

Optimizing plasmonic transfection using nanostructured substrates

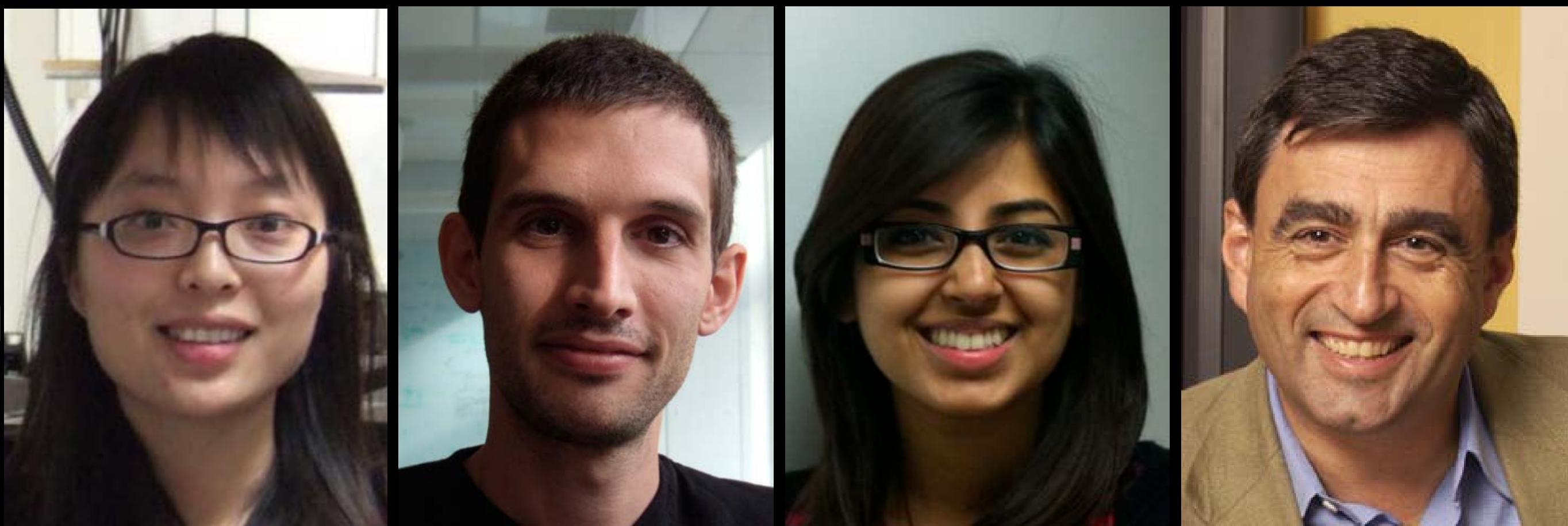
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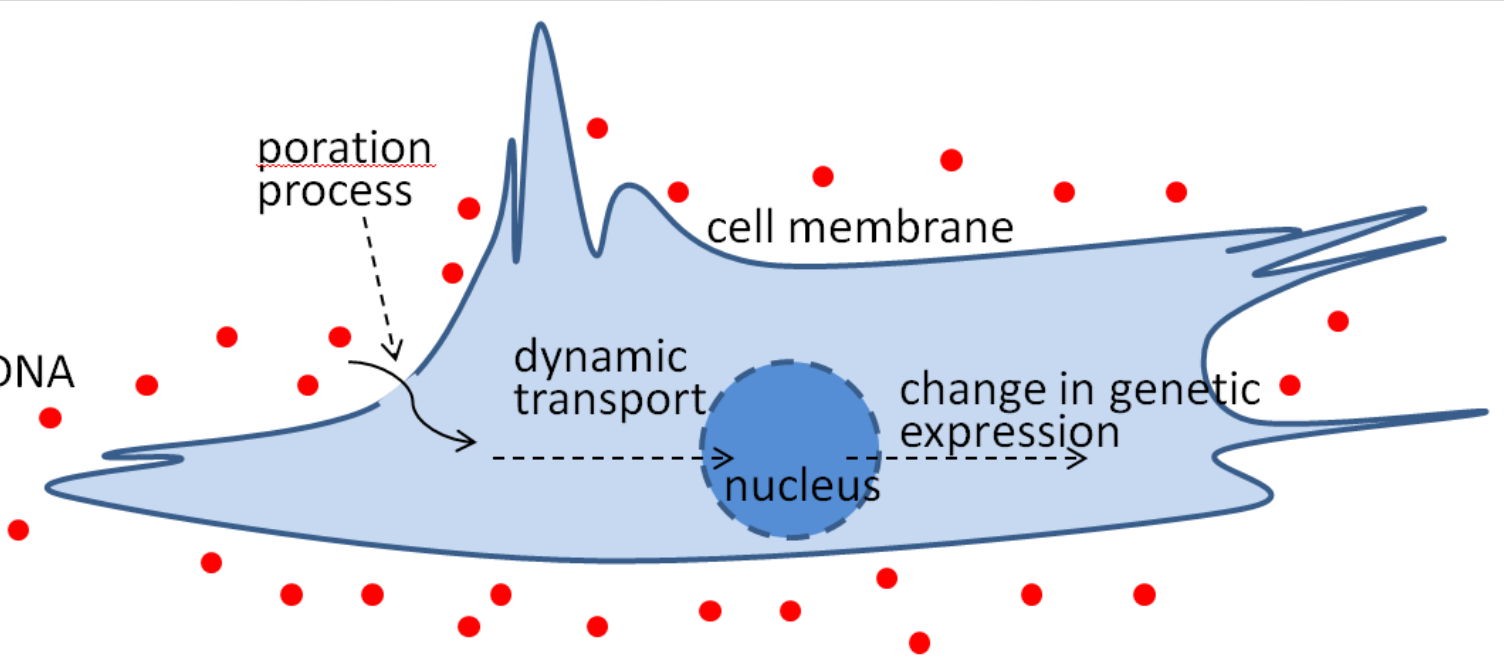
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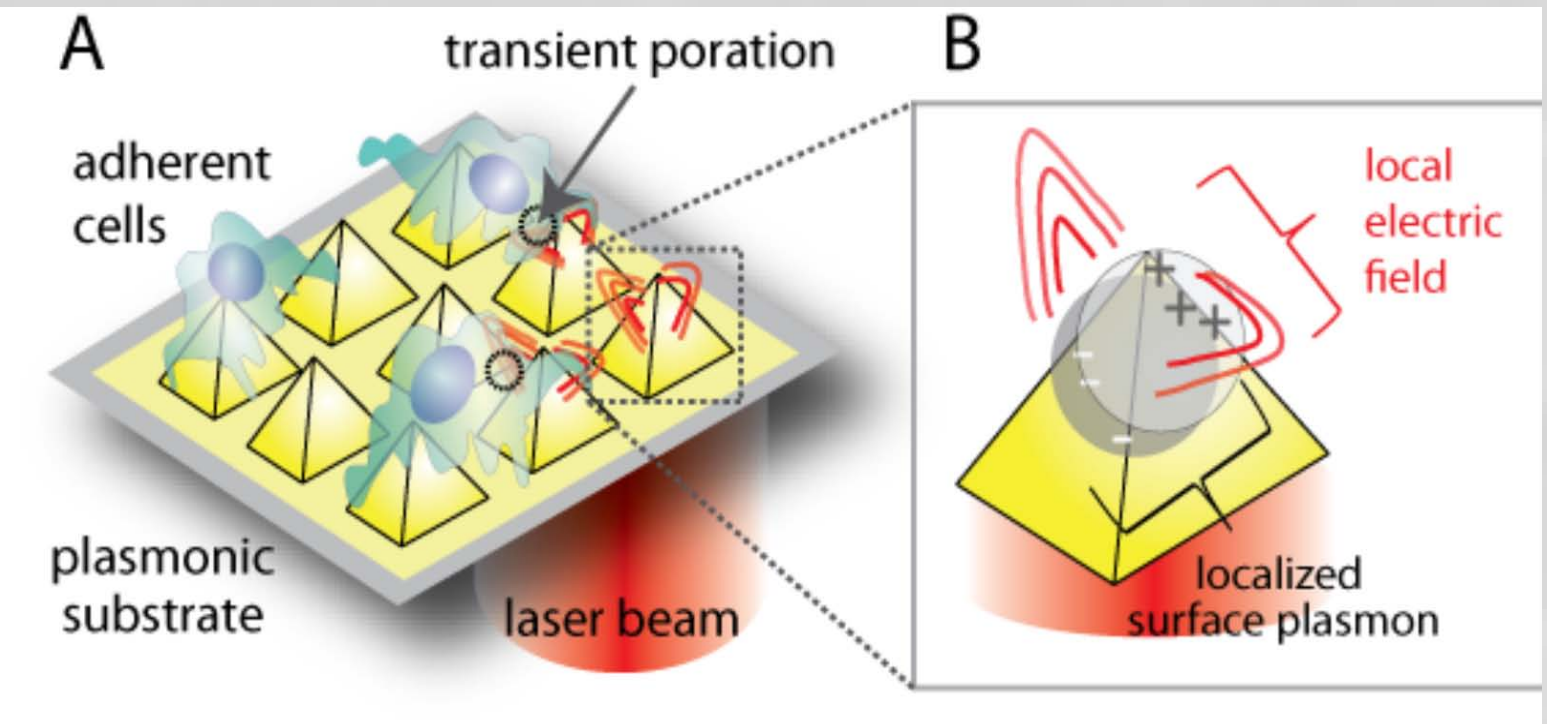
Background

Gene therapy is the use of DNA as an agent to cure or slow down the progression of a disease. A crucial requirement for gene therapy is the efficient and safe introduction of genetic vectors into mammalian cells. Good transfection methods should be key to develop novel approaches for gene therapy and regenerative medicine. We are developing a high-efficiency, low-toxicity, spatially-selective and high-throughput transfection method using femtosecond laser induced-plasmons on a nanostructured substrate.

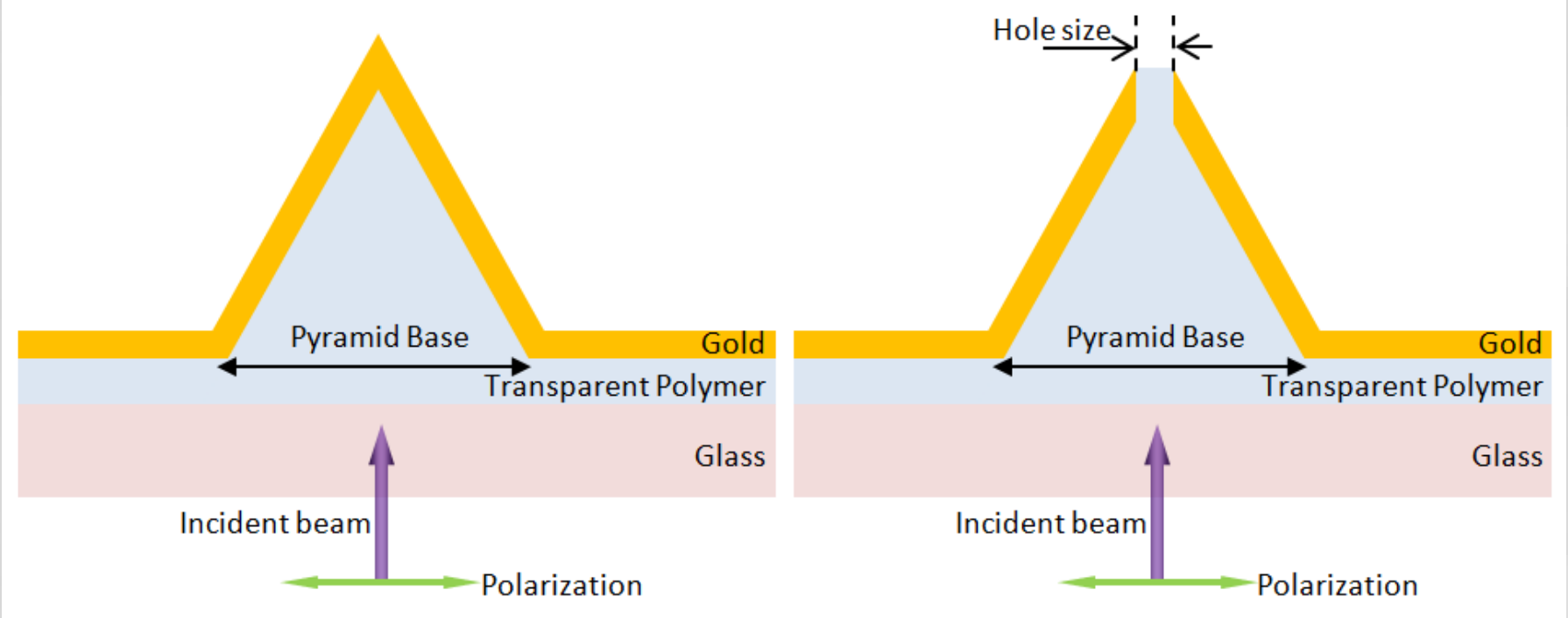
Cell transfection



Plasmonic transfection



Two nanostructure designs



Plasmonic enhancement on pyramid

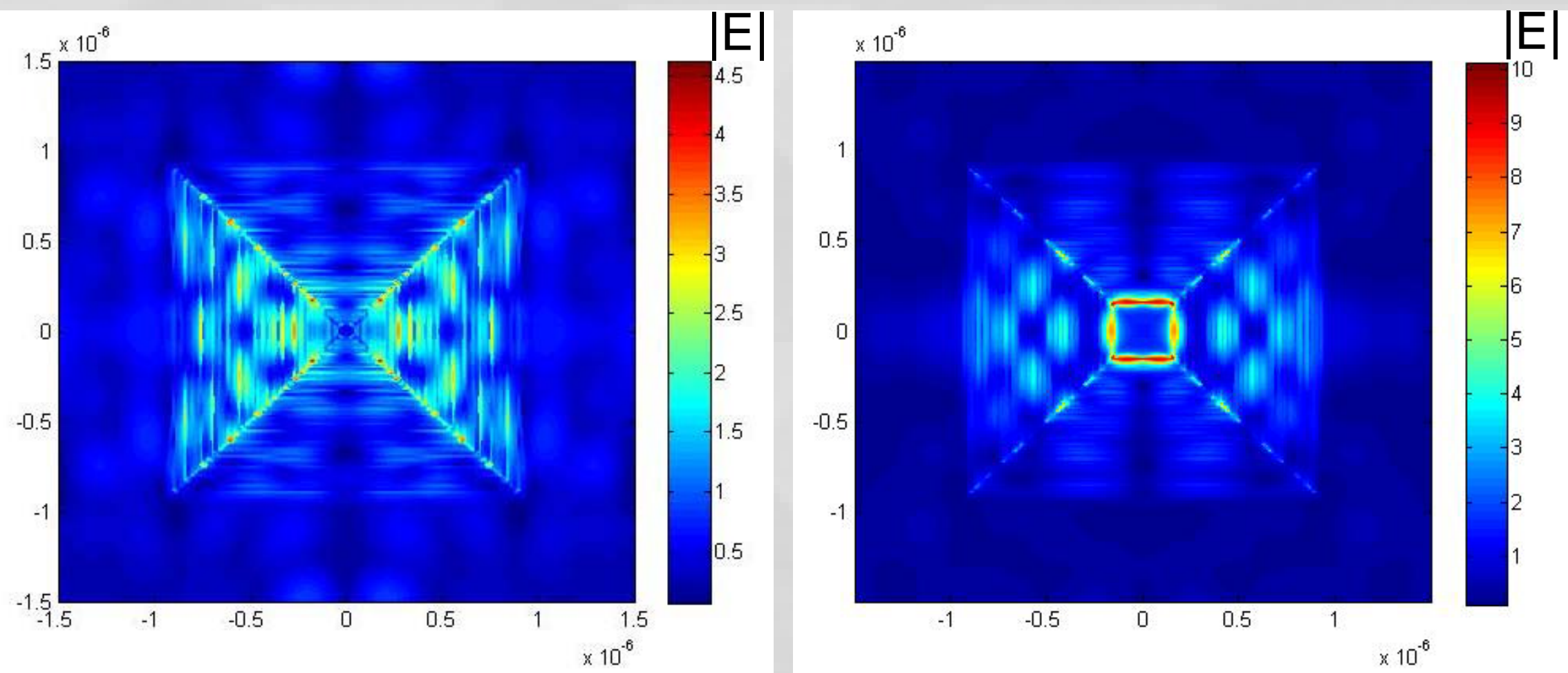
A. Simulation

We simulated the propagation of the electromagnetic field in selected geometries by Finite Difference Time Domain (FDTD) method. We specifically compare two designs of plasmonic substrates (whole pyramid arrays and tipless pyramid arrays) using simulations.

Top view of $|E(x,y)|$ on pyramids:

Whole pyramid

Tipless pyramid

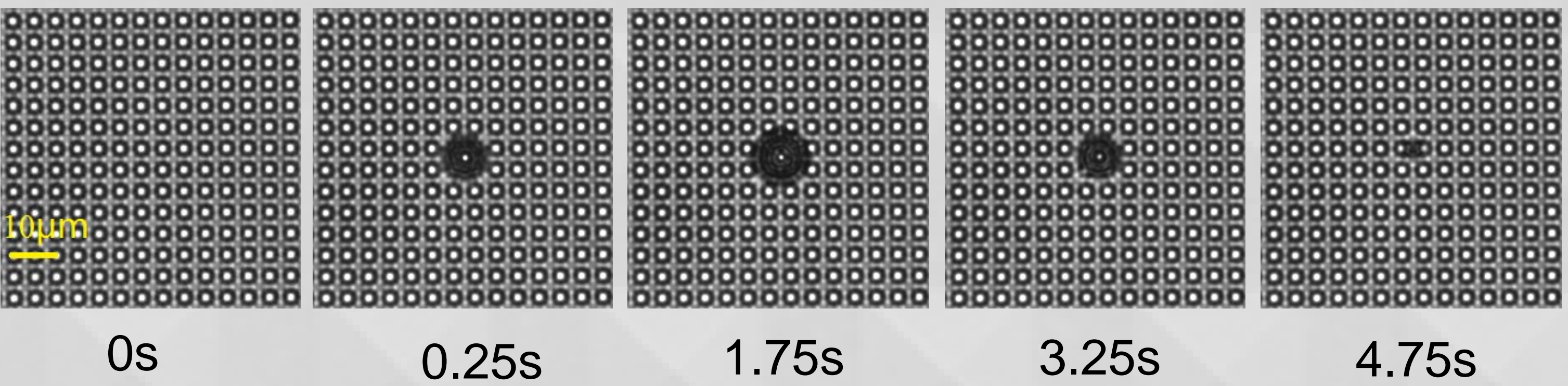


Pyramids show good electric field enhancement. Enhancement on tipless pyramids is higher and more localized on the apex than whole pyramid.

B. Microbubble on Pyramid

High electric field enhancement on pyramid creates microbubbles in liquid. Size of microbubbles can give us electric enhancement information on pyramids.

Single microbubble sequence:

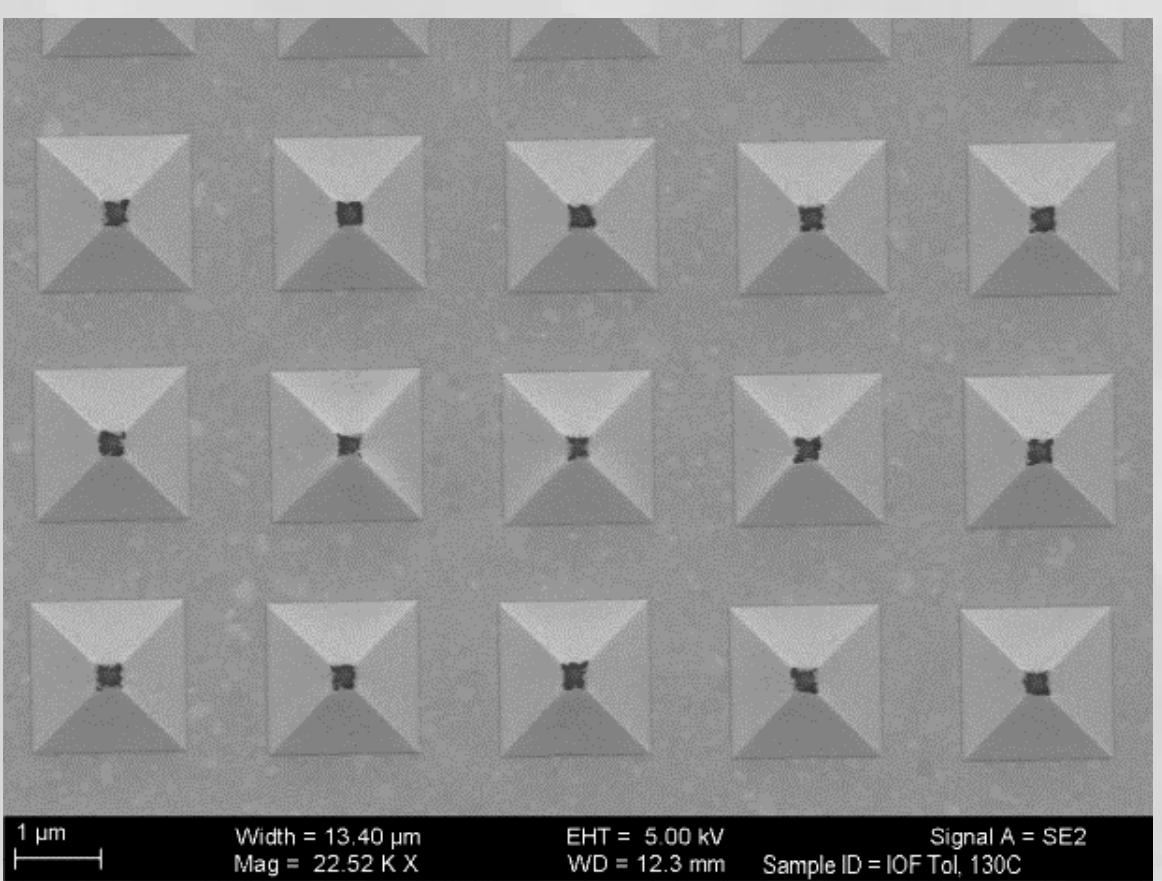
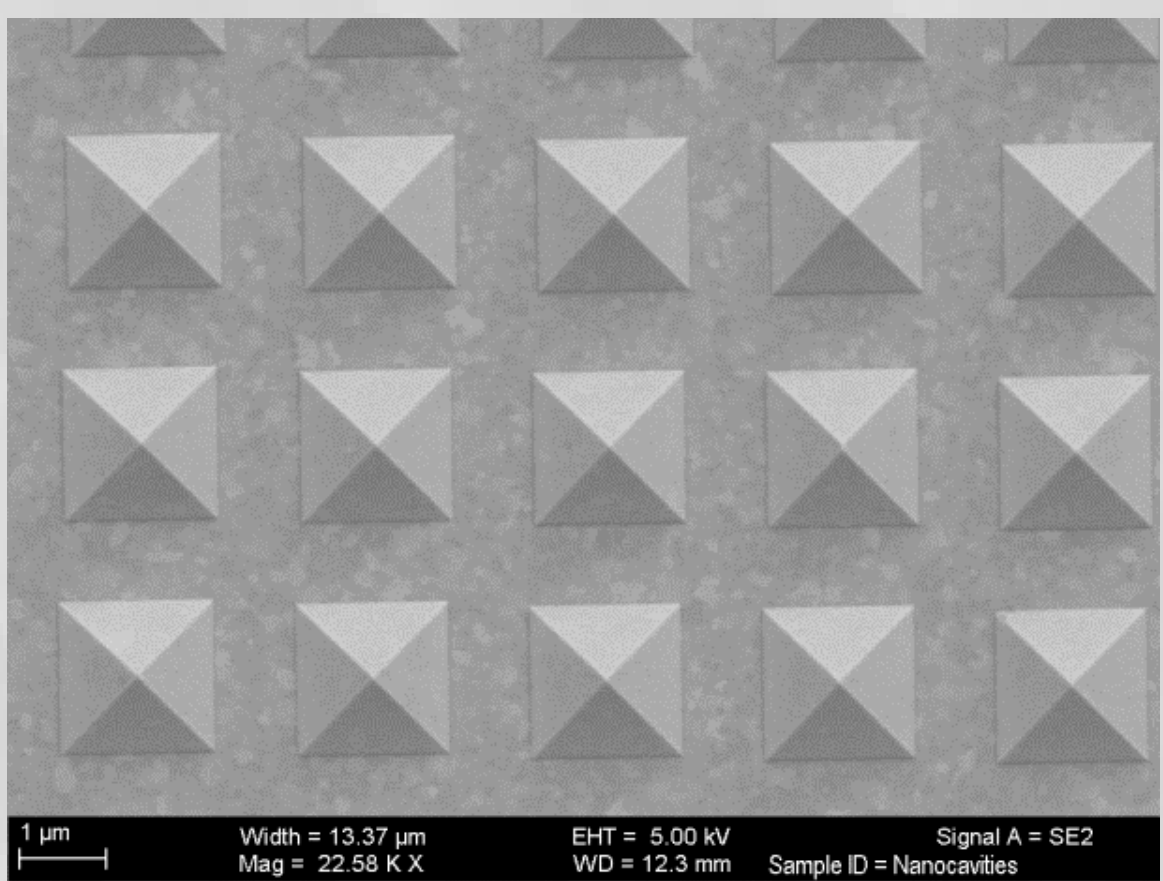


Fabrication

Scanning Electron Microscopy shows that our fabrication process can control precisely the geometrical parameters.

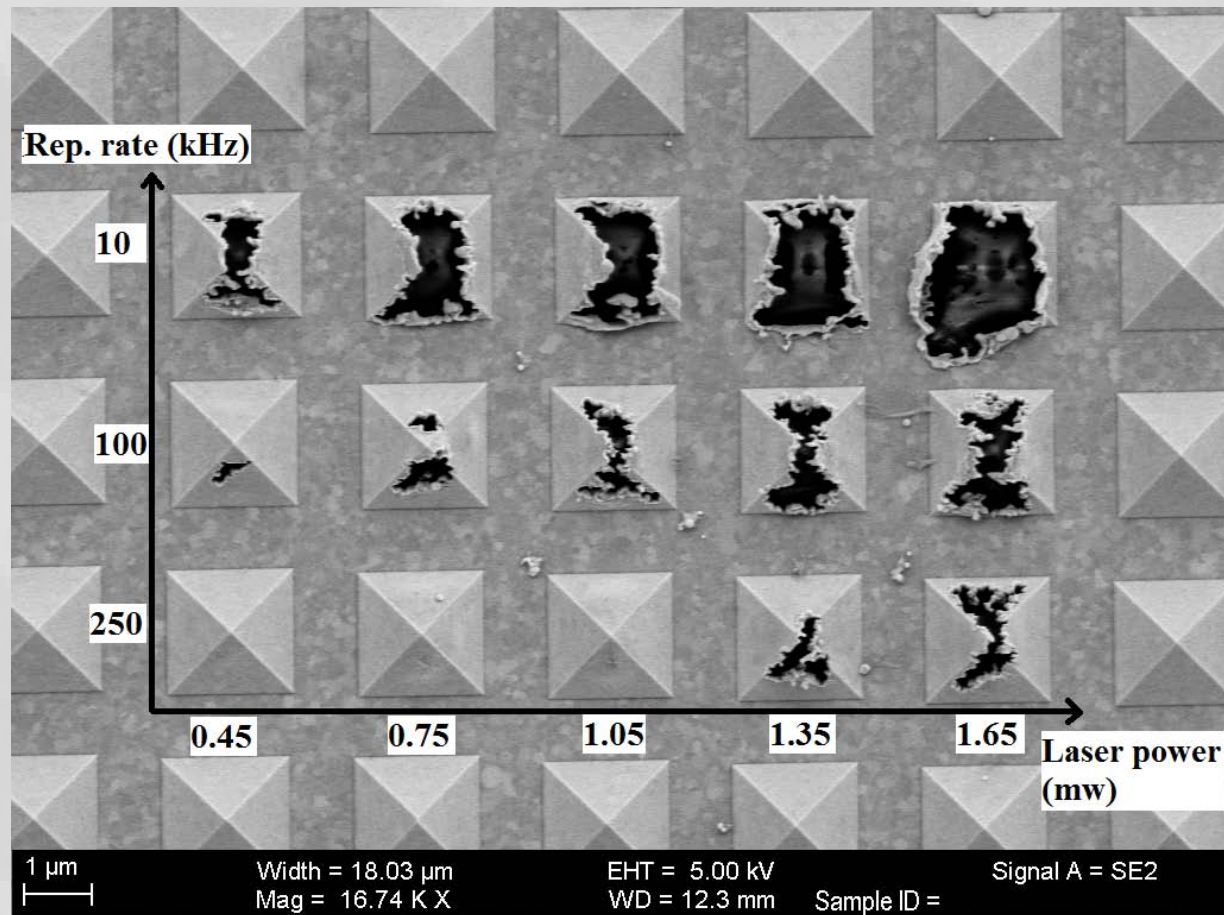
Whole pyramid

Tipless pyramid



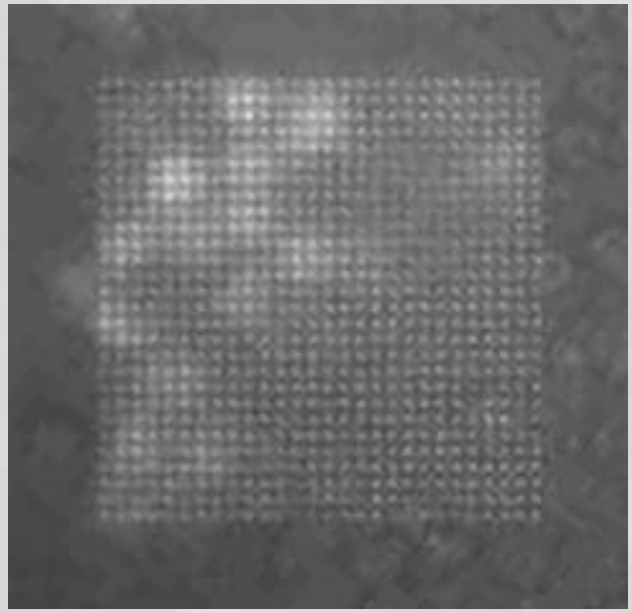
Pyramid damage test

Laser parameters (power and repetition rates) are experimented on pyramids in order to find the damage threshold and the localization of the near field enhancement.

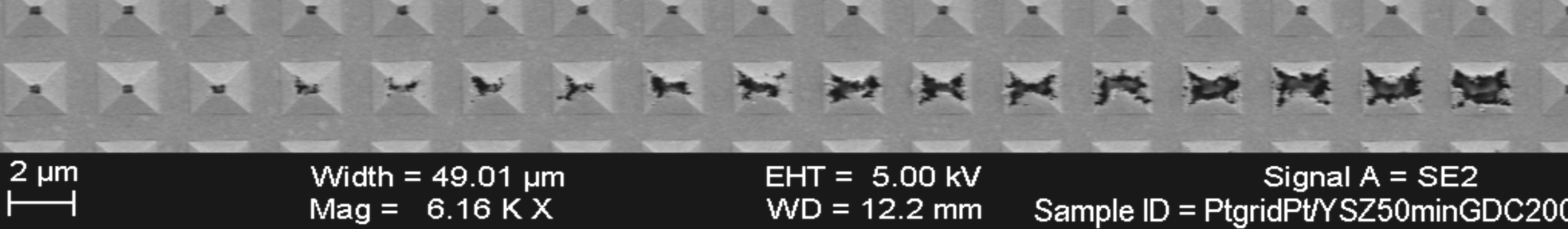


Cell poration

The bright cells were undergoing successful poration and subsequent intake of a fluorescent probe on a array of bioplasmonic pyramid.

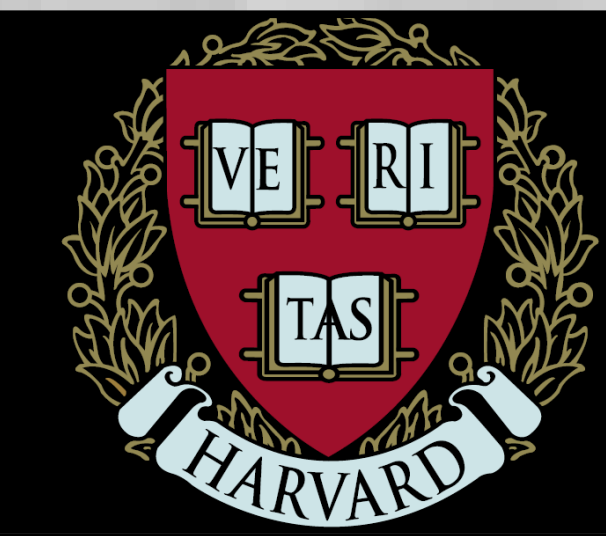


250kHz, 0.2mW-1.8mW



Future work

1. Laser parameters optimization.
 - Energy
 - Dwell time
 - Repetition rate
2. Cell transfection experiment.
 - Efficiency
 - Cell viability



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