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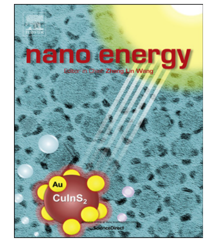


RAPID COMMUNICATION

# Wireless, power-free and implantable nanosystem for resistance-based biodetection

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**Abstract**
*In-vivo* devices and systems are extensively used in medical field to real-time detect and adjust the physiological status of human being, but supplying energy *in-vivo* for these devices and systems is still a great challenge. In this work, we first developed a new kind of wireless nanogenerator (WLNG) based on biocompatible BZT-BCT nanowires (NWs). It works through compressing and releasing BZT-BCT NWs/PDMS nanocomposite by a changing magnetic field in wireless non-contact mode. The maximum output voltage reaches 3.9 V, and the maximum output current is 1.17 μA, which are 21.9% larger than the reported maximum output voltage 3.2 V and 23.4 times of the reported maximum 50 nA of non-contact nanogenerator. And we further integrated it with a new kind of transmitter into a wireless, power-free and implantable nanosystem for *in-vivo* biodetection. This nanosystem does not need any electrical power. An *in-vitro* changing magnetic field can be used to drive it to detect the variation of resistance *in-vivo* and wirelessly transmit the signal to the equipments *in-vitro*.


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## Introduction

Nowadays, *in-vivo* devices and systems are extensively used in medical field, such as detecting and adjusting physiological function of human *in-vivo* or substituting a lesion organ [1-4]. Till now, nearly all the *in-vivo* devices and systems rely on a battery for operation, but the capacities of a battery is still limited. Therefore, surgical procedures to replace the depleted batteries are inevitable, which bring many health risks to the patients [5]. So *in-vivo* powering these devices and systems is still a huge challenge which restricts the application of these technologies. Transporting energy wirelessly from *in-vitro* to *in-vivo* should be an effective way to solve this problem. In previous works, scientists have developed a technology on the basis of electro-magnetic induction [6] and ultrasonic wave [7]. But, the high frequency electromagnetic field or sound wave used in these technologies is harmful for the body and their penetration depth is limited [8-10]. So by now, it is still a great challenge to search a way safe to the body to power *in-vivo* devices.

Nanogenerator (NG) is a technology which could convert low frequency, weak mechanical energy into electrical energy based on the piezoelectric effect [11,12]. After increasing the output voltage to more than 1 V, [13] many devices and systems as UV sensors, [13-15] chemical sensors [16] and biosensors [17] have been powered by the NG. In principle, the output power of NG is large enough to power many *in-vivo* devices, which makes NG a good candidate as an *in-vivo* power source. But powering an *in-vivo* biodetection system by a NG is still infeasible for the following reason. First, the energy export by human movements is unstable. Second, harvesting these movements may influence the normal work of human organ. Third, the energy generated by an *in-vivo* NG is still too low to directly power a wireless transmitter without energy storage. So it is almost impossible for NG to power the medical devices at present stage. In this work, we developed a power-free nanosystem for all time, wireless and *in-vivo* biodetection. In this nanosystem, a high performance wireless NG driven by a changing magnetic field was used for power supplying. As magnetic field could cross over human body without any hindrance and act on any materials with ferromagnetic property, this NG could be driven by a changing magnetic field applied *in-vitro* and provide energy for the nanosystem. In this way, the output is stable and influences less on the normal work of human organ. Its maximum output voltage reaches 3.9 V, and the maximum output current is 1.17 μA, which are 21.9% larger than the reported maximum output voltage 3.2 V and 23.4 times of the reported maximum 50 nA of non-contact nanogenerator [18]. Then, a new wireless transmitter with low energy consumption was integrated with the WLNG into a nanosystem, which could work *in-vivo*, send the *in-vivo* resistance's response to the *in-vitro* equipment. This power-free nanosystem makes it possible to all time, wirelessly and *in-vivo* detect the physiological parameters that can influence the nanodevice's resistance.

## Material and methods

### Preparation of BZT-BCT nanowires

The BZT-BCT NWs are fabricated by the electrospinning method shown in previous works [21]. First, tetrabutyl titanate (2.4750 g) is mixing with ethanol (3 g), acetylacetone (1.5 g), acetic acid (9.75 g) and stirring until homogenous. After that, calcium hydroxide (0.0900 g), barium hydroxide octahydrate (2.1717 g), zirconium acetylacetonate (0.3939 g) and polyvinylpyrrolidone (0.53 g) are added into the solution in order, each composition is added after the previous one dissolved totally, the precursor solution is prepared after stirring homogenously. The solution is

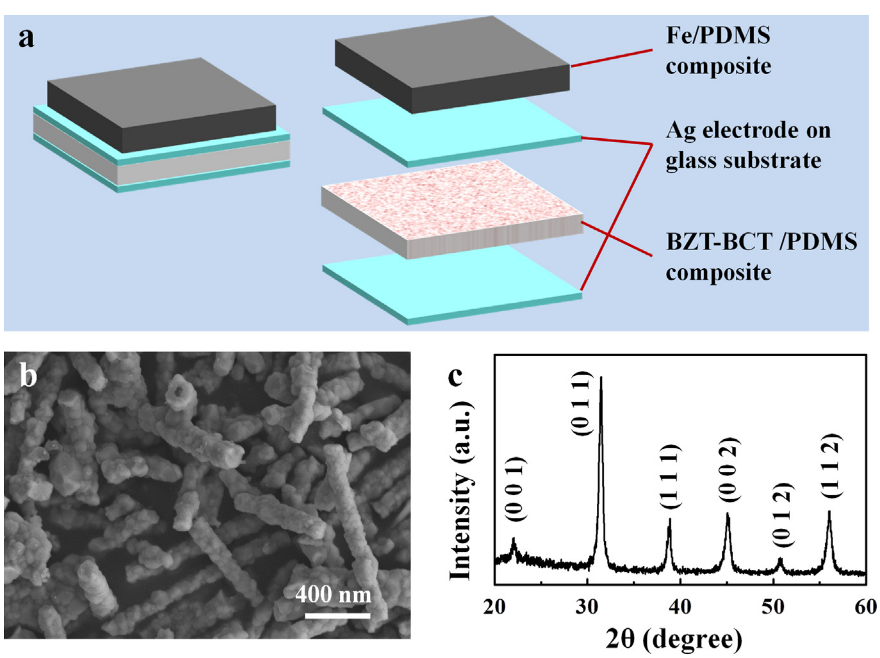


**Figure 1** Structure of the WLNG. (a) Schematic image showing the structure of the WLNG. (b) SEM image of the BZT-BCT NWs after grinded. (c) XRD spectrum of the BZT-BCT NWs.