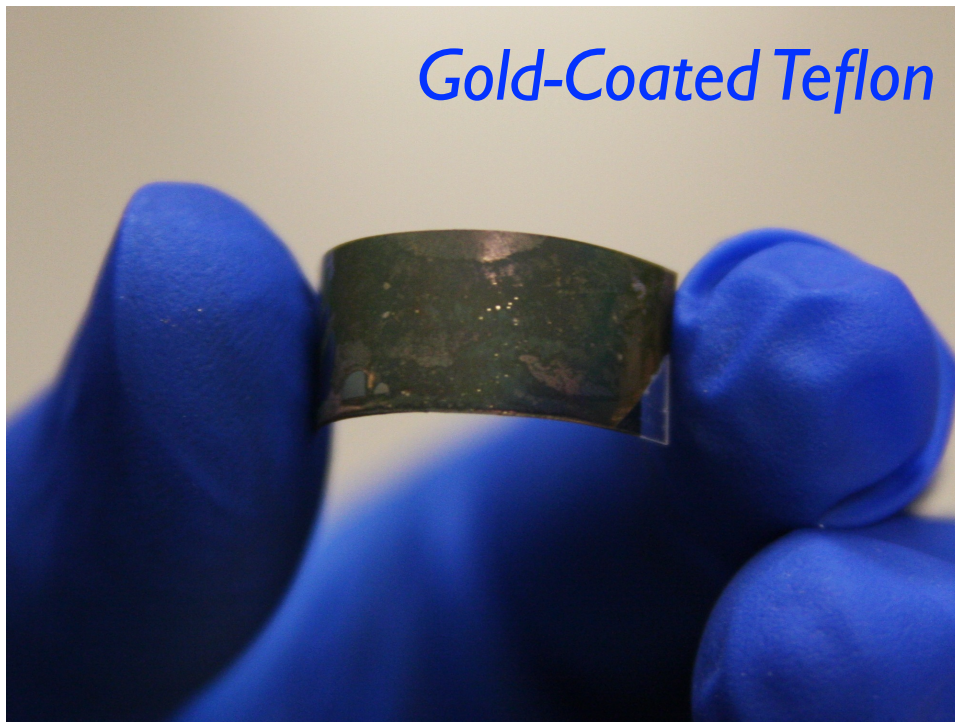


Nanocone Array Surfaces are Biomimetic

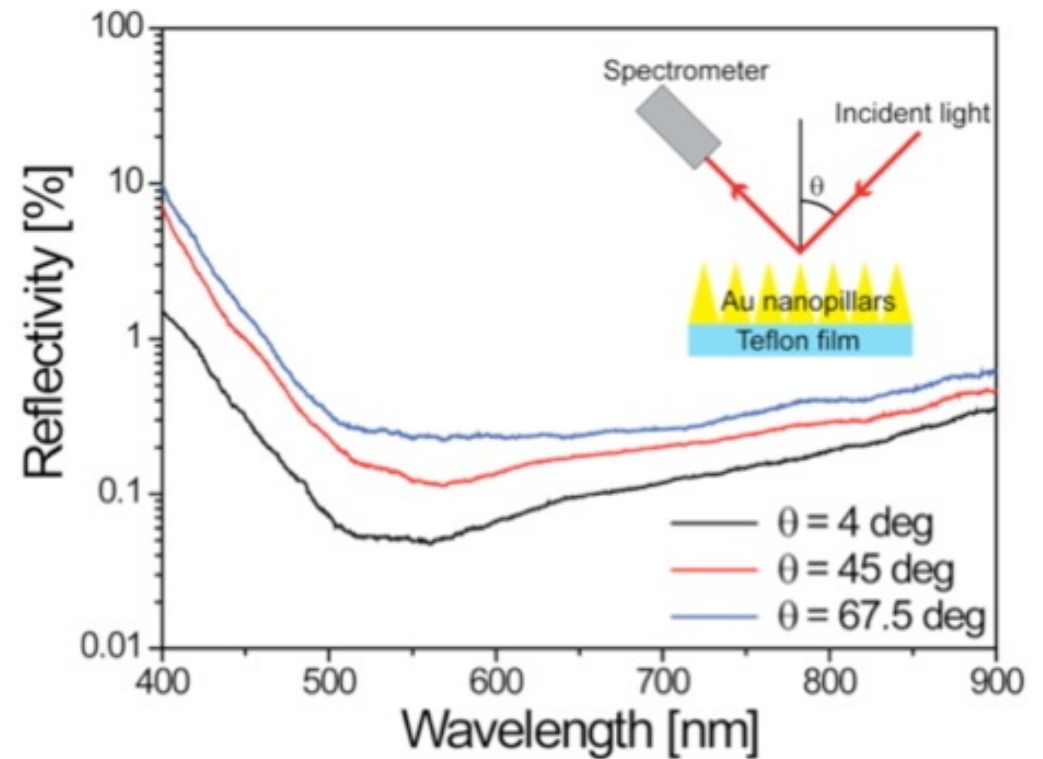
Moth eye



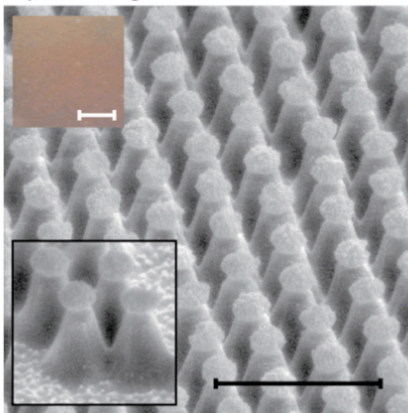
Broadband Plasmonic Nanocone Anti-Reflection Surface



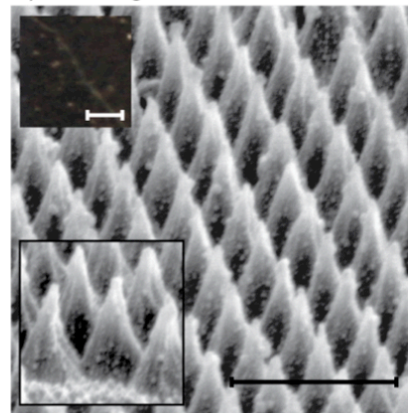
30 nm Au deposition



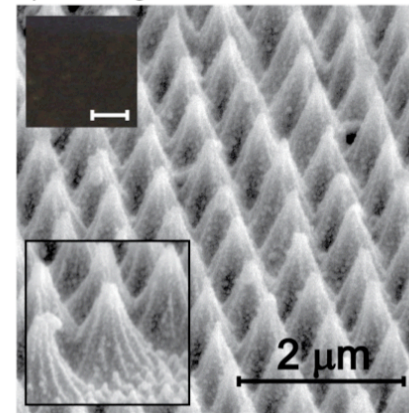
a) Etching time: 3 min



b) Etching time: 6 min

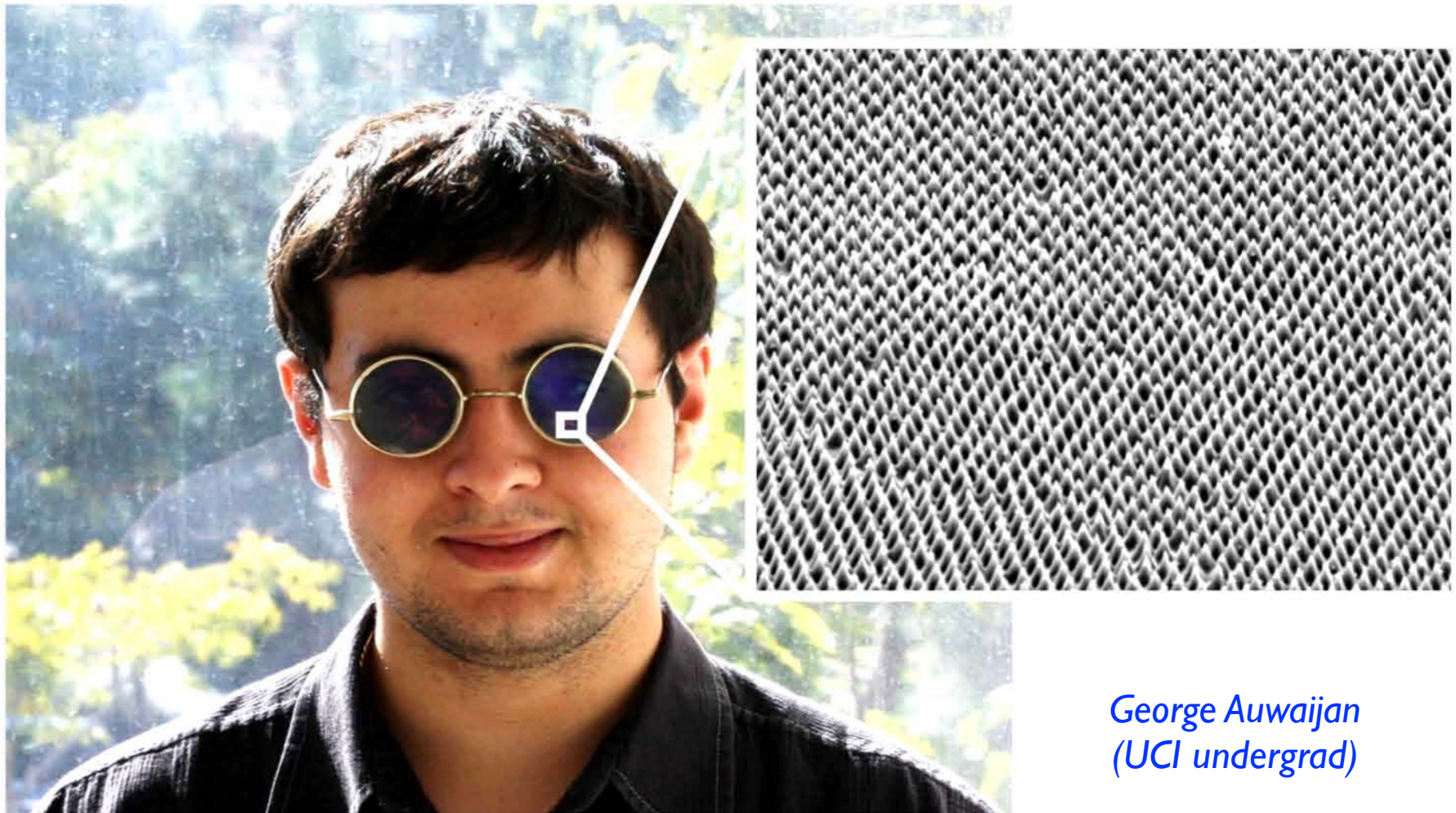


c) Etching time: 12 min



Nanocone Array Surfaces are Biomimetic

George eye

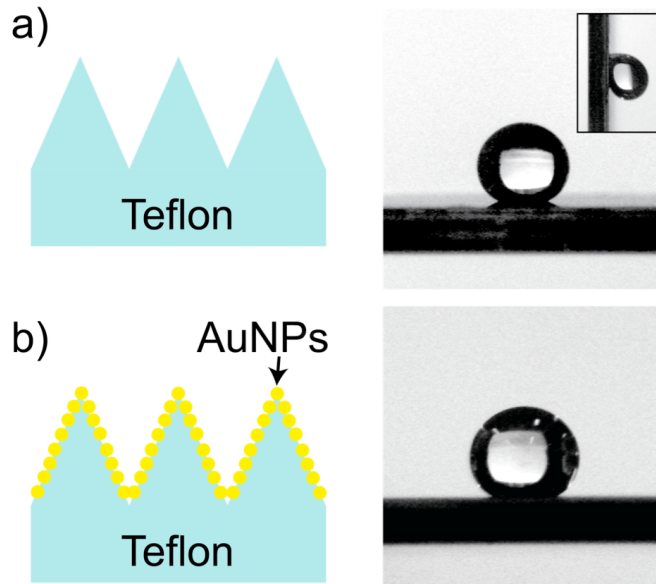


George Auwaijan
(UCI undergrad)

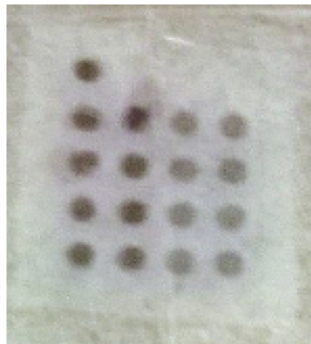


Superhydrophobic Nanocone Array Surfaces

Superhydrophobic Surfaces



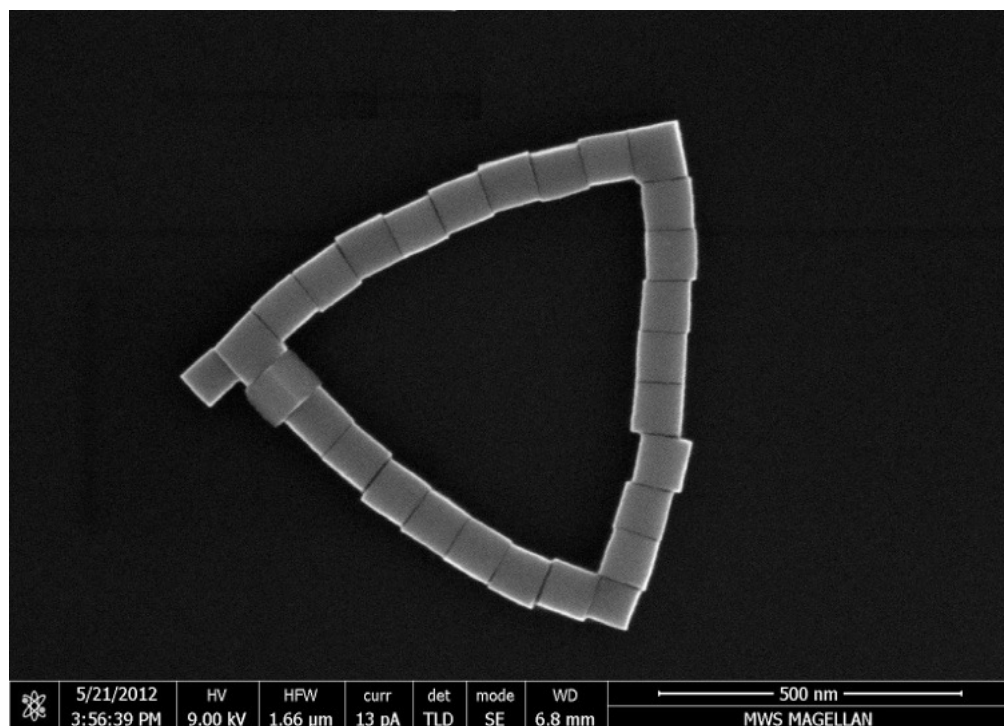
*Simple Biosensor Chips
for rapid miRNA profiling*



*Teflon
(Gecko Style)
or
Gold-Coated Teflon
(Lotus Style)*



Self-Assembly of Magnetite Nanocubes into Flux Closure Polygons



Dr. Megan
Szyndler

Charlene
Konkankit



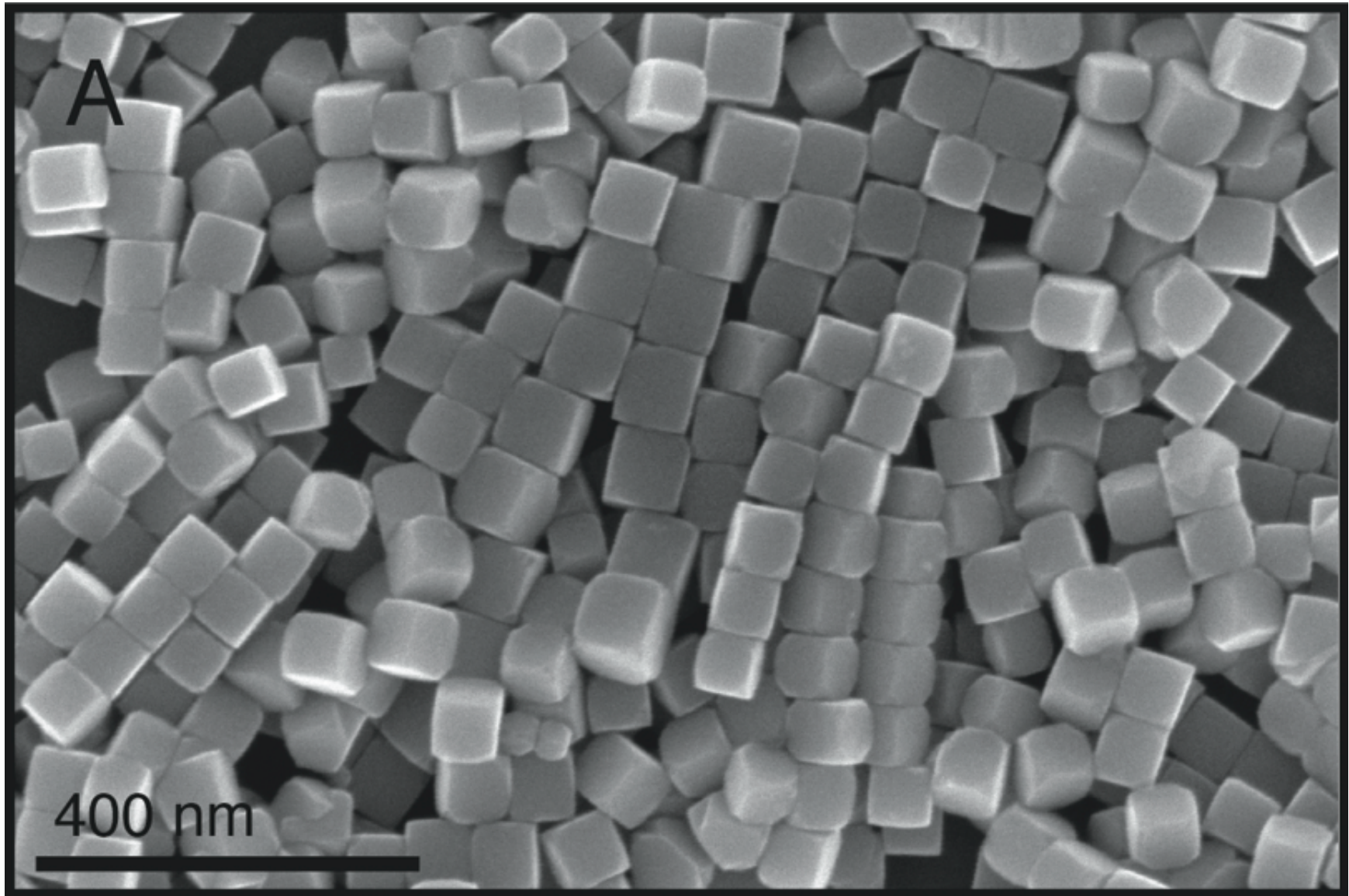
*Magnetite: Fe_3O_4 :
Ferrimagnetic*

*Magnetite Nanoparticles:
Super Paramagnetic?*



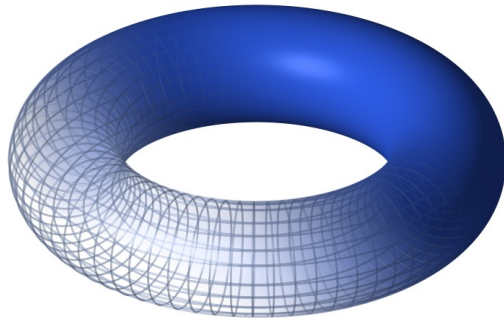
M.W. Szyndler and R. M. Corn, J. Phys. Chem. Lett., 3 2320-2325 (2012).

Magnetite Nanocubes: Fe_3O_4



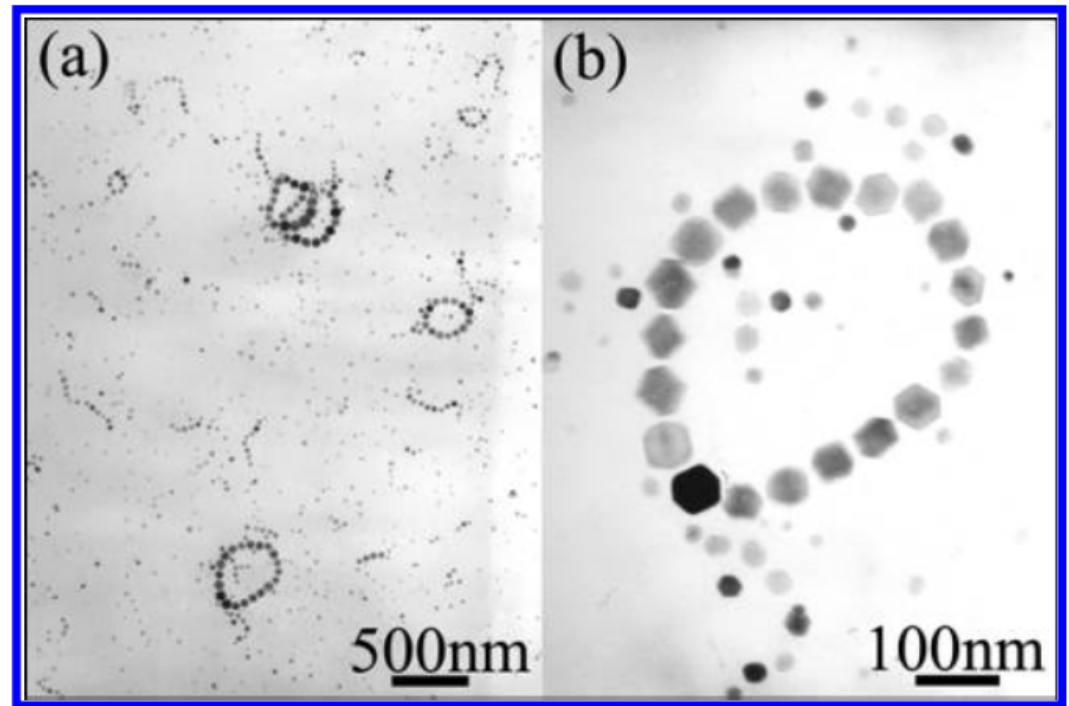
Magellan SEM image

Nanoparticle Flux Closure Rings



Toroidal Transformer

<http://phy214uhart.wikispaces.com>



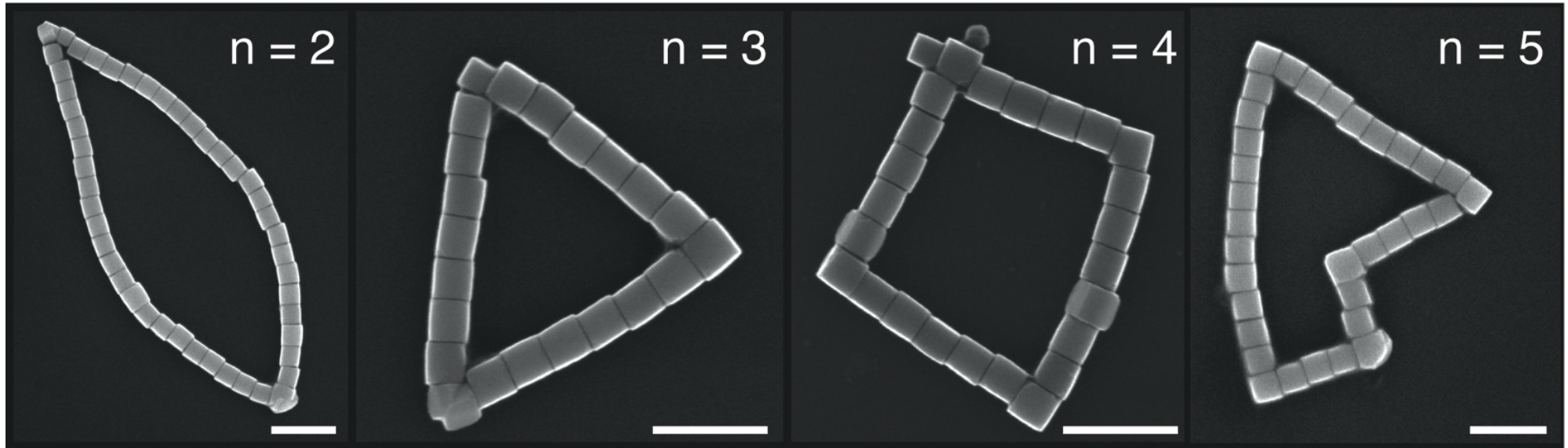
Magnetite Flux Closure Rings

Y. Xiong, J. Ye, X. Gu, and Q-W Chen,
J. Phys. Chem. C, **111**, 6998-7003 (2007).

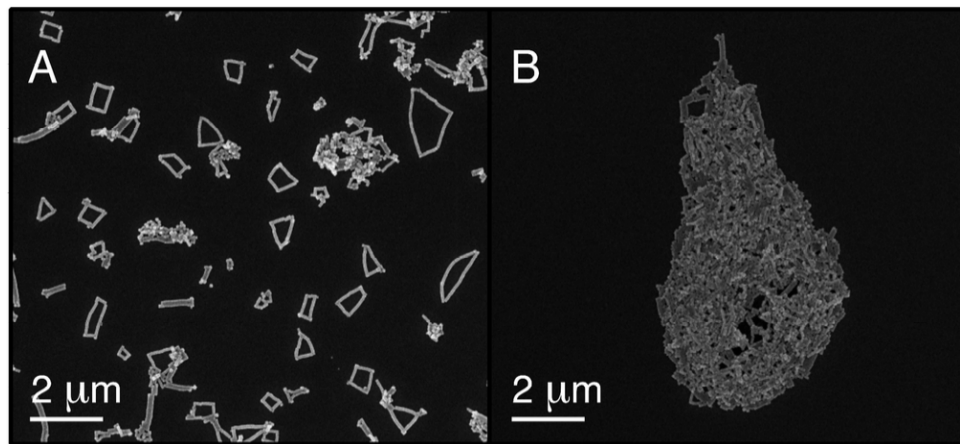
*Self-assembly of nanoparticles
into flux closure rings*



Nanopolygon Self Assembly: $n = 2-6$ observed.



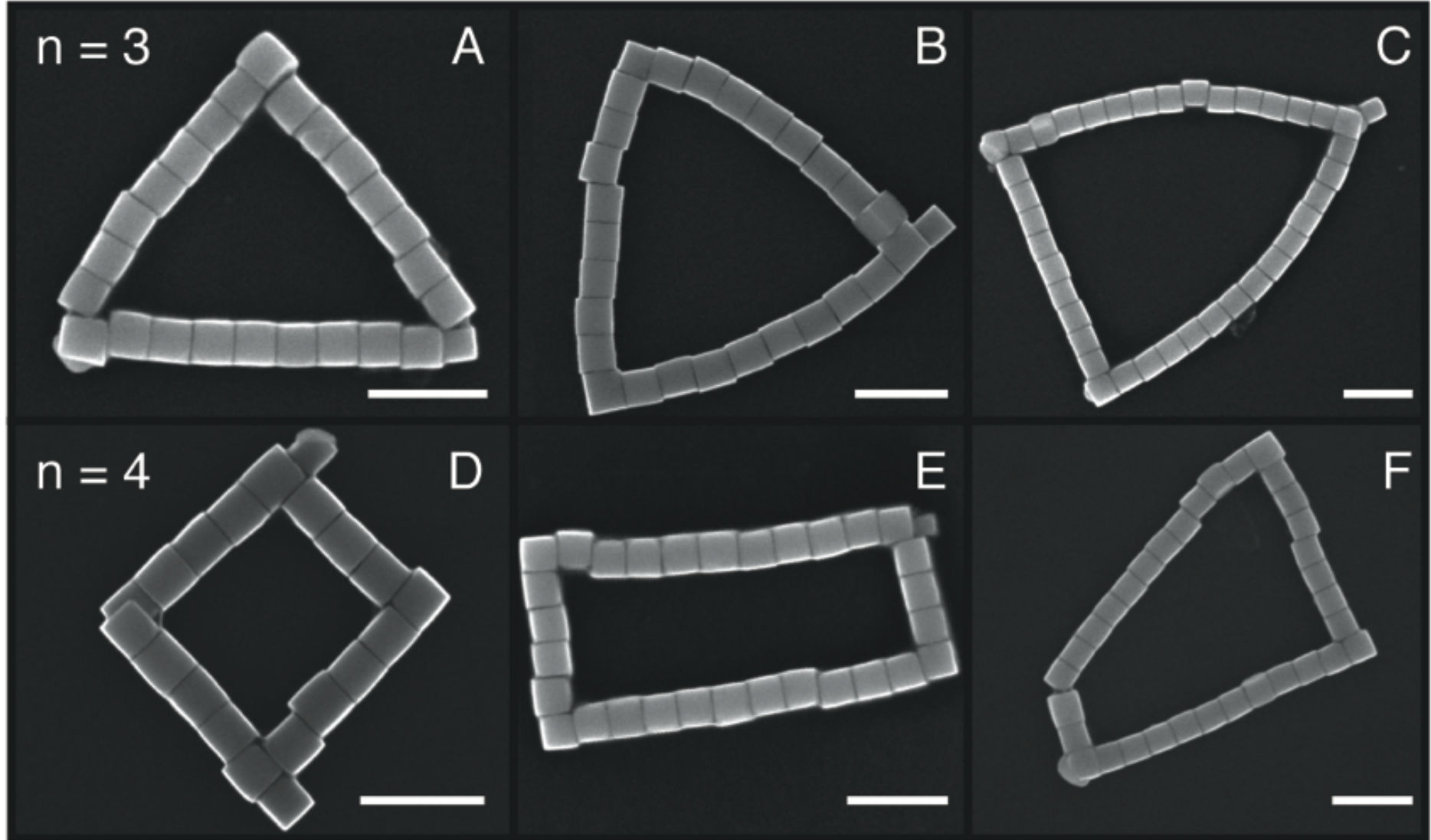
Flux Closure Polygon Formation Requires Surface Functionalization



Good

Bad

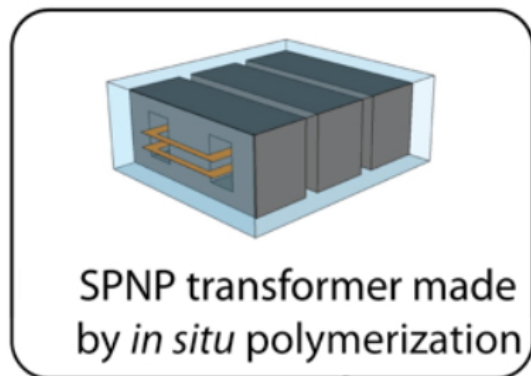
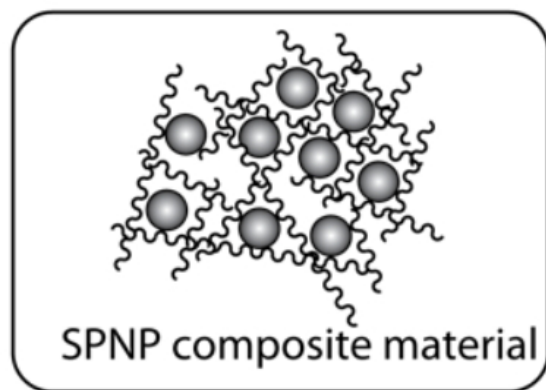
Nanotriangles and Nanosquares



- *Angle Strain*
- *Fringing Fields at Vertices*



Next Step: Ferrite Nanoparticles & Nanocubes - HF transformers



Charlene
Konkankit



Kellen
Kartub

Ferrites: ZnFe_2O_4
 CoFe_2O_4
 $\text{Ni}_x\text{Zn}_{1-x}\text{Fe}_2\text{O}_4$
 $\text{Mn}_x\text{Zn}_{1-x}\text{Fe}_2\text{O}_4$

(Magnetite: Fe_3O_4)

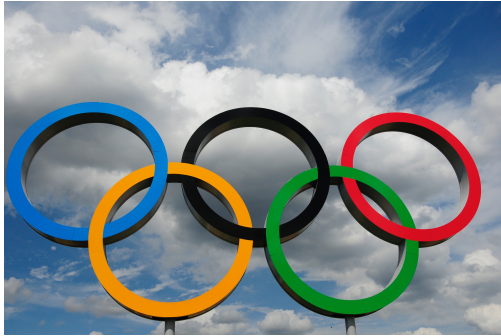


Nanotextured Surfaces: Smart Materials With Unique Properties

Prof. Robert Corn

UCI Departments of Chemistry & Biomedical Engineering

Rings



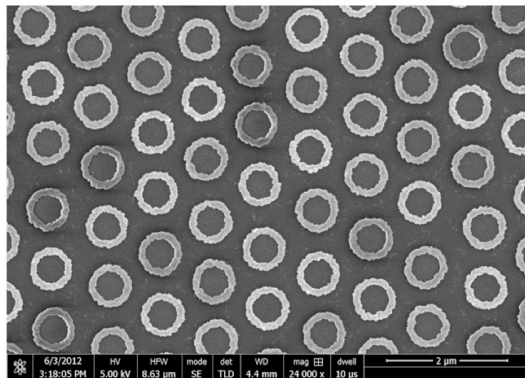
Cones



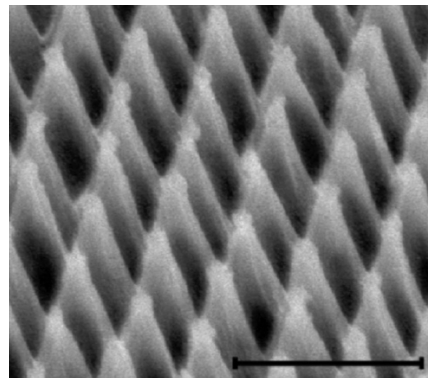
Cubes



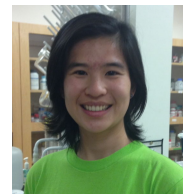
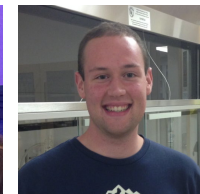
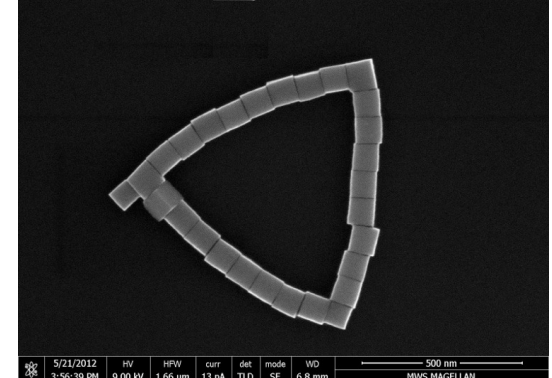
Nanorings



Nanocones



Nanocubes

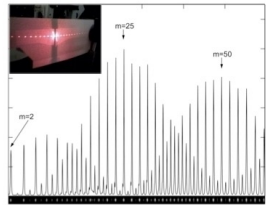


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University of California, Irvine

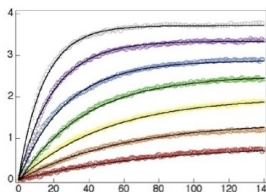
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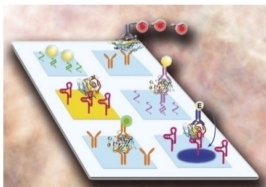
UCI Departments of Chemistry & Biomedical Engineering



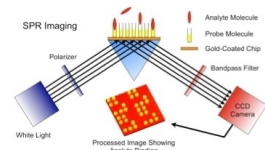
Surface Spectroscopy



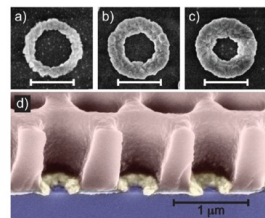
Surface Chemistry



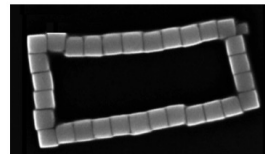
Surface Biochemistry



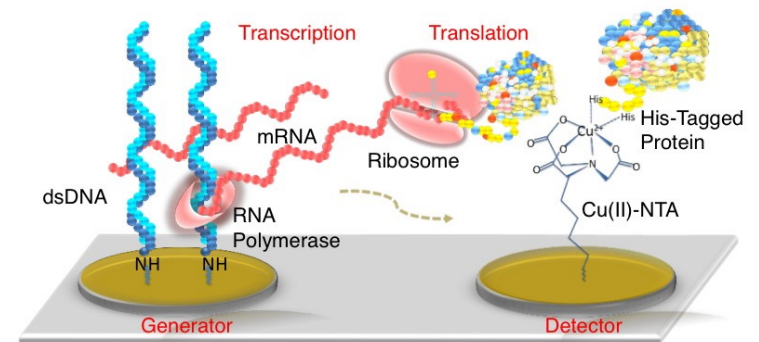
Biosensors



Nanomaterials



Programmable Self Assembly



Surface Enzyme Chemistries

More at our website: <http://corninfo.ps.uci.edu>



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