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Self-Assembly of One-Dimensional Nanoparticles on Two-Dimensional Plane

Anindya Majumder[1,2*], Oliver Jost[3], Jörg Opitz[2,4], Gianaurelio Cuniberti[2], Eckhard Beyer[1,3]

[1]*Institute of Surface and Manufacturing Technology, Dresden University of Technology, D-01062 Dresden, Germany*
[2] *Institute of Materials Science and Max Bergmann Center of Biomaterials, Dresden University of Technology, D-01062 Dresden, Germany*
[3] *Fraunhofer Institute for Material and Beam Technology, Winterbergstrasse 28, 01277 Dresden, Germany*
[4]*Fraunhofer Institute for Nondestructive Testing, Maria-Reiche-Strasse 2, D-01109 Dresden, Germany*
* *correspondence: anindya.majumder@nano.tu-dresden.de*

Motivation

Self-assembly of nanoparticles has promising technological applications since it provides efficient building blocks for physical, chemical, and biological systems. Localization of nanoparticles at liquid-liquid interfaces by manipulating the particle surface energy is an upcoming area with great potential for applied and fundamental research. Apart from regular technological applications, such tailor made assembly opens a window to fabricate self assembled interfacial structured hybrid materials with unique properties. Carbon nanotubes (CNTs) represent an anisotropic and perfectly one-dimensional class of nanoparticles with extraordinary properties. Several self assembly techniques exploit liquid-liquid interface for nanoparticle assembly. CNTs were functionalized by various surfactants to prevent its agglomeration due to van-der-Waals forces. The dominating driving force for getting the particles to assemble at the interface is reduction in interfacial energy and capillary forces. The lateral interface mediated capillary forces are particularly dominant for anisotropic particles like carbon nanotubes (CNTs) having extraordinary properties. This phenomenon at the interface can be exploited further with the aid of external field via alternating current dielectrophoresis (ac-DEP) to align CNTs at the interface.

Strategy for self-assembly

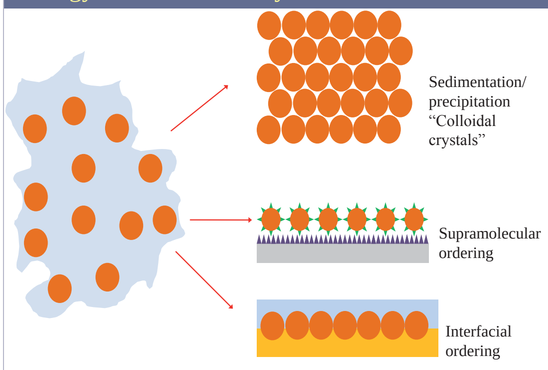

Figure 1: Schematic represting various possibilities of of self-assembly for nanoparticles

- One-Dimensional -nanoparticles mostly in solution (nanowires, nanotubes, dna..)
- Assembly of nanoparticels on a surface necessary for applications
- Assembly by crystalization or supramolecualr ordering lacks speed and reversibility
- Interface of two liquids used as a template to assembly nanoparticels
- Assembly of nanoparticles at interface opens up the possibility for fabricating new hybrid materials with interesting properties
- Possibility for any error correction during self-assembly process since the system is dynamic and has reversible
- With the aid of external appiled field the position of nanparticles can me manipulated at the interface
- Applications: electronics, biology, composites, filters, osmostic membranes, novel materials, templates, optics etc.

Technique for self-assembly

Ideal system:

- 2-Liquids with adjustable contact angle at the interface
- Compatibility to manipulate nanoparticles at such interface
- Immiscible solvents
- High dielectric constant
- CNT dispersion only in one phase of the system

Possibiity 1

- Solvent2: good for CNT dispersion
- Solvent1: CNT immiscible in solvent 1
- Both solvents needs to be compatible with their surface tension

Possibility 2

- Solvent2: ionic medium for good CNT dispersion by micelles encapuslation
- Solvent1: ionic or non-ionic medium carrying opposite charge, CNT immiscible in solvent 1

Dielectrophoresis (DEP)

$$F_{DEP} = \frac{2\pi abc}{3}\epsilon_m R_e\left[\frac{\epsilon_p^*(\omega)}{\epsilon_m^*(\omega)} - 1\right]\nabla|E|^2$$

2πabc/3 = geometric factor

R_e = Clausius Mossotti (CM)Factor

E = Electric field

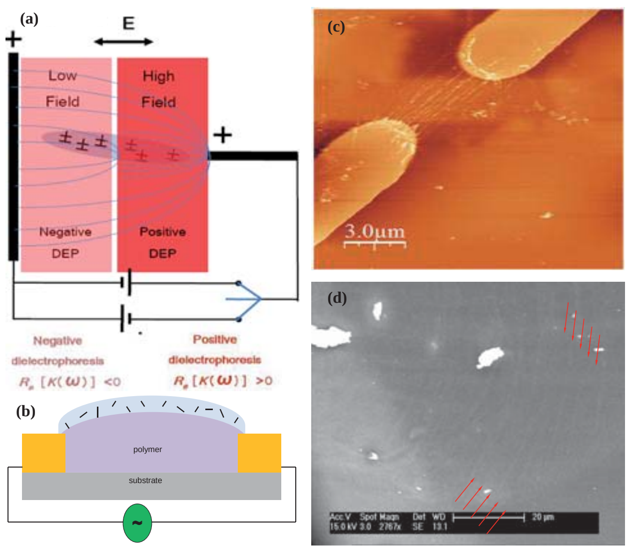

Figure 2: Self –assembly techqnues. (a) Schematic showing ac-dielectrophoresis (b) Schematic view of the set-up for self –assembly of nanoparticles at interface (c) CNTs aseembled between electrodesby ac-dielectrophoresis (d) CNT s assembly by ac-dielectrophoresis at the interface pf twp fluids.