

ZnO nanorod bunches formation by Electrophoresis Deposition Technique: influence of the conductivity of the substrate

Authors

Prof. MONICA TIRADO - NanoProject, Departamento de Física, Facultad de Ciencias Exactas y Tecnología, Universidad Nacional de Tucumán (UNT) and Instituto de Física del Noroeste Argentino – INFINOA (CONICET-UNT), Av. Independencia 1800, San Miguel de Tucumán 4000, Argentina

Dr. Omar Espindola - NanoProject, Departamento de Física, Facultad de Ciencias Exactas y Tecnología, Universidad Nacional de Tucumán (UNT) and Instituto de Física del Noroeste Argentino – INFINOA (CONICET-UNT), Av. Independencia 1800, San Miguel de Tucumán 4000, Argentina

Dr. Silvina Real - NanoProject, Departamento de Física, Facultad de Ciencias Exactas y Tecnología, Universidad Nacional de Tucumán (UNT) and Instituto de Física del Noroeste Argentino – INFINOA (CONICET-UNT), Av. Independencia 1800, San Miguel de Tucumán 4000, Argentina

Dr. María Priscila Zelaya - NanoProject, Departamento de Física, Facultad de Ciencias Exactas y Tecnología, Universidad Nacional de Tucumán (UNT) and Instituto de Física del Noroeste Argentino – INFINOA (CONICET-UNT), Av. Independencia 1800, San Miguel de Tucumán 4000, Argentina

Dr. OSCAR Marin - NanoProject, Departamento de Física, Facultad de Ciencias Exactas y Tecnología, Universidad Nacional de Tucumán (UNT) and Instituto de Física del Noroeste Argentino – INFINOA (CONICET-UNT), Av. Independencia 1800, San Miguel de Tucumán 4000, Argentina

Dr. David Comedi - NanoProject, Departamento de Física, Facultad de Ciencias Exactas y Tecnología, Universidad Nacional de Tucumán (UNT) and Instituto de Física del Noroeste Argentino – INFINOA (CONICET-UNT), Av. Independencia 1800, San Miguel de Tucumán 4000, Argentina

Abstract

A novel and simple self-assembled direct formation of ZnO nanorod (NR) bunches on boron (p-type)-doped crystalline Si (100) substrates has been achieved by the EPD technique. All the nanostructures were formed from a colloidal dispersion of ZnO NPs in 2-propanol, at room temperature, and without the use of sacrificial templates or pre-deposited Au nanoclusters on Si substrates. ZnO nanoparticle (NPs) colloidal dispersions were prepared based on a modification of the precipitation method reported by Bahnemann et al. [1]. ZnO NPs sizes were estimated from the absorbance spectra of NPs colloidal dispersions and compared to measurements obtained by TEM, which yielded an average diameter of 5 nm with a narrow size distribution, between 4 and 7 nm. The morphology of ZnO NR bunches is affected by the p-type Si substrate whole conductivity (i.e., B dopant concentration). The nanorod diameters and lengths, as well as the bunch diameters, are larger for substrates with lower conductivity. A ZnO nanoporous film is obtained on non-conductive (nominally undoped) Si substrates without any one-dimensional formation. XRD patterns indicated that ZnO NRs were preferentially formed in (002) direction corresponding to c-axis orientation in the wurtzite structure. Photoluminescence (PL) spectra from NR bunches show a low UV excitonic emission peak and a broad visible emission peak. The light emission properties of nanostructures are strongly determined by the properties of NPs used for the EPD deposition and not by the nanostructure morphology. The incorporation of NaOH during ZnO NP synthesis is useful to complete reactions of all the available Zn²⁺ to form dispersions with a higher ZnO NPs concentration. Therefore, as virtually all the Zn is consumed, PL spectra do not exhibit Zn-type defects compared to previous work [2]. The easy obtaining of different morphologies of ZnO nanostructures depending on the Si substrate conductivity is desirable for their use as functional materials in technological devices. The results presented in this work expand the EPD technique applications to form nanorod nanostructures in a single step, representing a high technological potential for nanoscale device applications[3].

[1] D.W. Bahnemann, C. Kormann, M.R. Hoffmann, Preparation and characterization of quantum size zinc oxide: a detailed spectroscopic study, *J. Phys. Chem.* 91 (14) (1987) 3789-3798.

[2] C. Sandoval, O. Marin, S. Real, D. Comedi, M. Tirado, Electrophoretic deposition of ZnO nanostructures: Au nanoclusters on Si substrates induce self-assembled nanowire growth, *Mat. Sci. Eng. B.* 187 (2014) 21-25.

[3] S. Real, O. Espindola, M. P. Zelaya, O. Marin, D. Comedi, M. Tirado, Single-step ZnO nanorod bunches formation on p-type Si-conductive substrates by electrophoretic deposition, *Surfaces and Interfaces*, 23, 100930 (2021).

The effect of particle-wall proximity on the mobility of electrokinetically driven active colloids

Authors

Dr. Alicia Boymelgreen - Florida International University

Dr. Golak Kunti - Technion - Israel Institute of Technology

Dr. Pablo García-Sánchez - universidad de Sevilla

Prof. Antonio Ramos - universidad de Sevilla

Prof. Gilad Yossifon - Tel Aviv University

Prof. Touvia Miloh - Tel Aviv University

Abstract

The most common configuration of synthetic active colloid is the Janus particle, wherein a homogeneous dielectric sphere is coated on one hemisphere with a metallic coating. The weight of the metal results in the descent of the active colloid to the bottom of the microfluidic chamber whereupon activation with the electric field, it will translate parallel to the wall. Using a combination of theory, experiment and numerics we demonstrate that this wall proximity modulates both the magnitude and direction of the velocity of electrokinetically driven particles adjacent to a conducting wall (electrode).

At low frequencies, where induced-charge electrophoresis (ICEP) dominates, the ICEP force is shown to increase as the particle approaches the wall although the corresponding change in velocity is modulated by the increased Stokes drag. Additionally, a secondary characteristic charge relaxation time is observed to manifest.

Additionally, the interaction of the particle with the wall breaks the uniformity of the induced EDL at the surface of the electrode to produce an electrostatic driving force that is dominant at high frequencies. We have termed this force "self-dielectrophoresis" and show that it increases as the particle is adjacent to the wall.