NANOTECHNOLOGY-Research Experience for Teacher (RET) 2007

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ABSTRACT

Two projects are carried out: a novel three-dimensional thermal sensor based on Single-Walled Silver (Ag) nanoparticles utilizing dielectrophoretic (DEP) assembly, and electrohydrodynamic (EHD) based micropump.

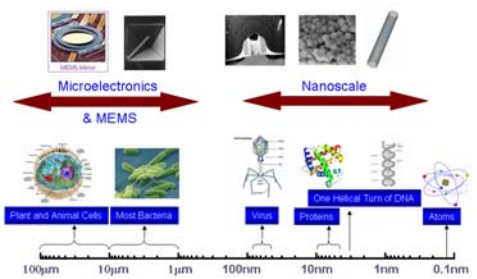
The sensor is fabricated using a hybrid assembly approach combining top down (fabrication of the microplatform) and bottom up (DEP assembly). Encapsulating the structure with a thin (1μm) parylene layer protects it from the environment and also improves the contact resistance.

EHD Micropump on Parylene-C Substrate provides several advantages: lightweight, flexibility, IC compatibility, mechanical strength, biocompatibility for in-vitro applications.

INTRODUCTION

The revolution of nanoscience brings to diverse areas of human endeavor–including medicine, industry, and environmental management–requires a commensurate response in the educational community to increase students' understanding of core concepts in the field.

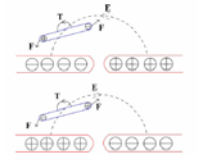
Two conceptual areas are likely to pose the greatest challenges to understanding of core nanoscience concepts for students at the high school level. The first of these arises because nanoscale entities are generally difficult to visualize or see. The second challenge to student understanding results from the concepts and physical laws that govern the behavior of particles at the nanoscale level.



Ag NANOPARTICLES

Dielectrophoresis

Dielectrophoresis: "A phenomenon in which a force is exerted on a dielectric particle when it is subjected to a non-uniform electric field. This force does not require the particle to be charged. All particles exhibit dielectrophoretic activity in the presence of electric fields."



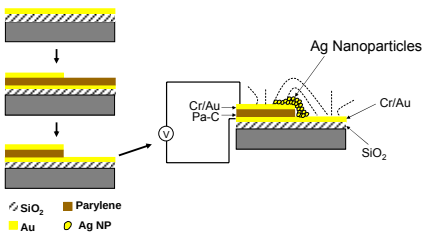
Peng et. al., *Appl. Phys. Lett.*, **100**, 2006.

$$F_{DEP} = \frac{\pi r^2 l}{2} \varepsilon_1 \, \mathrm{Re}(K) \nabla E^2$$

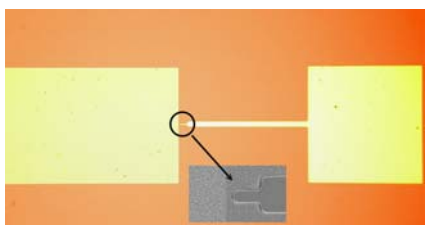
$$\text{where } K = \frac{(\varepsilon_2^* - \varepsilon_1^*)}{\varepsilon_1^* + (\varepsilon_2^* - \varepsilon_1^*)L_g} \text{ and } \varepsilon_{1,2}^* = \varepsilon_{1,2} + \frac{\sigma_{1,2}}{i\omega}$$

where ε_1 and ε_2 are the dielectric constants of the solvent and the nanotube medium and E_{rms} is the average field strength.

Fabrication of the MicroMachined Platform



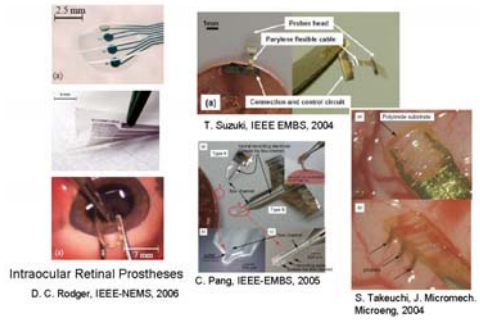
i. A 1μm thick isolation oxide layer is grown on a silicon wafer followed by the deposition and patterning of the first metal layer (Cr/Au – 200Å/1500Å) using a lift-off process.
ii. A thin (0.7μm), conformal parylene-C dielectric layer is deposited on the wafers at room temperature followed by deposition and patterning of the second metal layer (Cr/Au – 200Å/1500Å) lift-off technique.
iii. SWNTs are assembled between the top and bottom electrodes using dielectrophoresis.
iv. A second parylene layer is used to encapsulate the device. Contacts are opened on the top parylene layer using a third mask.



Optical pictures of the assembly electrodes. Inset shows the SEM micrograph

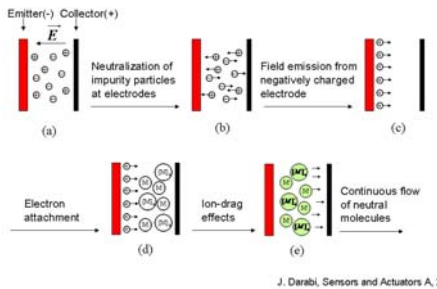
EHD MICROPUMP on Parylene

Biocompatibility of Parylene



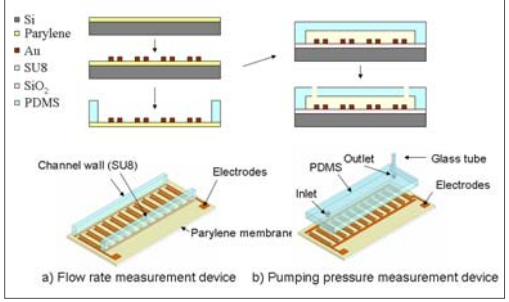
Mechanism of EHD Micropump

Electrohydrodynamic (EHD) pumps is a Non-mechanical micropump that Add momentum to the fluid for pumping effect by converting another energy form into the kinetic energy. Applications of EHD micropumps include: microfluidic systems, biotechnology, micromechanical analysis systems, drug delivery systems and on chip-integrated cooling systems



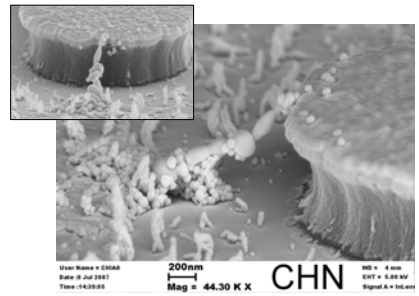
J. Darabi, Sensors and Actuators A, 2006

Fabrication of the EHD Micropump on Parylene



RESULTS

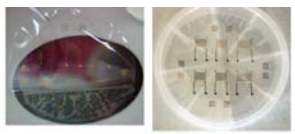
Ag Nanoparticle Assemble



SEM of 40 nm-Ag nanoparticle assembling

EHD Micropump on Parylene

Au micropump on parylene substrate on silicon wafer



Au micropump on parylene substrate

CONCLUSIONS

We have constructed two nano-devices. The assembly of three dimensional Ag nanoparticles used the same conditions as Au nanoparticles. EHD micropump was constructed using microphotolithography technique.

Future work for Ag nanoparticle assembly involves vary the conditions to obtain optimum assembly. Future work for EHD micropump involves vary solvents in order to obtain suitable solvents for particular application.

LESSON PLAN

1. Size matter: Can I see? Optical microscope vs. Scanning Electron microscope (SEM)
2. It is so small: How many atoms of gold in one 40 nanometer gold nanoparticle?
3. Properties of the material change at the nanoscale: Is gold always yellow? How can that white suncreen be clear?
4. Will my life be better with Nanotechnology? Of course.

References:

1. Khanduja, N.; Selvarasah, S.; Chen, C-L.; DOkmeci, M.R. Applied Physics Letters, **2007**, *90*, 083105.
2. http://www.nanosense.org/

Acknowledgement: This work was supported by the National Foundation Grant #0227577, #9986821, #0425826

Research Experiences for Teachers at Northeastern University
Claire Duggan, Program Director