Ultra-flexible battery's performance rises to meet demands of wearable electronics

November 18 2013, by Lisa Zyga

The wearable battery is embedded in the sweatshirt and in a watch strap. The battery in the watch strap is shown powering 6 LEDs. Both batteries are made of unconventional battery materials that are highly suitable for flexibility. Credit: Yong-Hee Lee, et al.

(Phys.org) —While there has been much research lately on the development of flexible electronic devices that can be integrated into clothes, glasses, watches, and even skin, the limiting factor of this

technology is the battery. Although flexible batteries made of carbon nanotubes and graphene have recently been developed, they still face hurdles due to their high resistance and scalability issues.

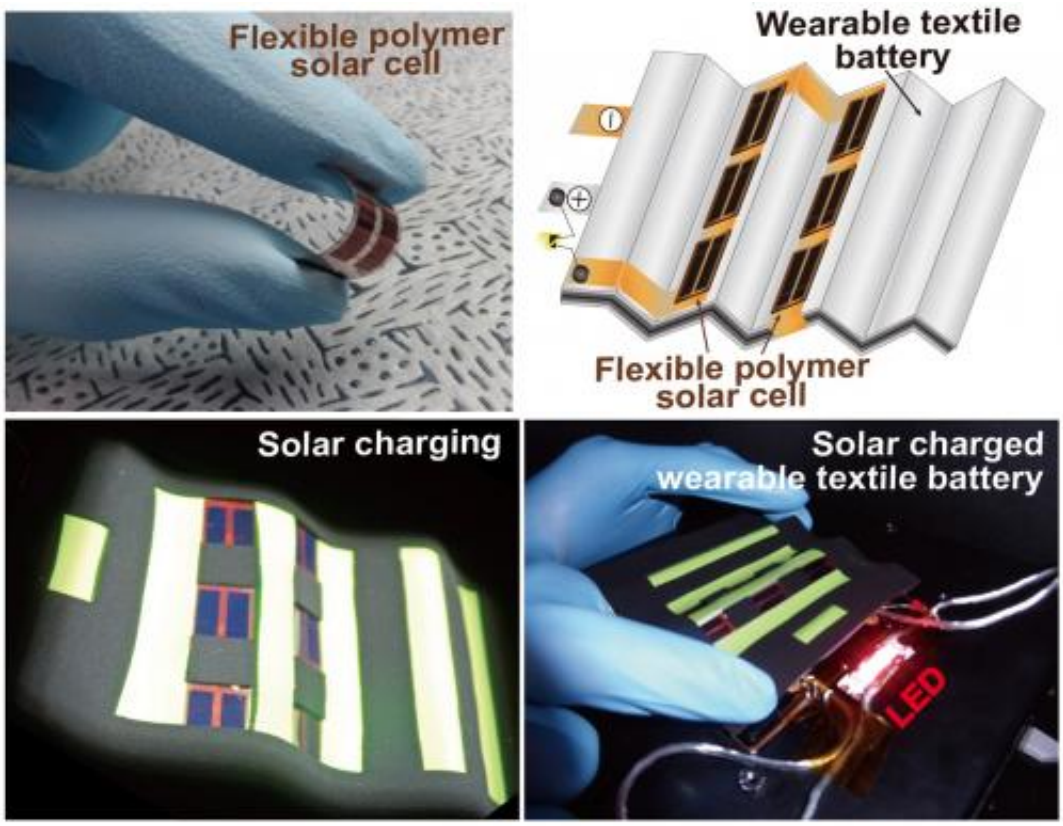
Now in a new study, researchers have completely overhauled the key components of a typical battery by using new materials that provide superior performance under extreme folding conditions compared to flexible rechargeable batteries made from carbon nanomaterials.

Ultimately, such a textile battery could be either attached onto clothes or embedded between the woven layers of the clothing fabric. It would supply the power for wearable electronic devices that fulfill the functions of today's smart phones, from watching videos to taking photos to using social media.

The researchers, led by Taek-Soo Kim, Jung-Yong Lee, and Jang Wook Choi at the KAIST Institute NanoCentury at the Korea Advanced Institute of Science and Technology (KAIST) in Daejeon, South Korea, have published their paper on the new wearable battery in a recent issue of *Nano Letters*.

Just as the limiting factor of flexible electronics is the battery, the limiting factors of the flexible batteries are the electrodes, current collector, and other key battery components that are traditionally made of rigid materials.

Instead of using carbon nanomaterials for these key components, the researchers here investigated a wide range of unconventional battery material candidates. They ultimately settled on using polyester yarn as the textile substrate, which they coated with nickel as the current collector. The nickel coating was then coated with polyurethane to form the electrodes, along with the binder and separator, which support the electrodes.



Flexible solar cells can be integrated into the textile battery and used to recharge the battery while it's being worn, eliminating the need to wire the battery to a power outlet. Credit: Yong-Hee Lee, et al.

"The greatest significance of our work is that the wearing capability of lithium ion batteries becomes facilitated by building the battery assemblies from the same material as the mother clothes, textile," Choi told *Phys.org*. "Reshaping the battery system by engaging the materials of the target applications to which the batteries are attached is a key idea in the current work."

Together, these materials create a battery that has both a high performance and excellent flexibility. Performance-wise, the nickel

coating gives the battery a very small resistance that is several orders of magnitude smaller than that of carbon nanomaterials, and similar to that of the aluminum used in conventional (inflexible) batteries.

The researchers demonstrated the battery's good performance under folding conditions by building a home-made folding instrument that folds the battery every 1.5 cm at a tightly compressed folding radius of 0.65 mm—a degree of folding that is more extreme than that used to test most other textile batteries. Nevertheless, the new battery shows that, after 5500 deep folding-unfolding cycles, it retains 91.8% of its original capacity. (The capacity of this battery is 13 mAh, but can be improved to 85 mAh using a different method of weaving the polyester yarn, and the researchers expect further improvements in the future.)

In addition to these attractive properties, the researchers also demonstrated that flexible polymer solar cells can be integrated into the textile battery and used to recharge the battery while it's being worn, eliminating the need to wire the battery (and your shirt or watch, etc.) to a power outlet each time it needs to be recharged. The researchers write that the solar charging system is decent, and demonstrate that a fully solar-charged textile battery can light up nine LEDs, each of which has a power consumption of 0.042 W.

Overall, the new textile battery shows that the energy storage component of wearable electronics is catching up with other the components, bringing wearable electronics a step closer to reality.

"We need further tuning of battery properties in several aspects (energy density, operating voltage, etc.) depending on target applications," Choi said. "Communication with industry dealing with end applications is currently going along this direction."

More information: Yong-Hee Lee, et al. "Wearable Textile Battery

Rechargeable by Solar Energy." *Nano Letters*. DOI: 10.1021/nl403860k