Simulation, fabrication and characterization of transparent piezoelectric transducers based on ZnO nanowires

Detailed Topic

Piezoelectric devices are attracting growing interest as a micro-source of energy by harvesting mechanical ambient energy, and as sensors via the direct piezoelectric effect. In this context, semiconducting materials in the form of nanowires constitute a promising building block for the fabrication of innovative devices. The nanowires typically exhibit diameters of several tens of nanometers along with a length of around one micrometer. Thanks to that geometry, they generally present an excellent crystalline quality and benefit from remarkable physical properties that are related to their high surface/volume ratio. Zinc oxide (ZnO) as a biocompatible semiconductor composed of abundant elements specifically has numerous assets and can be grown in the form of nanowires by a large number of deposition techniques. Owing to its wurtzite crystalline structure, ZnO nanowires grow along the piezoelectric c-axis. Vertically aligned ZnO nanowire arrays are thus sensitive to mechanical constraints and are liable to be integrated into piezoelectric nanocomposites aiming either to sense mechanical inputs (e.g. fingerprint scanners) or at harvesting with a good efficiency the mechanical energy in the environment and hence playing the role of an energy micro-source.

The objective of this PhD thesis is to explore theoretically and experimentally the performance improvement of high-density arrays of ultimate-size ZnO NWs on a transparent substrate (i.e. glass) covered by a transparent conductive electrode (AZO, etc.). ZnO nanowires with controlled dimensions and properties (surface states, doping) will be developed using a low-cost, low-temperature, chemical deposition technique with a low environmental impact and a high industrial potential. The integration into devices will be performed based in the know-how of the laboratory consortium. Advanced complementary characterization techniques will be used at device and nanowire level: Home-made set-ups will be used at device level. Complementary AFM platforms (SSRM, SCM, TUNA, SMIM, etc.) will be used to characterize single nanowires. All these experimental data (geometry, doping, surface states) will help us to build and validate a simulation platform both at single nanowire and device level. The simulation platform will provide optimization guidelines for future devices sensors and energy harvesting devices.

References:

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Location

The candidate will work in the Micro Nano Electronics Devices (CMNE) group from the Centre for Radiofrequencies, Optic and Micro-nanoelectronics in the Alps (CROMA), in the Nanomaterials and advanced heterostructures (NanoMAT) group from the Laboratory in Materials Science and Physical Engineering (LMGP), in the PROSPECT group from LTM and the Nanocharacterization platform team (PFNC) from CEA-LETI.

Web sites: https://croma.grenoble-inp.fr/, http://www.lmgp.grenoble-inp.fr/, https://ltm.univ-grenoble-alpes.fr/, https://ltm.univ-grenoble-alpes.fr/research, https://www.leti-cea.fr/cea-tech/leti/Pages/recherche-appliquee/infrastructures-de-recherche/plateforme-nanocaracterisation.aspx

Profile & Required Skills

The applicant should be an Engineering School or Master 2 student in the fields of electronics, nanosciences and/or semiconductor physics. It is desirable that the candidate has knowledge in one or more of these areas: semiconductor physics, finite element simulation, Atomic Force Microscopy (AFM), clean room techniques and associated characterizations (SEM, etc.). The grades and the rank as undergraduate and especially at the Master degree are a very important selection criterion for the doctoral school. Specific skills for teamwork and oral and written English expression will be appreciated. We are looking for dynamic and highly motivated candidates.

PhD Thesis Funding: Funding is available *via* the Microelectronics LABEX (2024 - 2027) joining CROMA, LMGP, LTM and CEA-LETI in the Grenoble region.

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