REDEC Reliability of Electron Device and Circuits

Piezoelectric nanogenerators with graphene and nanowires

Charge your phone while you walk!

Summary

Current metodologies like graphene/PEN (polyethylene naphthalate) stacked as an electrode can improve the efficiency bring about two associated problems: first, and mainly, the low density (~6%) of nanowires that contact the top electrode, and second, the existence of wrinkles on the graphene transferred to the PEN. These two problems result in a large contact resistance.
On the other hand, graphene grown by chemical vapor deposition (CVD) impoverishes the properties of these devices by lowering the conductance and increasing their variability.

We developed an electrode for a nanogenerator with a piezoelectric material made of an array of nanowires comprising of an interfacial flexible graphene single layer film between the nanowire apexes of the piezoelectric material and the top electrode. The graphene is transferred directly on the nanowires before mounting the top electrode, said graphene layer being suitable of being adapted to said irregular shape. This methodology increases the contact area between the metal of the top electrode and the nanowires, reducing the contact resistance and enhancing the performance of the whole device.

We are looking for a company willing to acquire a competitive advantage via a license agreement.

Innovative aspects and applications

> Lowers the electric contact resistance.
> Enhance the performance
> Provides very homogeneous current distribution along graphene electrode.
> Design of high efficiency devices such as uniform field effecct transistors, piezoelectric nanogenerators and electrodes in capacitors.

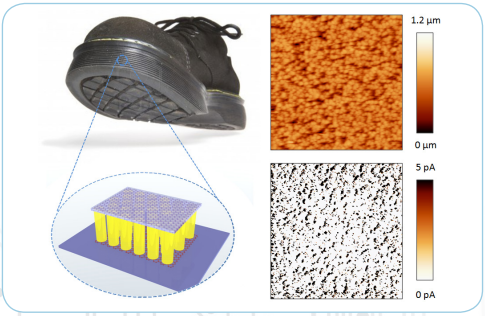

Fig. 1. (left) schematic of a possible application of nano-generators based on nanowires. Inserted in the schoes, theycould transform the mechanical movement in electric-ity, for example to charge a phone. (right) topographic and current images of the nanowries array. Each single nanowire produces current densities above A/cm²

IP Rights

Priority patent application 10.7.2013

State of development

The prototype has been fabricated and tested under different compressive stresses in the laboratory, leading to a great performance. Now we are trying to implant it in pavements and shoes to produce electricity for daily basis.

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Wrinkle-Free Graphene Electrode:

New way to the design of high efficiency devices

The Invention

Substrate-induced corrugations and strain-related wrinkles present in CVD-grown graphene on copper, which are harmful in device fabrication, can be effectively eliminated by optimizing the transfer process and adequately tuning the morphology of the substrate, respectively. Particularly, a piezoelectric material made of nanowires has remarkable advantages in term of electrical generation, and furthermore, the great adaptability of graphene to such substrate can be used to reduce the interfacial contact resistance, which opens a door to design of high performance electronic devices such as piezoelectric nanogenerators. Additionally, while the compressive strain in graphene on flat substrates is minimized by creating wrinkles, on rough substrates it is minimized by improving the graphene-substrate adhesion. As a result, a wrinkle-free sheet of graphene has been created by using a nanowire-array substrate.

Since the contact area between graphene and nanowires is much larger (at least the 70% and/or 90%), the contact resistance decreases, and the propagation of the piezo-electricity generated in the nanowires is improved.
In addition to, the flexible graphene layer is in contact with a conductive cover, following the need of protecting the graphene layer from external mechanical frictions, and at the same time, conduct electrical current. The higher rigidity the higher is the mechanical protection against external frictions.

Manufacturing process

According to a further aspect of the invention, the manufacturing process of an electrode for a nanogenerator which comprises a piezoelectric material with irregular shape, comprises the step of deposition of a flexible graphene layer over the irregular surface of said piezoelectric material, such that said flexible graphene layer is in contact with at least the 20 50% of the apexes of said piezoelectric material with irregular shape. The graphene electrode directly transferred to the nanowire arrays adapts much better to its morphology than other electrodes, which provides a large contact area and a low interface electrical resistance. The structure with the graphene sheet adapted to the nanowire array can be used as a high quality cell ideal for fabrication of high efficiency devices, such as 25 piezoelectric nanogenerators. Additionally, and as a secondary advantage, substrateinduced corrugations can be relaxed by optimizing the transfer process, while the amount and shape of strain-induced wrinkles can be tuned by substrate morphology, and the density of wrinkles is much reduced on rough substrates. It is possible to fabricate a wrinkle-free graphene sheet by transferring it onto a nanowire array as an electrode.

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