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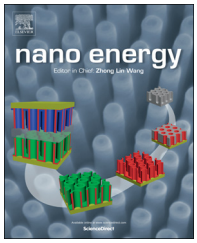

Editorial

Nanogenerators and piezotronics

KEYWORDS
Nanogenerators;
Piezotronics

The second international conference on nanogenerators and piezotronics (NGPT 2104) was held at Atlanta from June 9–11, 2014, which gathered over 130 participants from all over the world. This special issue published in *Nano Energy* collects some selected papers presented in the conference to comprehensively review and communicate some of the most important progresses in the fields. These papers mainly belong to the following categories.

Nanogenerators are primarily developed based on piezoelectric and triboelectric effects for converting mechanical energy into electricity. Ever since it was first demonstrated in 2006 using piezoelectric effect, it has gradually attracted a lot of interest because of the increasing demands in energy worldwide. The invention of triboelectric nanogenerator (TENG) has greatly expands the field because the energy conversion efficiency of using triboelectric effect is at least 5 times of that using piezoelectric effect, reaching 55%, and the modes for power generation are rather diverse and cover the most conventional mechanical/kinetic actions in our daily life. Applications of nanogenerators are mainly in three important areas. Firstly, it severs as the micro-power source for mobile/wearable electronics, internet of things and sensor networks, which require a tremendous amount of mobile power sources, and in many cases, batteries could not completely satisfy the practical requirements in terms of size, capacity, or flexibility. Secondly, it can serve as a self-powered sensor (or active sensor) for detecting mechanical triggering, pressure fluctuation and environmental stimulation without requiring an external power to the sensor tip, which thus possesses great potential for human-machine interfacing, security systems, physiological characterization, and infrastructure monitoring. It has applications in human-machine interfacing, smart skin, robotics, MEMS, security, biomedical science, infrastructure monitoring and more. Lastly, nanogenerator can be a possible approach for harvesting large-scale energy from ocean waves. By constructing units that are in the size of a baseball, inside which the TENGs are installed, millions or even billions of such units can be interconnected into a "fishing net", which can float on the water surface for harvesting the kinetic wavy energy. This technology has the merits of low cost, light weight, high efficiency, high output power density, and easy scaling, leading toward the dream of "blue energy", the energy from ocean water.

Piezotronics is a field coined using piezoelectric effect for controlling electronics by mechanical stimuli. For wurtzite structures that have non-central symmetry, such as ZnO, GaN and InN, piezoelectric polarization charges are created at the interface/surface by applying a strain. The strain created inner-crystal piezopotential can serve as a "gate voltage" that can effectively tune/control the charge transport across an interface/junction, which is named the *piezotronic effect*; electronics fabricated based on such a mechanism is coined as *piezotronics*, with applications in force/pressure triggered/controlled electronic devices, sensors, logic units, memories, and catalysts.

The presence of polarization charges at a *pn* junction can effectively distort the local band structure and consequently affect the carrier transport, separation or recombination. Applying either a compressive or tensile strain depending on the polarization of the piezoelectric material, the efficiency for charge carrier separation or recombination can be effectively enhanced. By introducing photon excitation, a coupling among semiconductor, photon excitation and piezoelectricity creates a new field of research called piezo-phototronics. The *piezo-*

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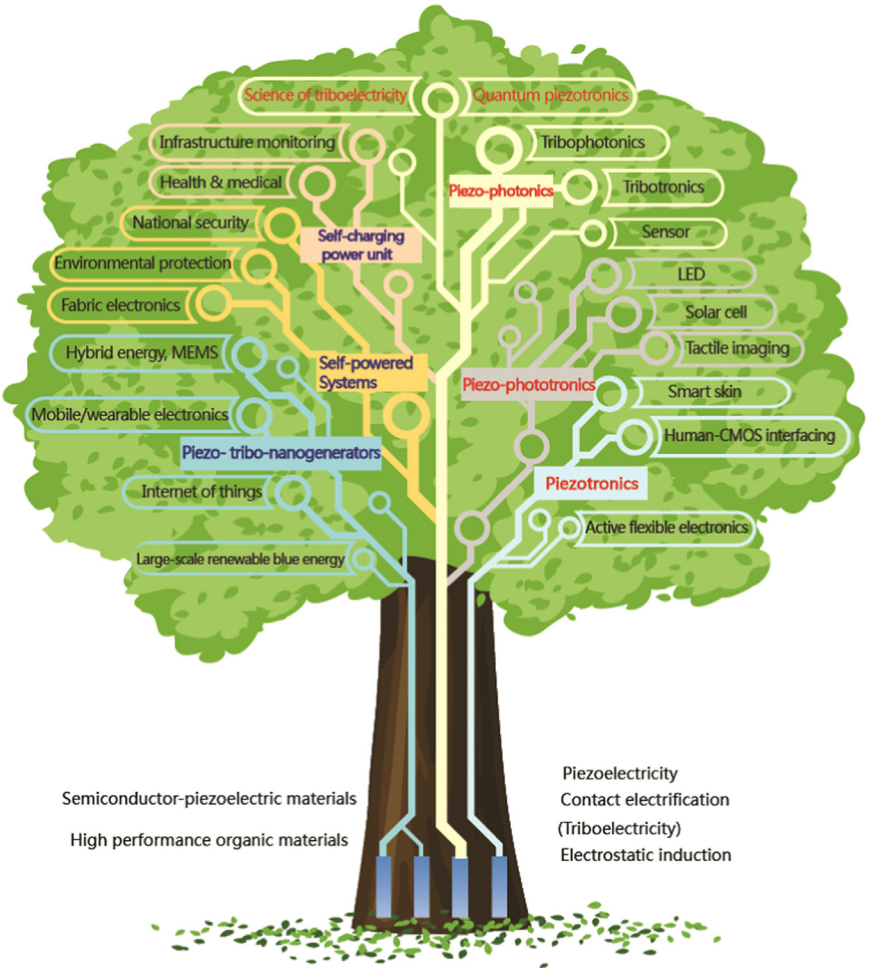

Figure 1 A tree-design represented blue print about the nanogenerator driven self-powered systems and piezotronics led sensors and energy sciences.

phototronic effect is the tuning and controlling of charge carrier generation, separation or recombination at a hetero-junction by the strain induced piezoelectric polarization charge. This effect could lead to tremendous performance gain in LEDs, laser diodes, photodetectors, and photovoltaic devices by applying static mechanical strains.

The fields of nanogenerators and piezotronics can be summarized using a "tree" idea (Figure 1) for projecting its root, major fields and applications. The root is based on fundamental materials and physics effects. The major branches are the major research directions, and the small branches are the potential applications. The left-hand side represents the nanoenergy technologies as a result of nano-generators; the right-hand side is the fields of piezotronics and related as well as future perspectives. The top of the tree is the fundamental sciences to be explored for enhancing the basic understanding. We anticipate this tree will grow fast and expand quickly with abundant fruits in the near future.

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