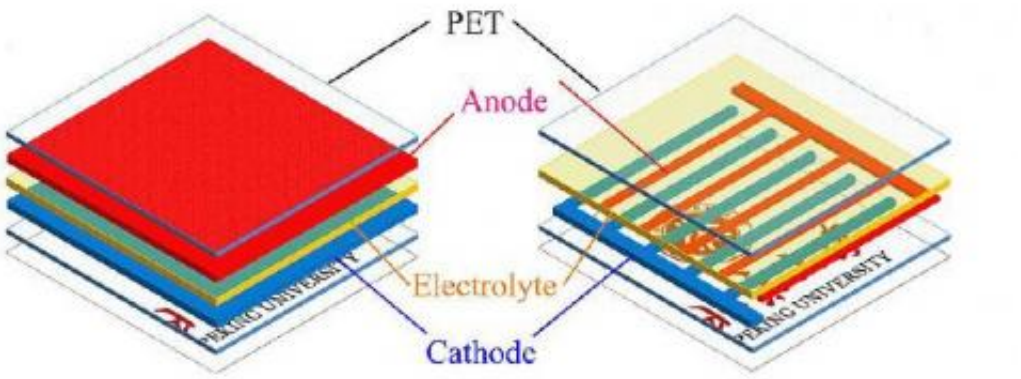
Flexible, semitransparent power source made with novel comb-teeth structure

March 12 2013, by Lisa Zyga



(Left) In the sandwich structure, the two electrodes occupy different layers and face each other. (Right) In the new comb-teeth structure, the two electrodes are integrated in the same plane. The empty space in between them allows for the structure to be flexible and semitransparent. Credit: Heng Lit, et al. ©2013 American Chemical Society

(Phys.org) —Most batteries, supercapacitors, and other energy storage devices are based on a sandwich structure, where two electrodes face each other and the charge flows between them. However, when these structures are folded or bent, the electrodes can easily fracture or the device can short-circuit if the electrodes come in direct contact. In a new study, researchers have come up with a new design for energy storage devices that is both flexible and semitransparent, in which the electrodes are fabricated on the same two-dimensional plane in a novel comb-teeth

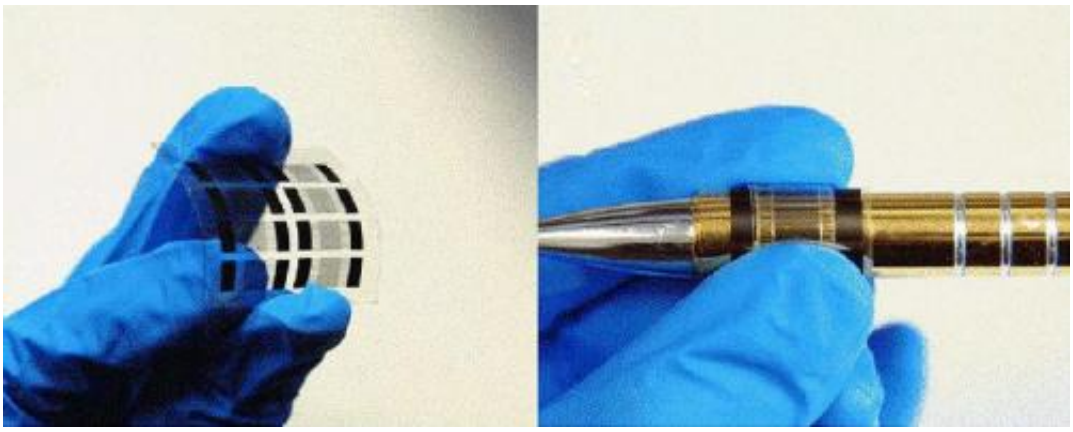
structure.

The researchers, Heng Li, et al., from the School of Physics at Peking University in China, have published their paper on the new structure for flexible and semitransparent electrochemical devices in a recent issue of Nano Letters.

As the researchers explain, the key to achieving the device's flexibility and semitransparency is the electrode comb-teeth pattern. The researchers demonstrated that the new structures can withstand many cycles of bending and rebending—and even be wrapped around a pen—while retaining nearly all of their good performance. The structures don't require spacers like those used by some sandwich-structure devices to prevent short circuiting. Instead, the new structures can be easily bent because there is natural empty space between two neighboring comb-tooth areas.

The design also lends itself to semitransparency because the sizes of the electrode comb-teeth are less than 100 μm, which is the resolution limit of the naked eye. Using photolithography, the researchers could fabricate comb -teeth with widths of 40-60 μm, allowing for good light penetration.

Although other transparent, flexible energy storage devices have been previously demonstrated, these designs generally require complex and expensive processes and are not universal to other energy device systems. In contrast, the new comb-teeth structures can be fabricated with simple methods and can be integrated with other electronic systems.



Solar cells made with the electrode comb-teeth structure show good semitransparency and flexibility, as demonstrated by being wrapped around a 9-mm-diameter pen. Credit: Heng Lit, et al. ©2013 American Chemical Society

"In recent years, flexible electronics have become a hotspot and there has been an explosion of originalities and ideas in the area," coauthor Dapeng Yu at Peking University told *Phys.org*. He explained that the idea for the design stems from a study that he and some of the other authors published last year on solar cells made with wire electrodes.

"The electrochemical energy devices (they can be understood as batteries or cells) composed of two fibers (one is anode, the other is cathode) are highly bendable," Yu said. "We were inspired by the idea, and tried to integrate the fiber-like electrodes together to fabricate a planar device.

As we know, there are some similar designs in this area. For instance, the interdigital structure is applied to supercapacitors, but they are all fabricated on rigid and opaque substrates like silicon. Therefore, they cannot realize device transparency and flexibility."

Here, the researchers demonstrated the new comb-teeth structure by fabricating dye-sensitized solar cells and supercapacitors based on the

new design. The flexible, semitransparent solar cells could one day have applications in smart windows, building-integrated photovoltaics, and integrated photovoltaic chargers for portable electronics. The supercapacitors could also have a variety of applications, including for next-generation all-in-one transparent and wearable electronic systems.

In addition to dye-sensitized solar cells and supercapacitors, the comb-teeth design could also be extended to other electrochemical systems such as alkaline batteries, quantum dot solar cells, and other energy storage and generation devices.

"Theoretically, the comb-teeth structure can be applied to almost all kinds of electrochemical devices," coauthor Qing Zhao at Peking University said. "However, the fabrication process must be redesigned for individual electrochemical materials. And we plan to develop more kinds of flexible and semitransparent batteries or cells using the planar structure design. On the other hand, the efficiency of these flexible and transparent devices is a little lower than that of traditional devices now, and we want to improve their performance in the future."

More information: Heng Li, et al. "Novel Planar-Structure Electrochemical Devices for Highly Flexible Semitransparent Power Generation/Storage Sources." *Nano Letters*. DOI: 10.1021/nl4000079