Bending piezoelectric nanowires: application to force-displacement sensors based on individually contacted vertical ZnO piezoelectric nanowires

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One dimensional nanostructures are investigated in a large range of potential applications in nano-electronic devices. In particular zinc oxide (ZnO) piezoelectric nanowires (NWs) are suitable as elementary transducing blocks for force-displacement sensor applications[5,6]. Upon bending, a piezoelectric charge density distribution occurs within the NW, yielding a piezoelectric potential (piezopotential). This piezopotential is a function of the applied force or displacement onto the sensor. We intend to develop a force sensor based on piezoelectric NW matrices, where the elementary cell (pixel) is a single vertical-contacted-piezoelectric NW. We focus on force/pressure triggered electronic devices and aim to give in-depth understanding of pixel piezoelectric behavior and related technological considerations.

We report both finite element method (FEM) multi-physics simulations that we used as a tool for the device qualitative characterization and design optimization, and the low-temperature hydrothermal process which was implemented to grow NWs on different microelectronics-industry-compatible polycrystalline seed-layers, both template-free and patterned.

Individually contacted vertical NWs sensor approach

Simulation of one pixel

Existing results in simulation do not satisfactorily take into account the surrounding environment of the NW or the device feasibility:

- Single bent piezoelectric nanowire
- Electrical contacts position

Our work[5]

NW growth

We carried out NW hydrothermal growth[6] on different clean-room processed polycrystalline seed-layers.

ZnO nanowire growth on template-free layers

SEM X-section view

SEM top view

NW growth on pre-patterned seed-layer: control of NW density

The results below were obtained for a gallium-doped ZnO seed-layer.

Multiple and single NWs were obtained on the patterns, showing that it is possible to obtain isolated NWs suitable for our applications.