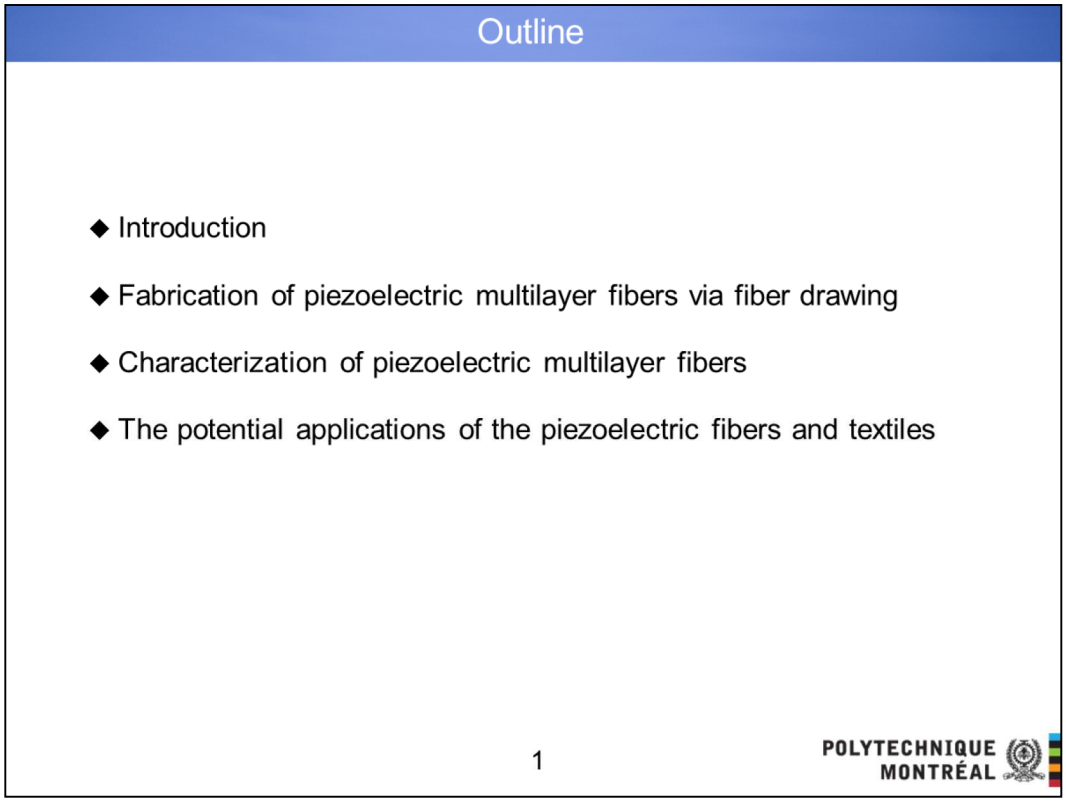
Good morinig, everyone, Thank you very much for your attention on my presentation. I am xiN, from university of montreal. My presentation I about smart fibers for the textukbe-based microgenerators and compliant energy stroge.



Here is the outline of this presentation. In the first stage, I will give a brief introduction. Then, I will review the fabrication of pieozlectric fibers. After THAT, I WILL introduce the structure and fabrication of our all-polymer piezoelectric fibers. Finally, I will take about the performance and applications of the piezoelectric fibers and textiles.

Introduction

Wearable mobile electronics have gained growing popularity and been used for many applications

- Communication;
- Health management
- Medical diagnostics;
- Entertainment;

...

Smart watches

Google glasses

Virtual-reality headset

Wearable medical sensors

POLYTECHNIQUE MONTRÉAL

In the past years, werable electronics have been more and more popular in our daily life. Potentail applications may include communication, health manage, medical, entertainment and environmental monitoring.

Introduction

Small batteries

Current power supply

- Rigid
- Heavy
- Pollution;

Solar power

Wind power

Hydro power

Geothermal power

Clean energy

- Dependent on the location and environment

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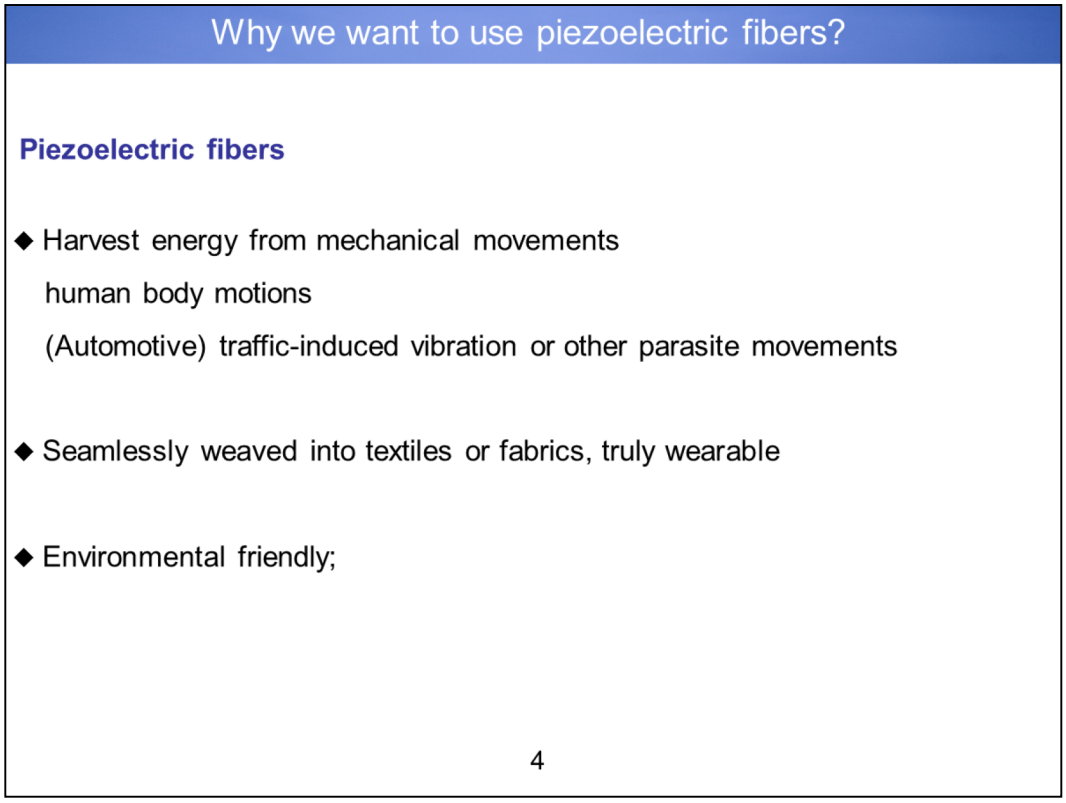
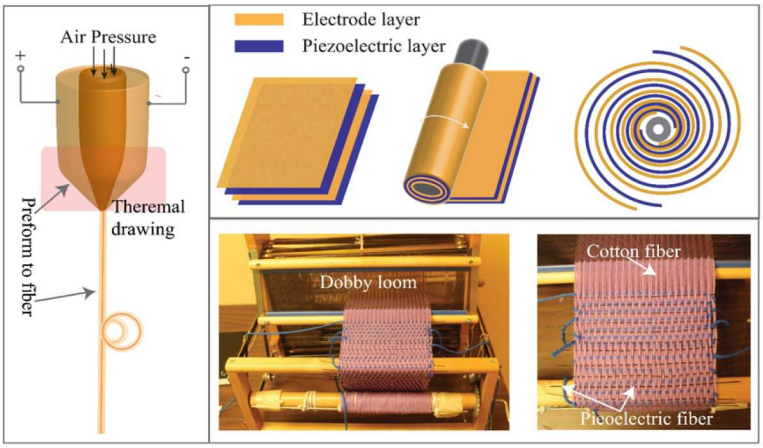
Most of the exsiting werable electronics use the batteries as the power supply. However, these batteries are heavy and will cause environmental pollution. Clean energy may include solar, wind, hydro and thermal. However, these energy would depend on the location and environment



Piezoelectric fibers has great advantages as they could harvest energy form mechnical movementt. For example, the piezoelectric fibers could be implanted on the human body or automoblie, and generate energy from human boday movements or traffic-induced vibrations. Also, piezoelectric textiles could be fabricated by intergrating the piezoelectric fiber into the cotton textiles.

The fabrication of our piezoelectric fibers



- The as-drawn fibers features similar structure possessed by the preform, while shrinking in diameter and having micro- or nano- structures.
- Hundreds of meters of fibers could be drawn in a single drawing process.

[1] X. Lu, H. Qu, and M. Skorobogatiy, "Piezoelectric Micro- and Nanostructured Fibers Fabricated from Thermoplastic Nanocomposites Using a Fiber Drawing Technique: Comparative Study and Potential Applications," ACS Nano, DOI: 10.1021/acsnano.6b08290, (2017).

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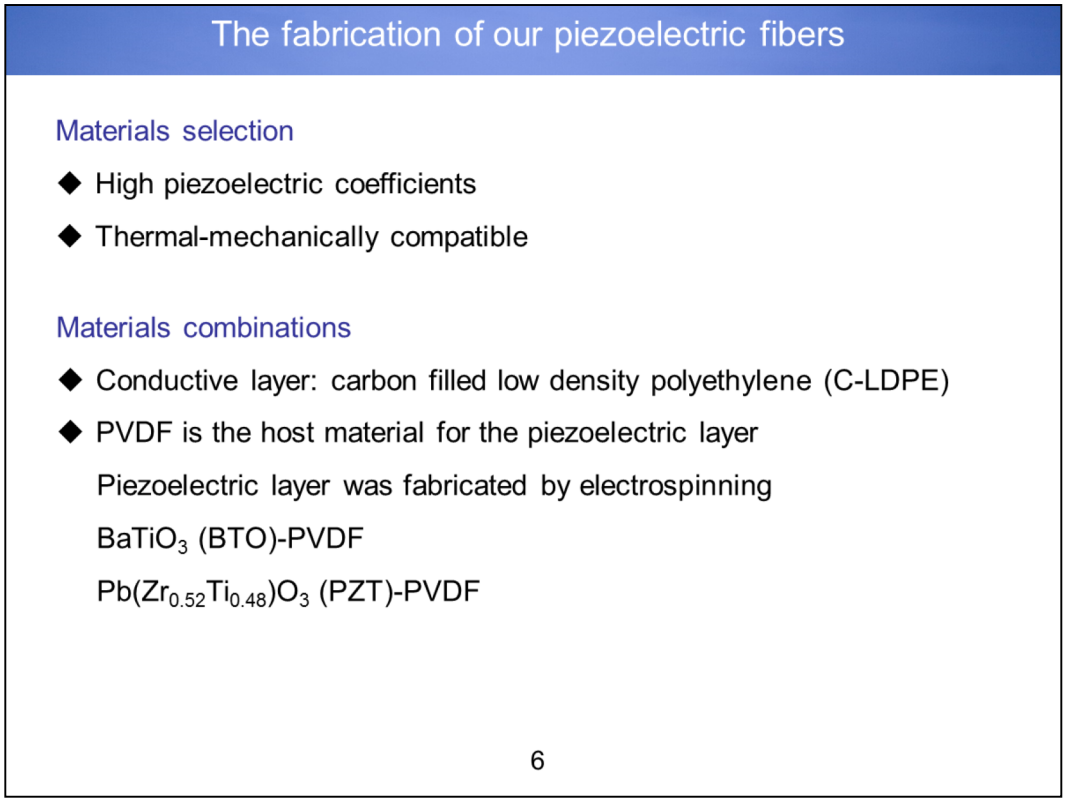
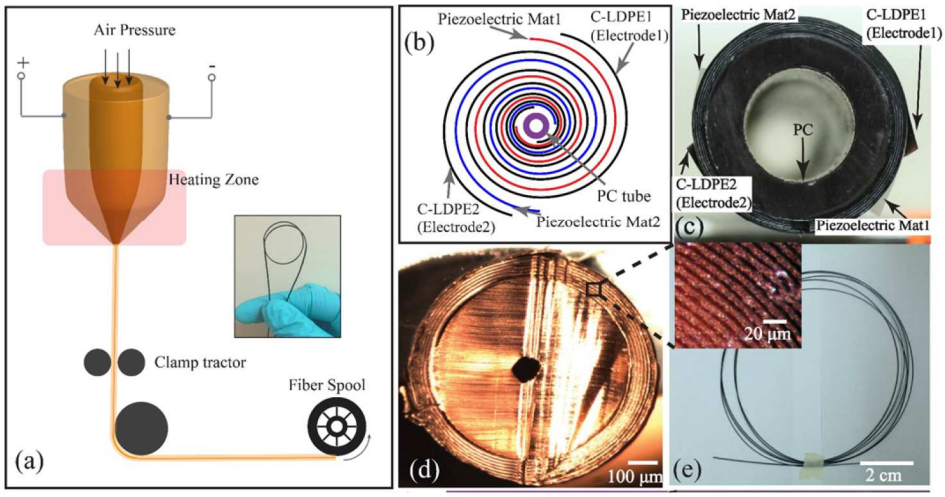
Our piezoelectric fibers are fabricated by fiber drawing process, which is generally used for the fabrication of optical fibers. The fiber drawing process starts with the fabrication of the fiber preform. Our preform is fabricated by co-rolling the conductive polymer films and piezoelectric mats along a polycarbonate core. After consolidationIn , the preform is placed into a vertical furnace and heated around the transition temperature. In the fiber drawing process, the preform tip gets melt and forms glob under the force of the gratity. A clamp-tractor is used to control the fiber drawing speed The as-drawn fiber could retained the structure of the preform, while the the cross-sections diameter would be reduced to millimeter even micrometer. Kilo-meters of the piezoelectric fiber could be drawn from a single-fiber drawing process. The as-drawn fiber could be weave into a cotton textile using the tradditonal weaving process.



In our choice of the materials for fiber fabrication we used two criteria. First, to obtain the fibers with high piezoelectric performance, the active material should have high piezoelectric coefficient. Second, to maintain the high degree of control over drawing of the kilometer-long piezoelectric fibers the materials in the fiber preform should be thermo-mechanically compatible. Thus, PVDF was chosen as the host material for the piezoelectric layers, as it is a low-cost, stable thermoplastic polymer that can exhibit relatively high value of the piezoelectric coefficient.

The fabrication of our piezoelectric fibers

Fabrication of microstructured piezoelectric fibers using fiber drawing technique



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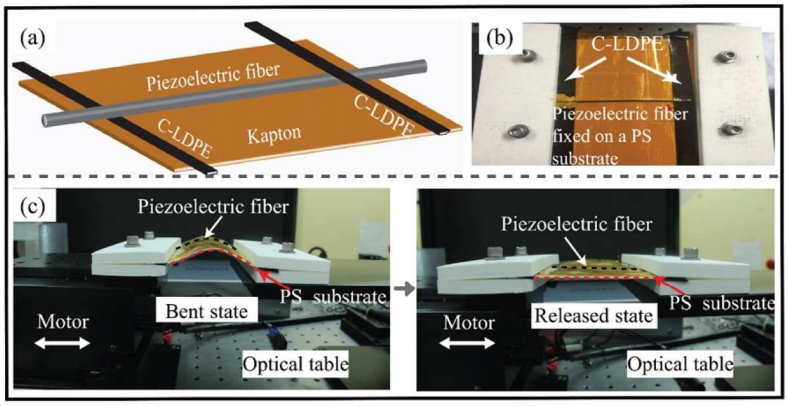
This slide shows the stucutrue of the preform and drawn fibers. As we can see, the piezoelectric fiber could retain the structure of the fiber perfeom. The thicknesss of the multilayer could be adjusted by changing the applied voltage, drawing temperature and drawing spped. For example, when we increased the applied voltage, nanosturcutred piezoelectric fiber could be fabricated because the two condutive laye in the molten preform has a tency to attract each otherAs shown in this piezoelectric. Meters long of piezoelectric fiber could be fabricated/

Bending test of our piezoelectric fibers



- C-LDPE is used to connect to the electrodes of the fiber (10 cm).
- One end of the fiber is fixed, while the other end is displaced by 5, 10, 15, 20 mm.
- The open-circuit voltage and short-circuit current is measured.

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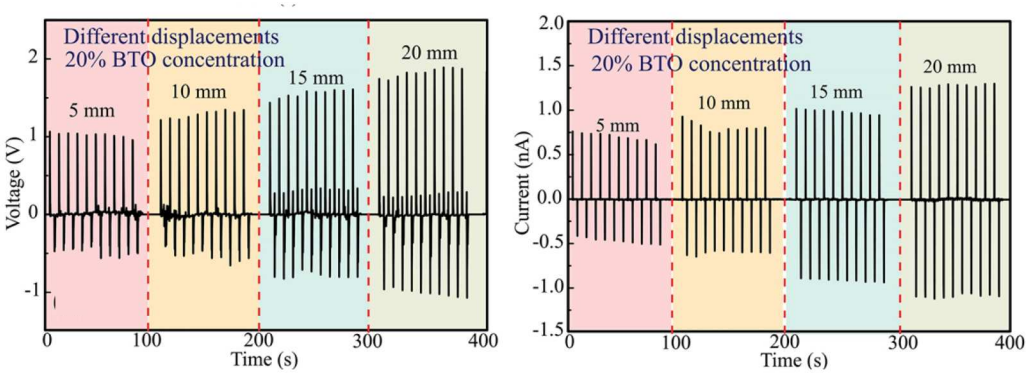
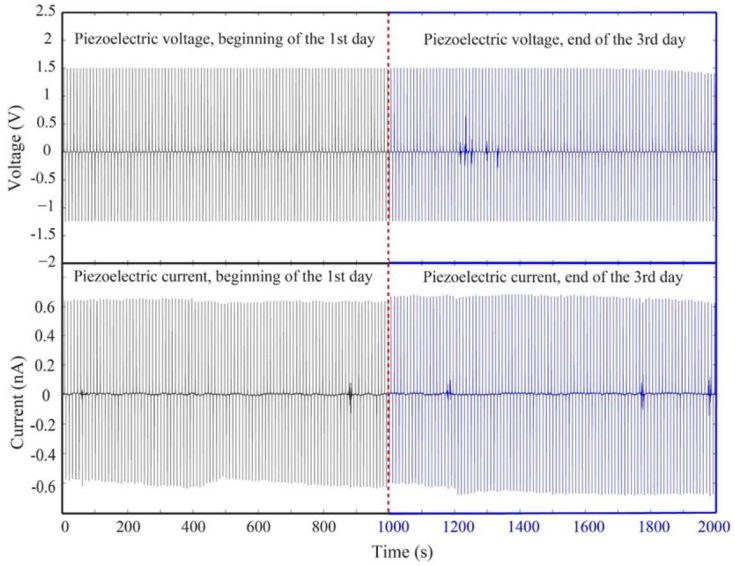
Then, we conducting the bending test of our piezoelectric fibers. The fiber generator consists of a piezoelectric fiber, a polymer substrate and two conductive polymer strips. Before the connection before the connection, the piezoelectric fiber should be placed in a specific position: one fiber electrode is on the top, while the other fiber electrode is on the bottom (this can be achieved by rotating the fiber). Then, one C-LDPE strip was attached to the top side of the fiber, while the other one was attached to the bottom side of the fiber on the opposite end. In this way, the two strips would connect to the two different electrodes of the fiber. In the experiment, one end of the ….

Bending test result



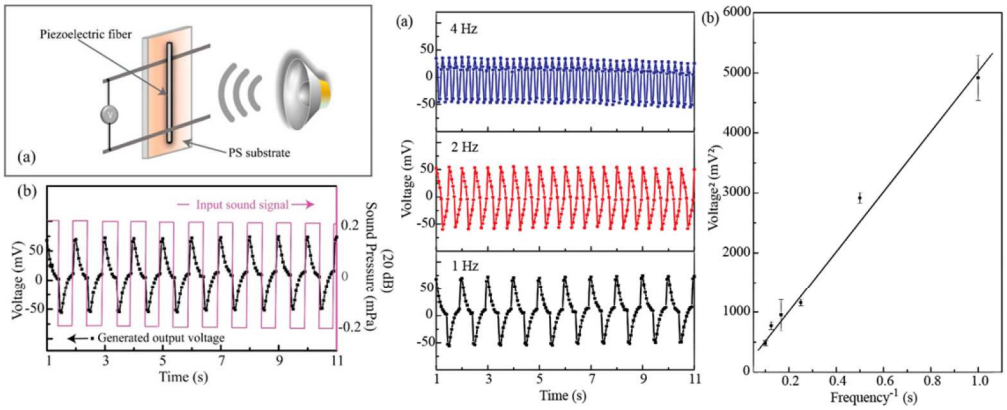
- With the fiber moving end displaced from 5 to 20 mm, the open-circuit voltage linearly increased from ~1V to ~1.8V, and the short-circuit current increased from ~0.7 nA to 1.3 nA.

Durability test of piezoelectric fibers



- The open-circuit voltage and short-circuit current barely change during the continuous bending-releasing tests in 3 days (more than 26000 cycles)

Response of the piezoelectric fiber to acoustic waves



- Square acoustic waves are generated by PC-controlled speaker.
- The sound pressure level (SPL) of the actuating sound was ~20 dB (0.2 mPa).
- $V^2 \sim P/f$,[2] P is the acoustic wave power, f is the acoustic wave frequency.

[2] Cha, S. N.; Seo, J. S.; Kim, S. M.; Kim, H. J.; Park, Y. J.; Kim, S. W.; Kim, J. M.Sound-Driven Piezoelectric Nanowire-Based Nanogenerators. Adv. Mater. 2010, 22, 4726– 4730, DOI: 10.1002/adma.201001169

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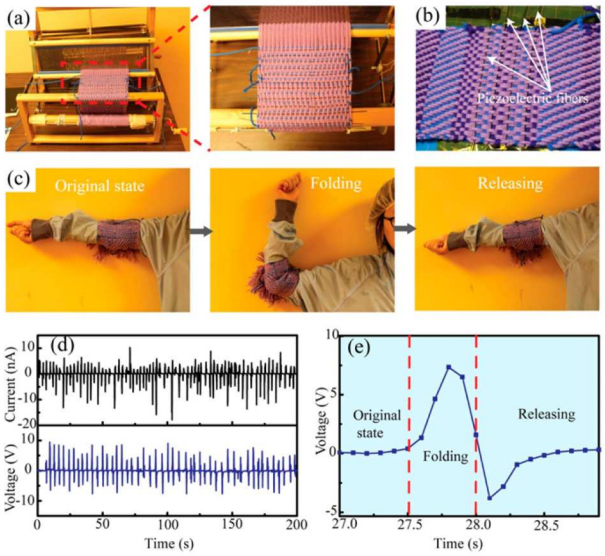
In the following slide, I will show some potential applications of the piezoelectric fibers. The piezoelectric fiber is sensitive the acoustic wave. In our experiment, the sound-wave is generated by a computer-controlled speaker. The sound pressure level (SPL) of the actuating sound was ~20 dB (0.2 mPa) at 1 Hz where dB = 20log10 (P/P0), P0 = 20μPa, and the amplitude of the fiber output voltage was in the range of 50 to 70 mV. Also note, whne

Piezoelectric textiles for detecting elbow motions



◆ 4 piezoelectric fibers are weaved into a textile and connected in series

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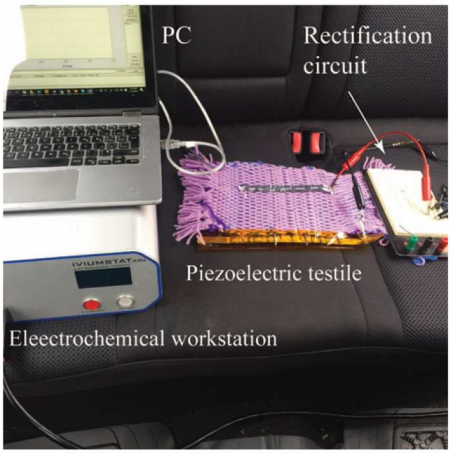
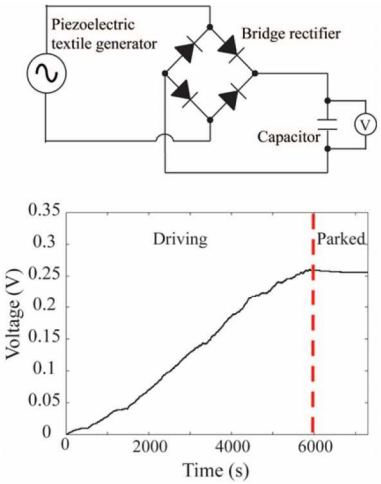
Piezoelectric textiles as in-car micro-generators





- A 22 kg sandbag is placed on the textile (15 fibers connected in parallel) during driving.
- The traffic-induced vibration in 6000 s urban-road driving could charge a 10 μF capacitor from 0 to ~0.3 V.

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Piezoelectic textile could also find application in the automotive industry. In this experiment, we implanted the piezoelectric textiles on the surface of a car seat. And a sandbag is put on the surface of the textile. In the drving, the piezoelectric textile could generate electricity form the the virbrations. Here we use the piezoelectric textile to charge a small capatiror. After 6000 urban-road driving, the voltage acorss the capacitor could increase to 0.3V

Summary

- The proposed piezoelectric fibers adopt a spiral multilayer structure, which considerably increases the active areas of the piezoelectric materials and thus results in higher energy generation efficiency.
- The outermost C-LDPE layers serve as two spatially offset electrodes on the fiber surface, thus greatly simplifying connectorization to our fibers.
- Owing to the thermal fiber drawing process, the dimensions of piezoelectric fibers can be as small as hundreds of microns, which enables their applications inside small tubes, such as blood vessels.
- Advantages of the piezoelectric fibers: low cost, high flexibility, good durability, and possibility of mass production.


Thank you!
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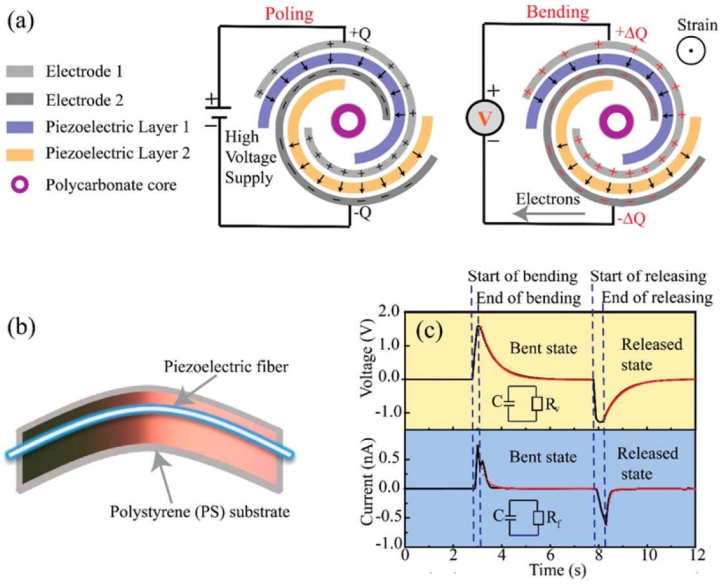
MRS meeting
April 18th

Charge separation mechanism



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