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OMICS Group International is an amalgamation of Open Access publications and worldwide international science conferences and events. Established in the year 2007 with the sole aim of making the information on Sciences and technology ‘Open Access’, OMICS Group publishes 400 online open access scholarly journals in all aspects of Science, Engineering, Management and Technology journals. OMICS Group has been instrumental in taking the knowledge on Science & technology to the doorsteps of ordinary men and women. Research Scholars, Students, Libraries, Educational Institutions, Research centers and the industry are main stakeholders that benefitted greatly from this knowledge dissemination. OMICS Group also organizes 300 International conferences annually across the globe, where knowledge transfer takes place through debates, round table discussions, poster presentations, workshops, symposia and exhibitions.

About OMICS Group Conferences

OMICS Group International is a pioneer and leading science event organizer, which publishes around 400 open access journals and conducts over 300 Medical, Clinical, Engineering, Life Sciences, Phrama scientific conferences all over the globe annually with the support of more than 1000 scientific associations and 30,000 editorial board members and 3.5 million followers to its credit.

OMICS Group has organized 500 conferences, workshops and national symposiums across the major cities including San Francisco, Las Vegas, San Antonio, Omaha, Orlando, Raleigh, Santa Clara, Chicago, Philadelphia, Baltimore, United Kingdom, Valencia, Dubai, Beijing, Hyderabad, Bengaluru and Mumbai.

An application of electron beam lithography: location of metallic nanostructures based on DNA

Enrique Samano
CNyN-UNAM, Ensenada, B.C., México

3rd International Conference on Materials Science & Engineering-2014

OUTLINE

- DNA is the carrier of genetic information. It is also “brick and mortar” for building at the nanoscale (N. Seeman, *Nature* 421, 427- 431 (2003)).

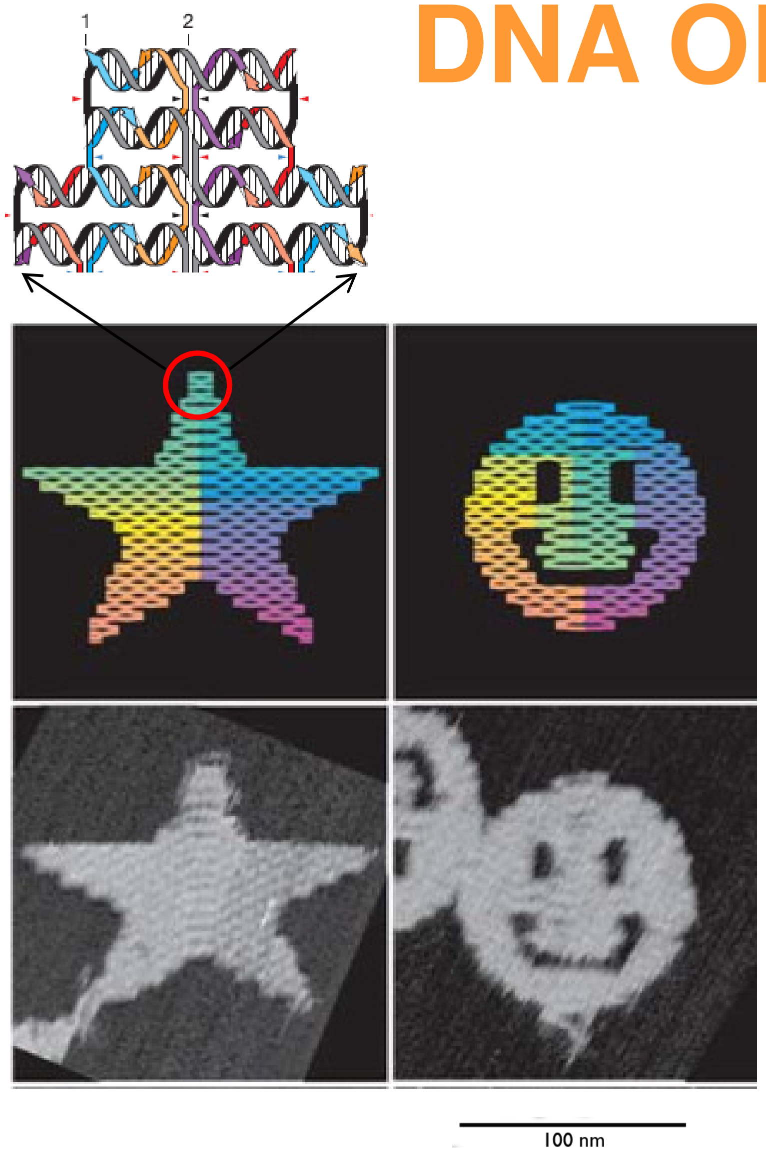
- DNA belongs to the nanometer scale, its diameter is approximately 2 nm and one full turn of the helix is about 3.5 nm (~ 10.5 bp long). Complex materials with micron-scale dimensions and nanometer-scale feature resolution can be created via engineered DNA self-assembly.

- These assemblies are increasingly being exploited as templates for the programmed assembly of functional inorganic materials.

- A scheme has been recently proposed to apply these bioinspired DNA templates towards the fabrication of composite materials for use in photonics, medicine, etc. (E. Samano *et al.*, *Soft Matter* (2011)).

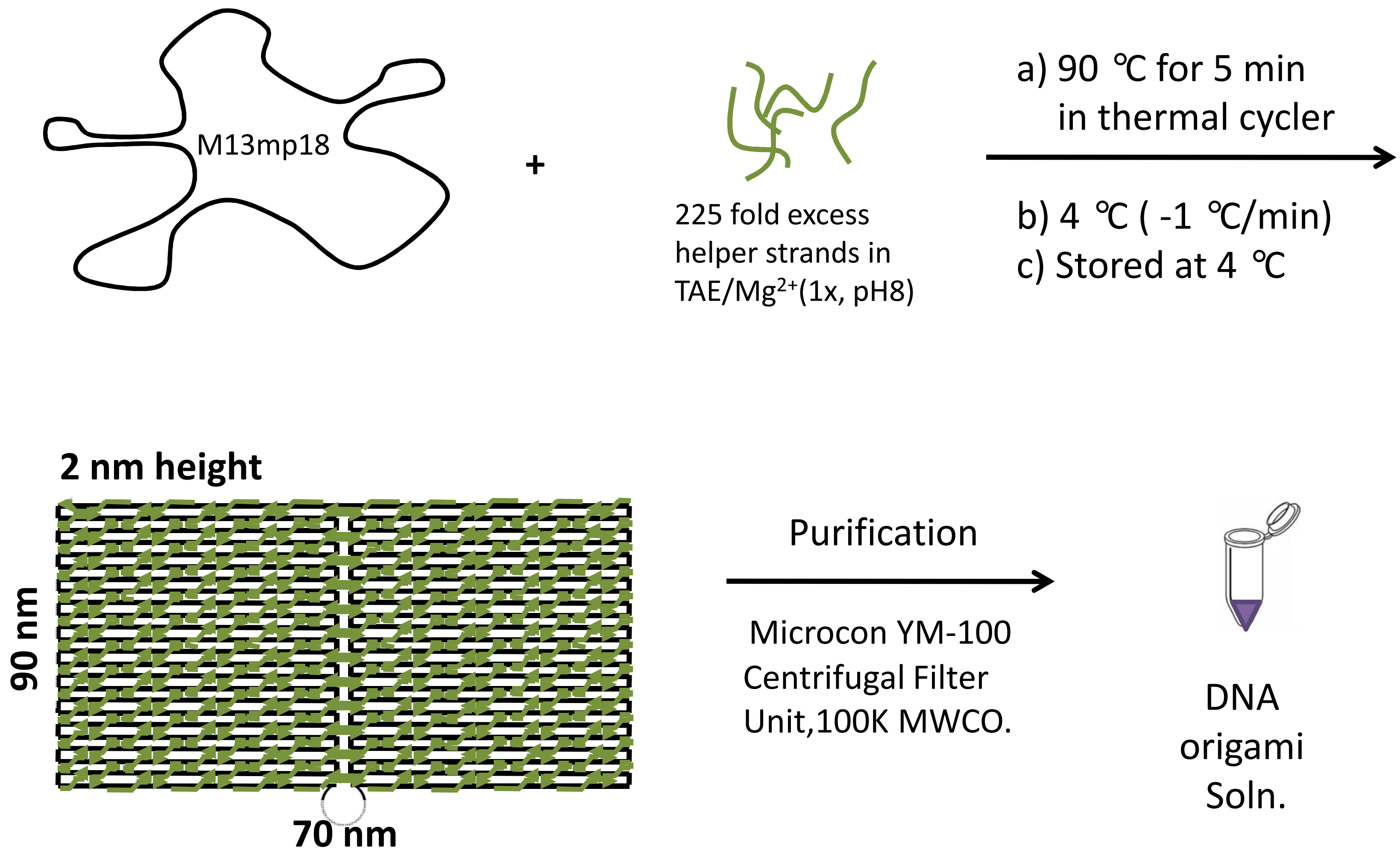
- A method for producing metallic nanostructures with a programmable design based on the specific positioning of AuNPs (5 nm size) on DNA origami is shown. The AuNPs can be enlarged by coalescence of Ag in a controlled manner by metallization (E. Samano *et al.*, *Nano Lett.* (2011)).

DNA ORIGAMI



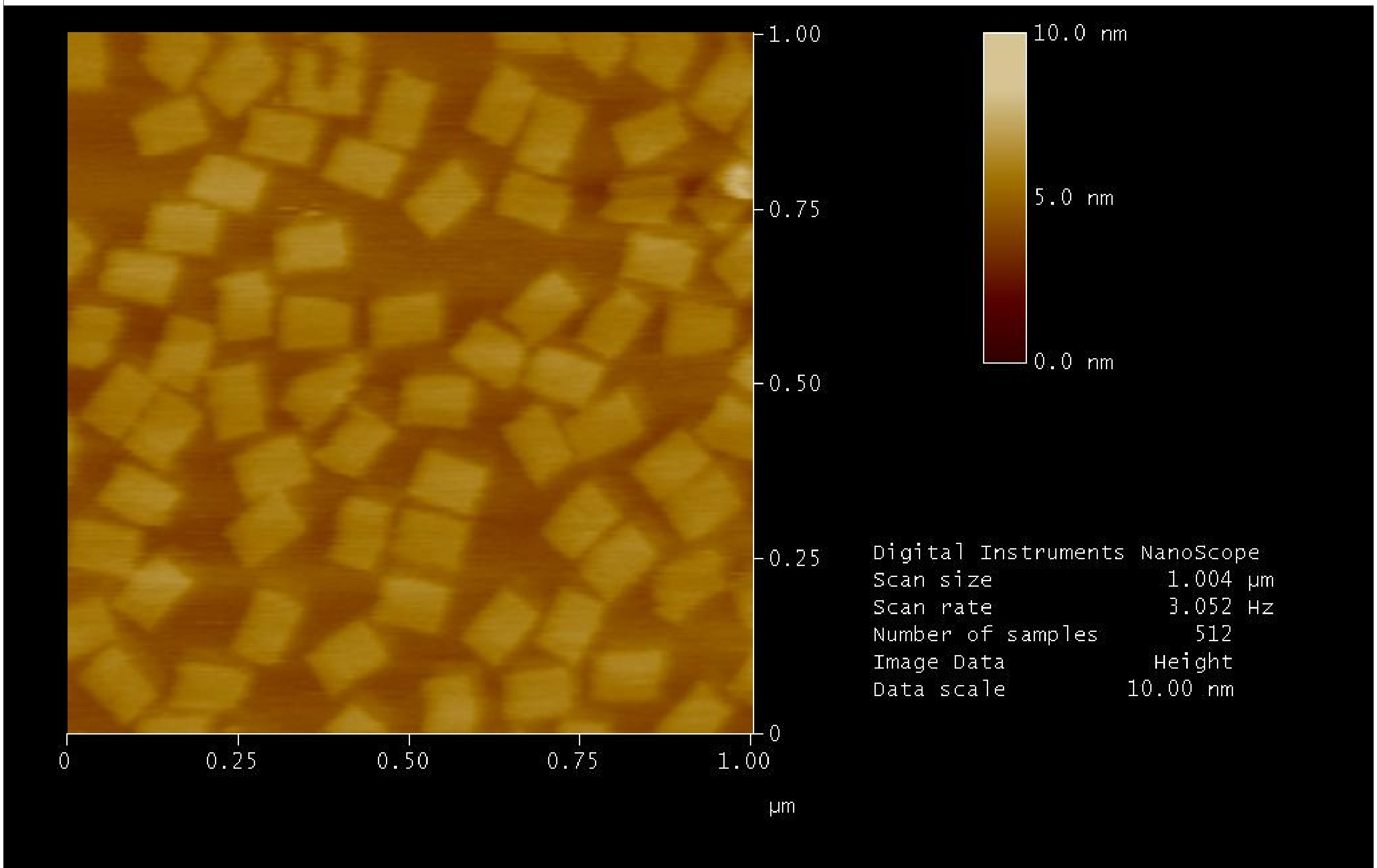
- Origami is the Japanese art of paper folding. Flat sheets can be folded into 3d-shapes.
- DNA origami is a 2d-nanostr. based on the ss-M13mp18 viral genome with 7 249 bases.
- This plasmid is folded in a planned and accurate manner by ~200 specific complement. "staple" strands of DNA (P. Rothemund, *Nature* 440, 297-302 (2006)).

DNA ORIGAMI



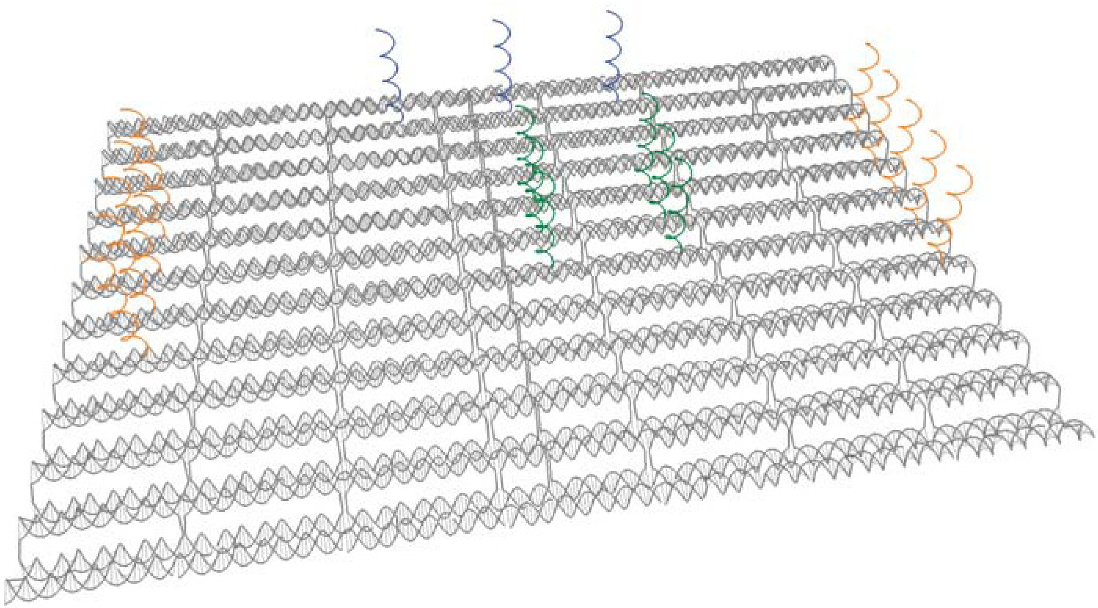
Self-assembly of Rectangular DNA Origami

DNA ORIGAMI IMAGING



AFM imaging of origami on mica in liquid (5 µl of 4 nM DNA origami)

AuNP:DNA ORIGAMI CONJUGATES



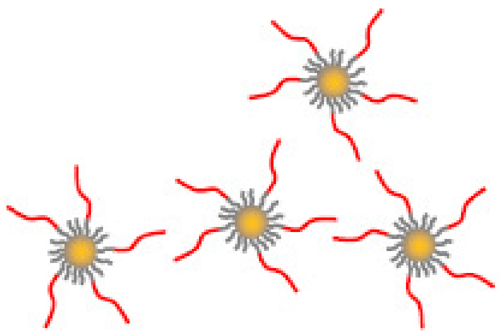
Strategy on rectangular origami to organize :

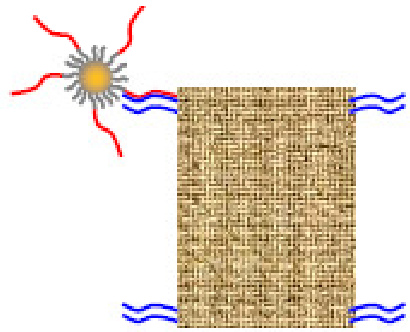
- **Biological materials and other chemical groups**
- **Quantum dots and Magnetic nanoparticles**
- **Carbon nanotubes**
- **Metal nanoparticles (NPs)**

AuNP:DNA ORIGAMI CONJUGATES

- DNA origami has the potential to act as a template for the accurate array of AuNP to produce precisely engineered DNA nanostructures.

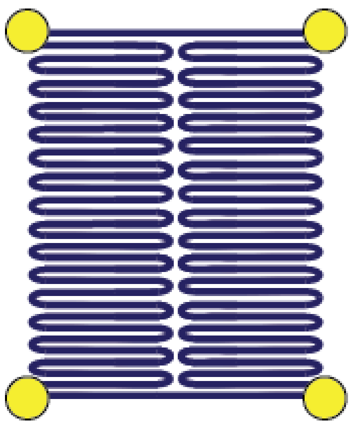
- This is possible because the "sticky ends" from the origami can be extended at binding sites enabling the attachment of complementary DNA-functionalized AuNPs; i.e, modified DNA origami is conjugated.

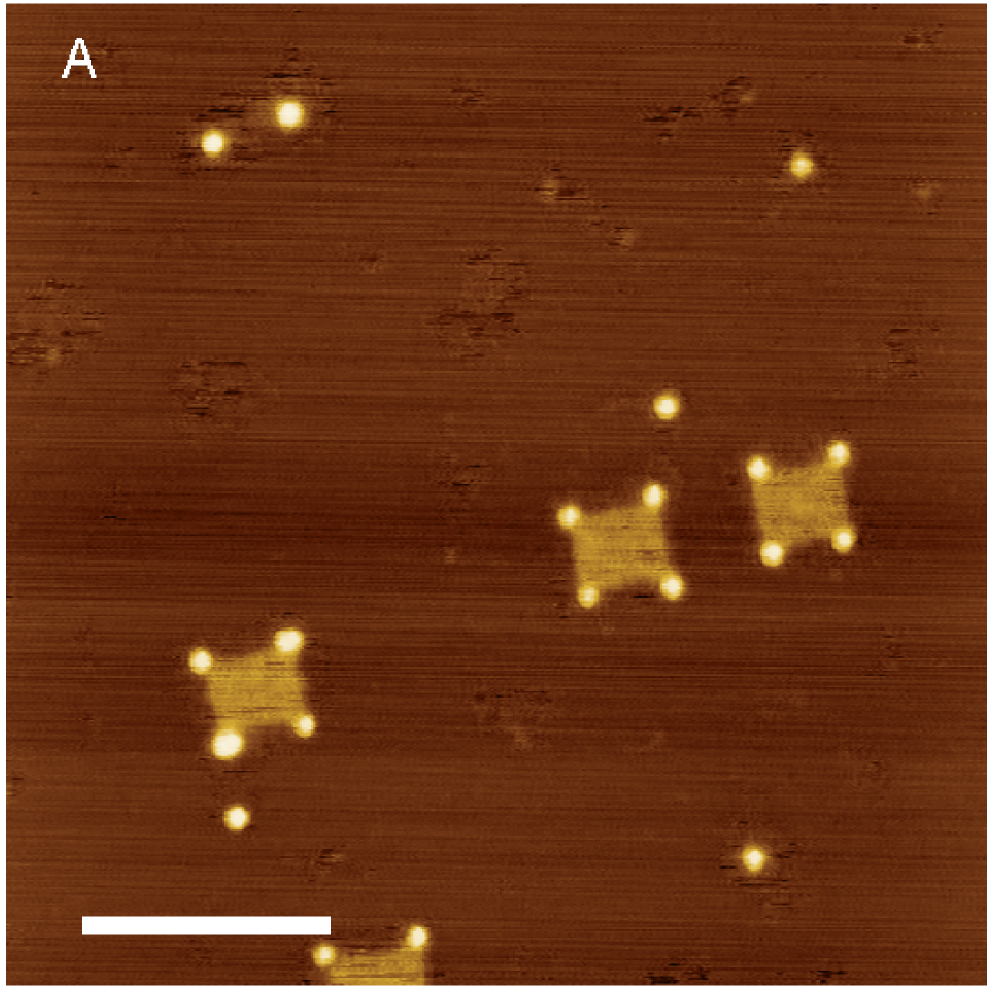




- Later, the size of the AuNP bound to DNA origami can be enlarged by reducing Ag ions using a kit (initiator, moderator and activator) at R.T.

ORIGAMI + AuNP ON EACH CORNER



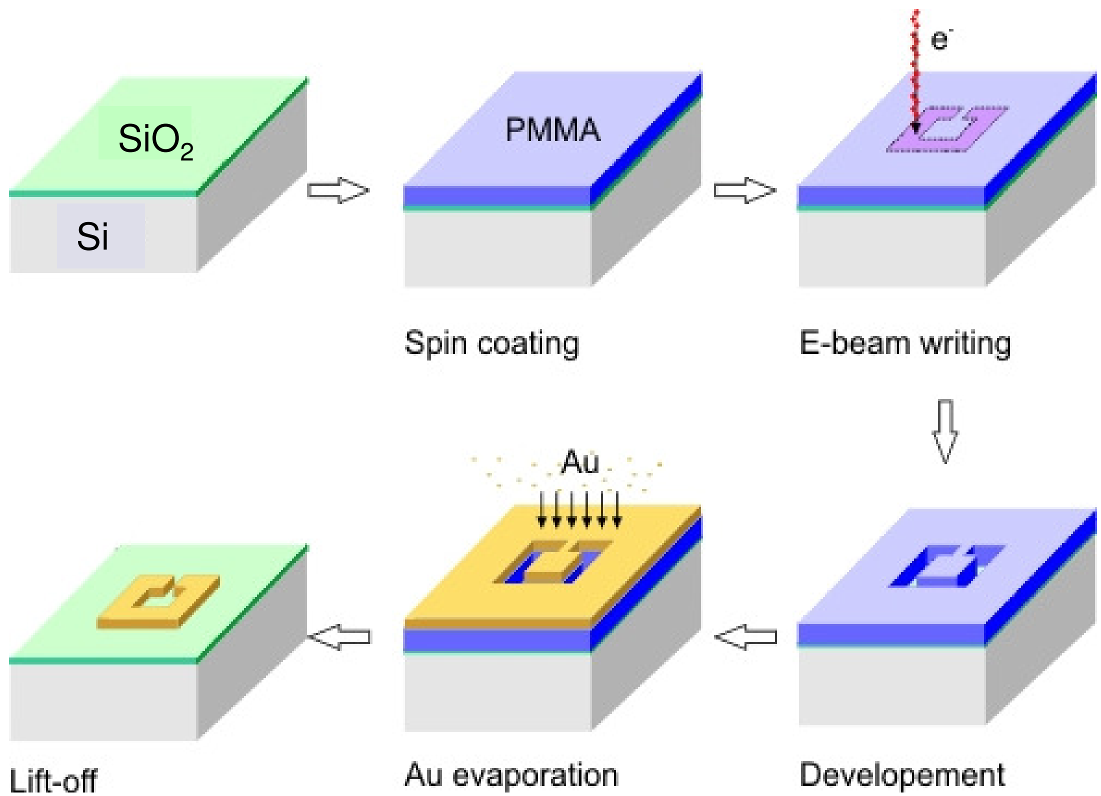


AFM image of AuNP + DNA (1.4:1) on SiO_2 in air. Each particle is attached to origami by two binding sites. Scale bar, 250 nm.

PATTERN GENERATION BY e-BEAM

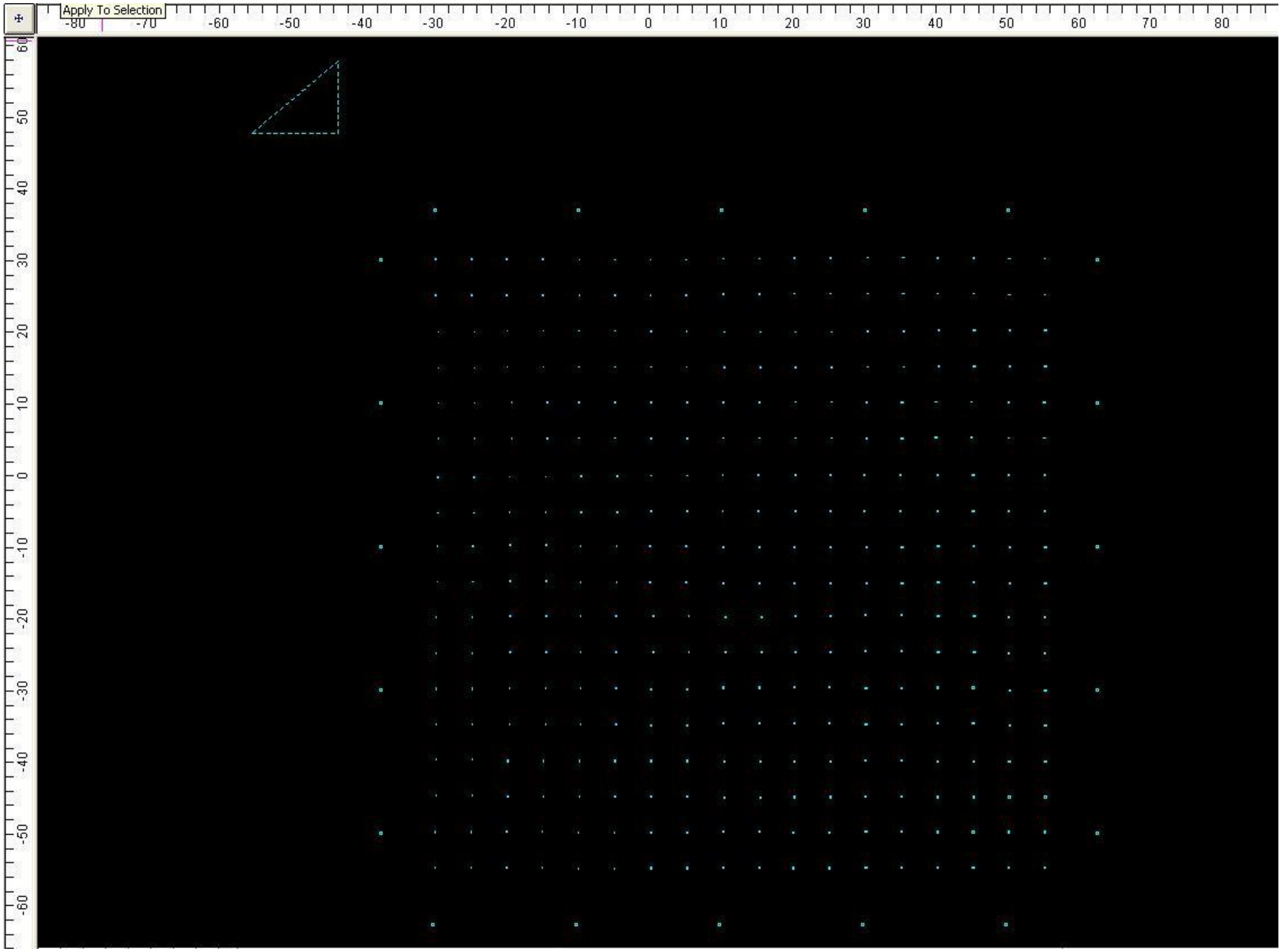
- The Nanometer Pattern Generation System (NPGS) has been designed to delineate complex structures with sizes from nanometers up to microns.
- There are three basic steps to generate a pattern by e-beam lithography:

i. Pattern design, ii. Parameter run file creation, iii. Pattern writing.



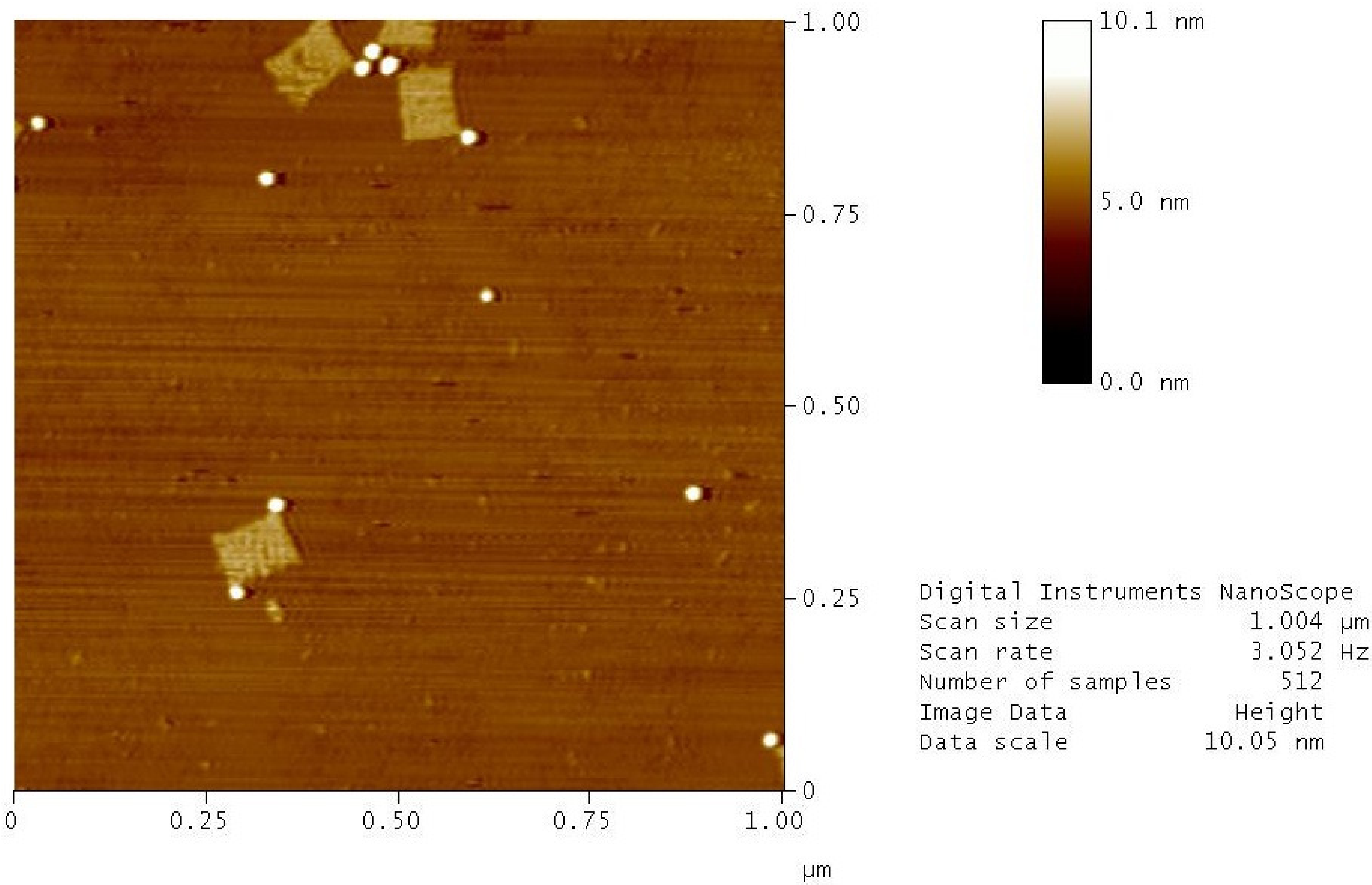
Scheme to generate the alignment marks and electrical leads by NPGS

PATTERN GENERATION BY e-BEAM



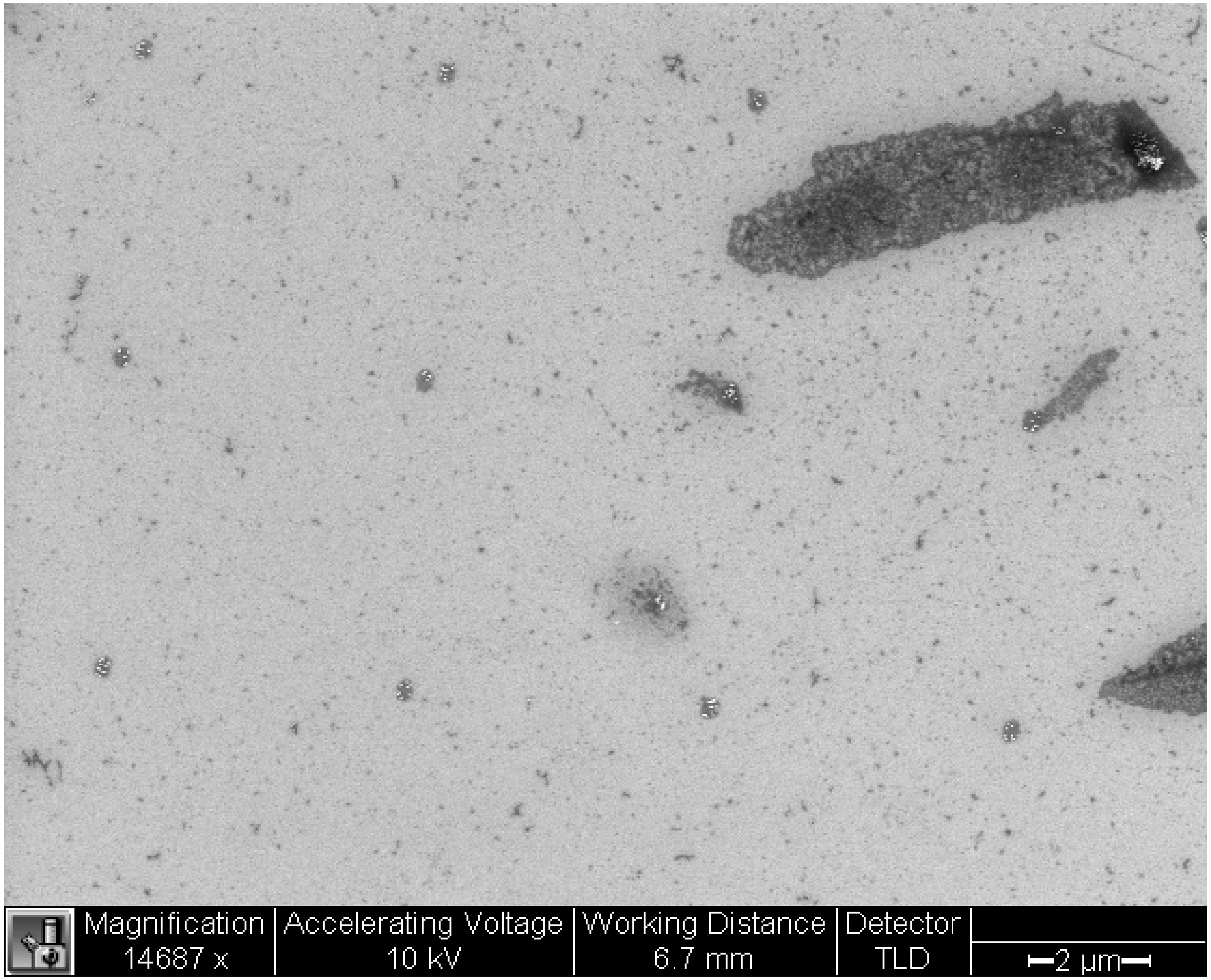
Design of a 100 µm x 100 µm pattern to write 100 nm x 80 nm rectangles, 5 µm apart, by e-beam lithography to place metallized DNA origami in each.

ORIGAMI + 2 AuNP ON 2 CORNERS



AFM image of AuNP + DNA (1.5:1) on SiO_2 in air for plasmonics exper. Each particle is attached to origami by two binding sites.

ORIGAMI + 2 AuNP ON 2 CORNERS



SEM image showing the 100 nm x 80 nm rectangles, 5 µm apart, carved on SiO_2 in order to immobilize Au NPs after 10 min. of metallization (~ 40 nm size).

PLASMONICS

- **There is a great interest in the study of the optical properties of metallic nanoparticles and their aggregates in the nanoscale vicinity.**

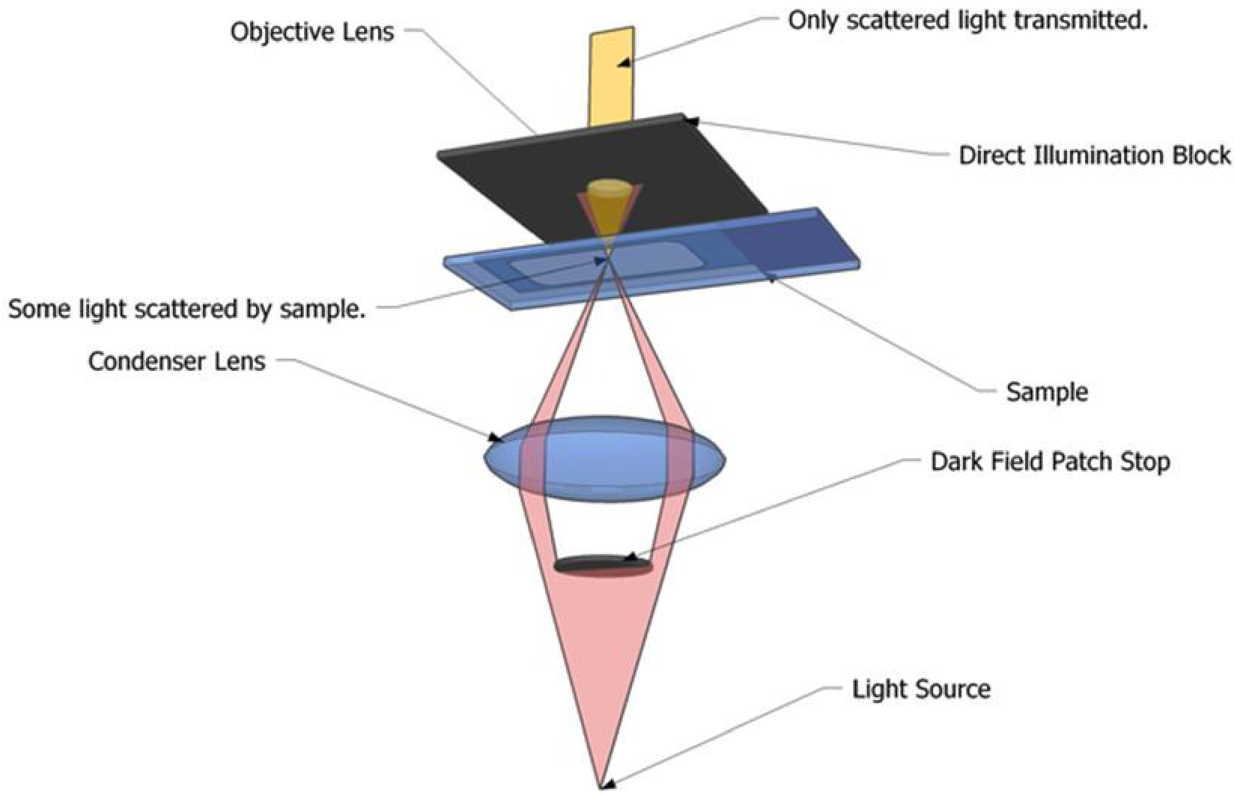
- **Plasmon is a collective oscillation of the valence electrons in a metallic particle. The resonance frequency depends on the material composition (mainly electron density) and the surrounding dielectric medium.**

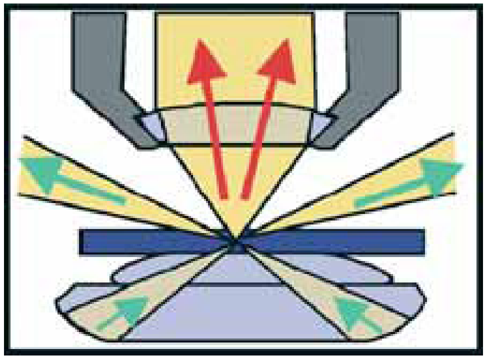
- **In particular, Ag and Au exhibit d $\rightarrow$ s interband transition in the UV region that mixes with the plasmon resonance and shifts it to the visible.**

- **In nanoparticles (NPs), the plasmons strongly couple to optical fields, producing intense light-scattering spectra. The intensity of the spectra from noble-metal NPs is highly dependent to particle size and shape.**

- **The light-scattering spectrum from a single noble-metal NP of 20 nm or larger can be readily observed by dark-filed microscopy. As two metal NPs are brought together, their plasmons couple and the resonance freq. changes as a function of particle separation. A red shift will occur due to constructive interference between the enhanced fields of each NP.**

DARK FIELD MICROSCOPY





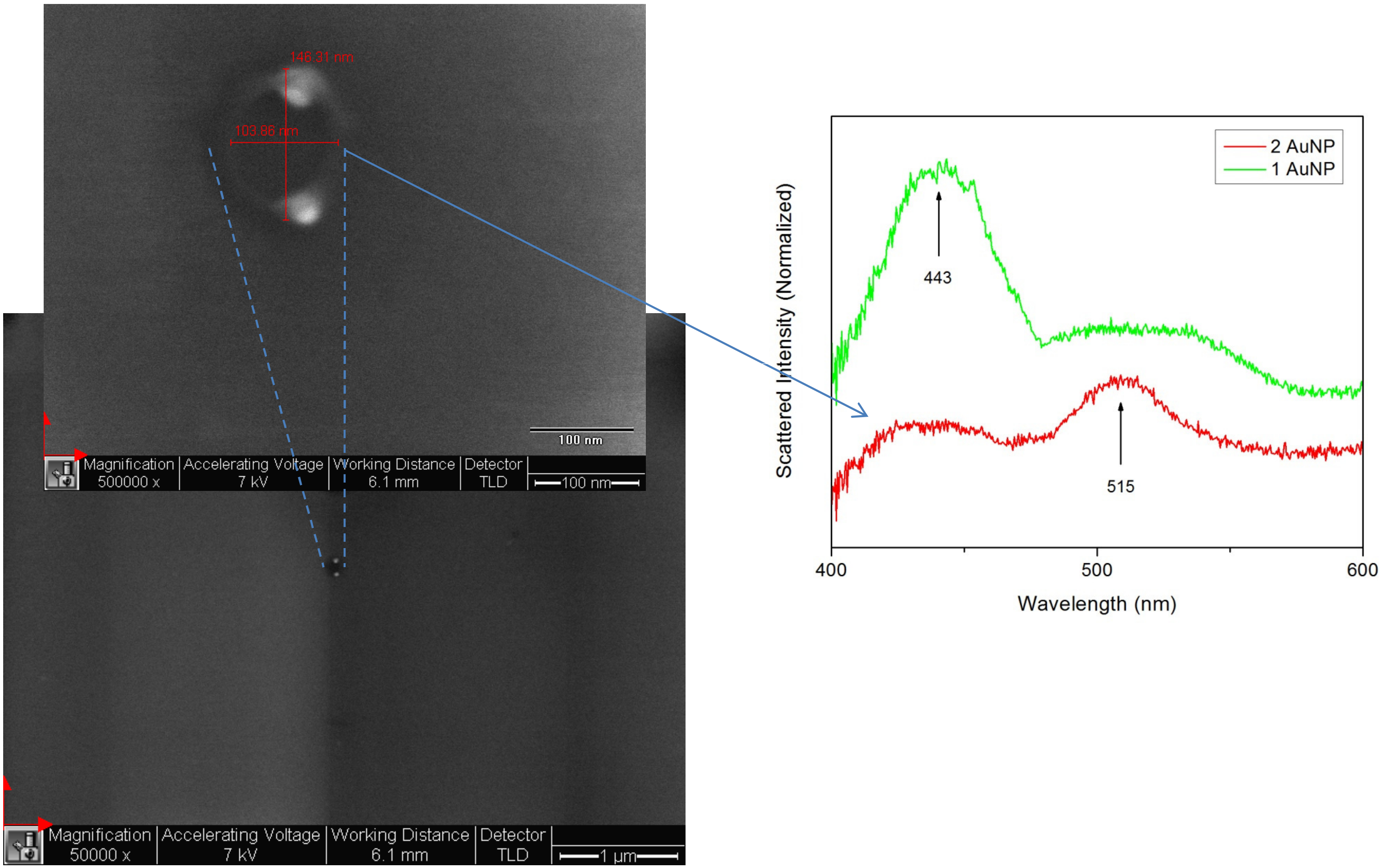
Experimental conditions:

i) Unpolarized white light from a tungsten lamp.

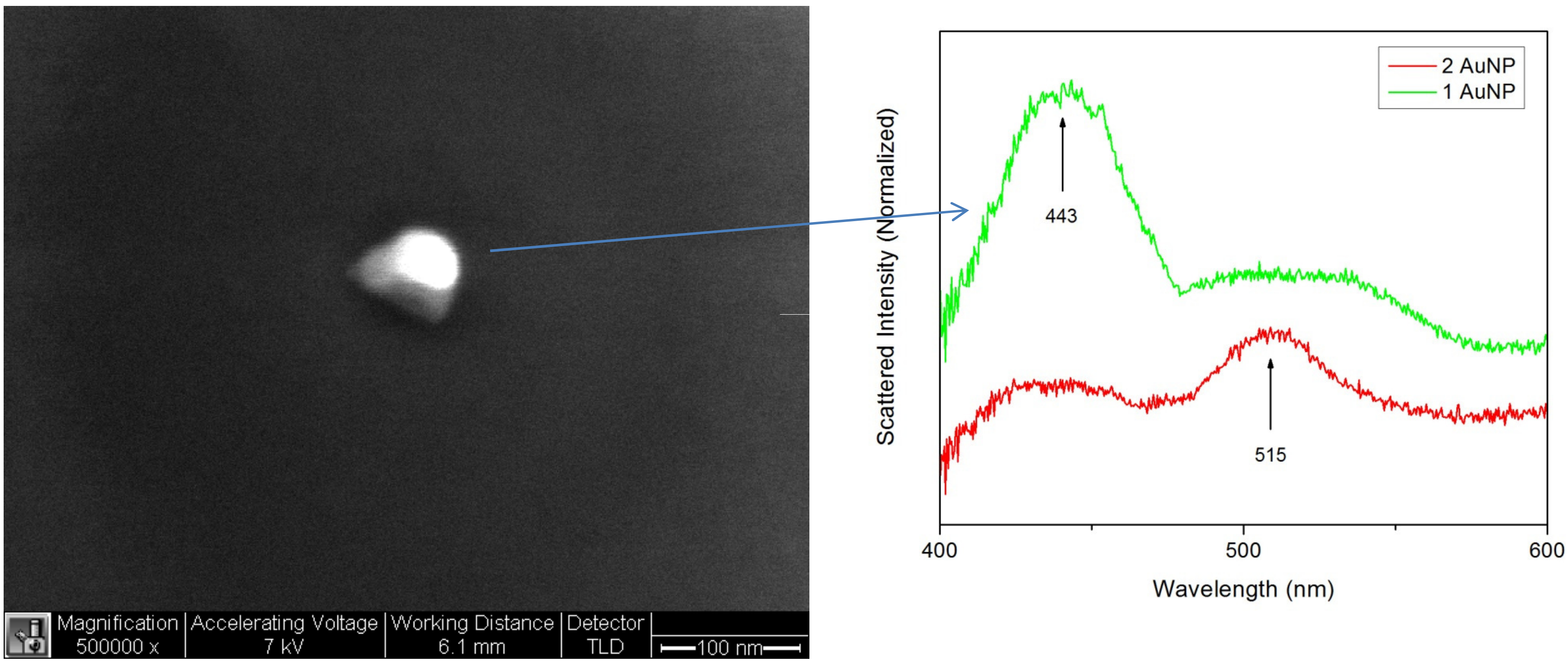
ii) The sample is placed on a glass slide.

iii) A 5 µm size aperture is used to collimate the transmitted light.

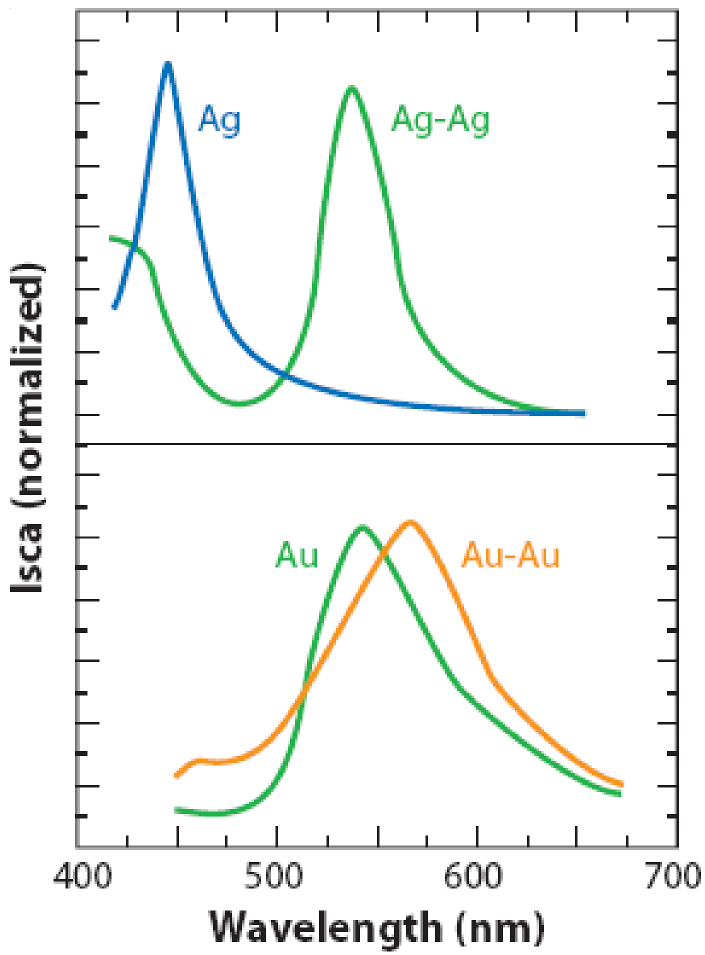
2 METALLIZED AuNP ON CORNERS

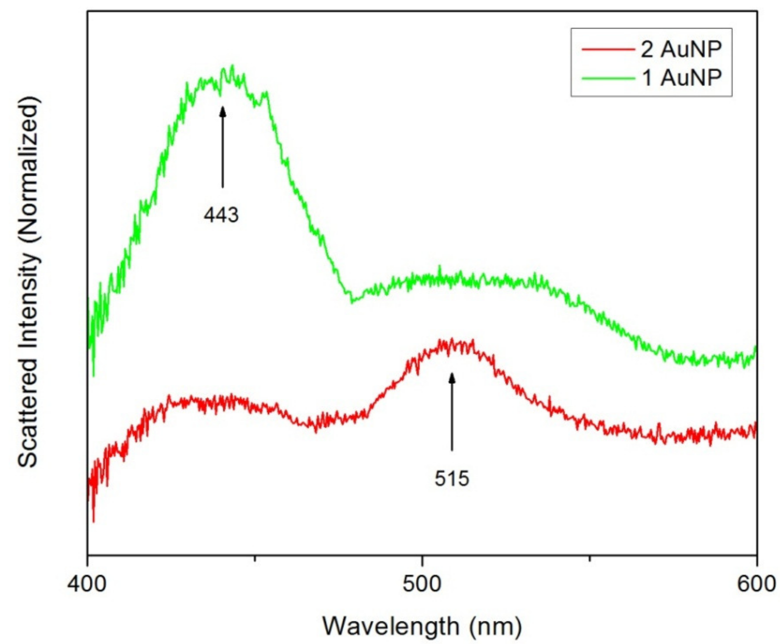


METALLIZED AuNP



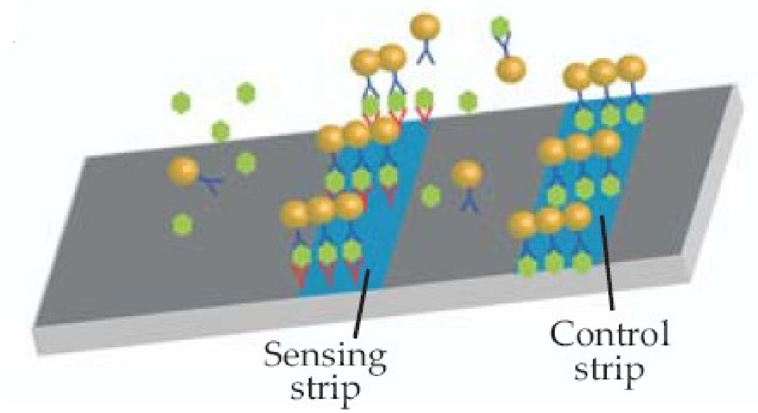
PLASMONICS RESULTS





P. A. Alivisatos et al., *Nature Biotech* 23, 741-745 (2005)

PLASMONICS APPLICATIONS

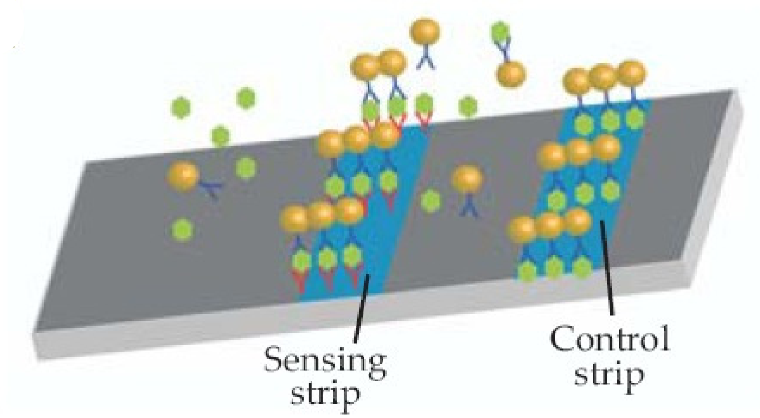


<u>Sensing</u>. The spectral red shift of localized plasmonic resonances due to the aggregation of metal NPs can be applied in sensing, HPT.

Sensing with localized surface plasmons. **(a)** A widely used test can detect the presence of human chorionic gonadotropin hormone (hCG) produced in a pregnant woman's uterus. When deposited on a sensing strip of antibody-laden chromatographic paper, the hCG analyte molecules (green) from a drop of her urine bind to the antibodies (red). To sense that reaction, a suspension of gold particles chemically linked to secondary antibodies (blue) is then added; when they bind to the analyte they strongly scatter light, producing a ruby-red color that can be compared with that from an adjacent control strip.

M. I. Stockman, *Phys Today* (Feb), 39-44 (2011)

PLASMONICS APPLICATIONS



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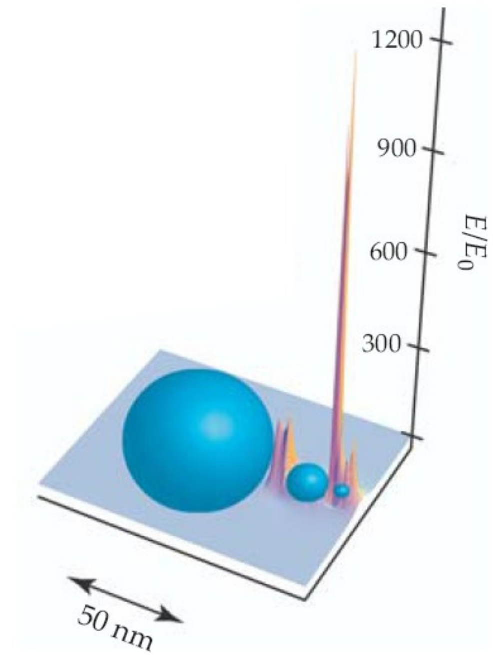
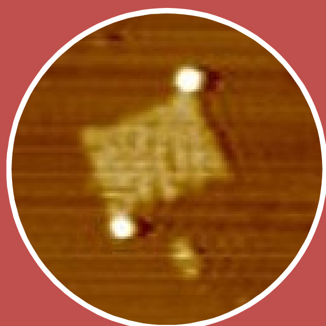


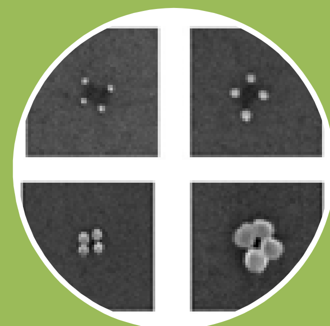
<u>Nanolens</u>. "Hot spots" in a system composed of 3 Ag NPs in a row whose sizes form a decr. geometric series. "Hot spots" are spikes of intense and highly localized fields.

M. I. Stockman, *Phys Today* (Feb), 39-44 (2011)

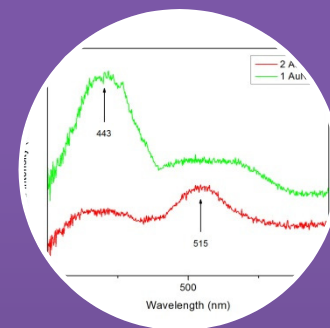
SUMMARY



Controlled placement of NPs on DNA-Origami



Controlled Ag metallization of NPs placed on DNA-Origami



Plasmon coupling for two Ag metallized NPs on DNA-Origami

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