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Polar Surface Induced Growth of Semiconducting and Piezoelectric Oxide Novel Nanostructures

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Quasi-one-dimensional (1D) nanostructures (nanowires, nanobelts and nanorods) are the forefront nanomateirals for nanotechnology. Oxide nanostructures have been synthesized for a wide range of semiconducting oxides [1] that are potential building blocks for constructing numerous nanodevices. Using the technique demonstrated for measuring the mechanical properties of nanotubes [2,3], the mechanical and field emission properties of the oxide nanobelts have been characterized. Field effect transistors [4], ultra-sensitive nano-size gas sensors [5], nanoresonators and nanocantilevers [6] have been fabricated using nanobelts.

Among all of the oxide nanostructures we have investigated, ZnO is very unusual. The two important characteristics of the wurtzite structured ZnO are the non-central symmetry and the polar surfaces. The structure of ZnO can be described as a number of alternating planes composed of tetrahedrally coordinated O^{2-} and Zn^{2+} ions, stacked alternatively along the *c*-axis. The oppositely charged ions produce positively charged (0001)-Zn and negatively charged (000-1)-O polar surfaces, resulting in a normal dipole moment and spontaneous polarization along the *c*-axis. Growth of (0001) facets dominated, freestanding, piezoelectric zinc oxide (ZnO) nanostructures is challenged by the divergence of the surface energy due to intrinsic polarization. By controlling growth kinetics, we show the success of growing nanobelt-based novel structures whose surfaces are dominated by the polarized ±(0001) facets. Owing to the positive and negative ionic charges on the zinc- and oxygen-terminated ±(0001) surfaces, respectively, a spontaneous polarization is induced across the nanobelt thickness. As a result, helical nanostructures and nanorings are formed by rolling up single-crystal nanobelts. This phenomenon is attributed to a consequence of minimizing the total energy contributed by spontaneous polarization and elasticity. The polar surfaces give raise a few interesting growth features, such as the formations of nanosprings [7], nanorings [8], nanobows [9] and nanohelices [10]. These nanostructure are semiconductive and piezoelectric and have potential applications as nano-scale sensors, traducers, and actuators. The polar surface dominated ZnO nanobelts are likely to be an ideal system for understanding piezoelectricity and polarization induced ferroelectricity at nano-scale; and they could have applications as one-dimensional nano-scale sensors, transducers and resonators.

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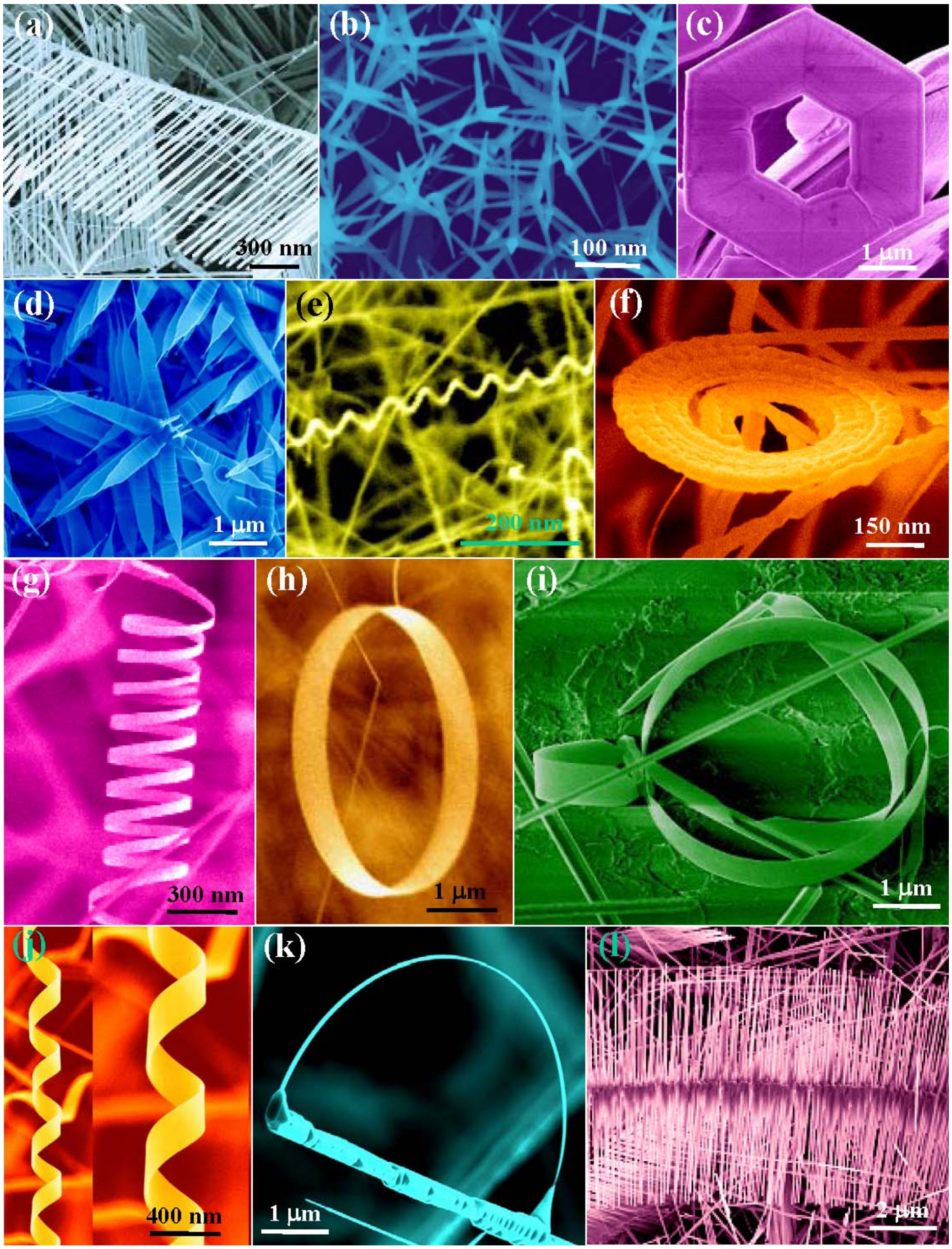

FIG.1 Nanostructures of Zinc Oxide formed due the presence of polar surfaces. These unique nanostructures were grown by a vapor-solid process

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