In Vivo
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Making A Mark In Materials Science

An Interview With In Vivo Rising Leader Jun Chen

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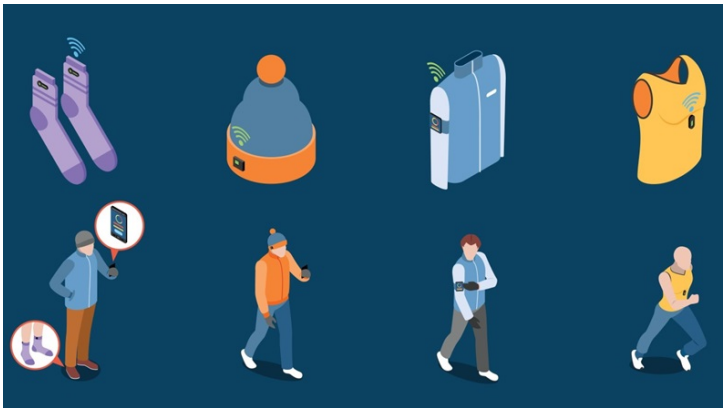
Executive Summary

As the leader of UCLA's Wearable Bioelectronics Research Group, Jun Chen, assistant professor and one of In Vivo's 2021 Rising Leaders, is deploying sensors, energy-hosting tiles, smart textiles and other technologies to tackle big problems, from health care to sustainable energy.



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The uses and potential applications of digital monitoring technologies, in service of better human health, are multiplying. Clinical trial investigators understand the value of objective measures when it comes to assessing patient outcomes and are increasingly using wearable sensors and smart devices to gather data. Chronic disease management and physical therapy, to cite just two examples, have benefited enormously from sensor

technology, which can alert caregivers when an intervention is needed, or demonstrate proper stretching techniques for people recovering from injuries at home.

The Internet of Things (IoT) is growing, as more and more devices come online: from supply chains to surgeries, distributed electronics are remaking old processes and infrastructures, while reducing human error and exposing correlations in complex systems, which leads to new insights. On one hand, health care has the potential to move from its current reactive and disease-centric system to a personalized, predictive, preventative and participatory model, with a focus on disease prevention and health promotion. As the world marches into the era of IoT and 5G wireless, technological innovation can help the industry provide a more individually tailored approach to healthcare, with better health outcomes, higher quality care and lower costs.

On the other hand, as the world moves toward an omnipresent congregation of connected digital devices – and tech companies and conference speakers hype the latest biosensor applications – one important component is rarely discussed: what is the source of power for this brave new world? “Our world is marching into the era of the IoT, and in 10 or 20 years, almost everything around us will interact with the internet,” said Chen. “All of those devices will need a pervasive power supply.”

A major focus area of UCLA’s Wearable Bioelectronics Research Group, where Chen is principal investigator, is on developing smart textiles for personalized healthcare and sustainable wearable power delivery. The textile forms developed in the lab endow wearable bioelectronics with biocompatible, biodegradable, even bioabsorbable features, and are also comfortable for people to wear. Personalized healthcare and sustainable energy are guiding principles across a broad array of the lab’s experiments with nanotechnology, machine learning and materials science. The necessity for sustainable energy and personalized healthcare has led Chen’s group to new inventions, such as energy hosting textiles and a wearable glove for sign-to-speech translation. Said Chen: "I really want to use my invented technology to change the world, or at least improve our way or living."

JUN CHEN, ASSISTANT PROFESSOR, UCLA

Discovering The Magic Of Nano

Chen grew up in Wuhan, the largest city in central China and the capital of Hubei province, and took an interest in the natural world at an early age. He received a bachelor’s degree from Huazhong University of Science and Technology (HUST) in Wuhan. As an undergraduate, Chen was exhilarated to learn that certain properties of nature change dramatically at nanoscale, compared with the same properties in a bulk state or scale. “To me, that was very magical,” said Chen. Materials or objects with key identifying properties, such as melting point, chemical reactivity and electrical conductivity, for example, can be different at nanoscale. “I found that [discrepancy] to be very interesting, with huge potential.”

After graduating from HUST, Chen moved to the US in 2009, and enrolled in the materials science engineering program at the Georgia Institute of Technology, or Georgia Tech, in Atlanta in 2012. He received his PhD in 2016, under the tutelage of professor Zhong Lin Wang, a 2019 Albert Einstein World Award of Science winner, and the leader of Georgia Tech’s Nanoscience Research Group.

After receiving his PhD, Chen moved to Stanford University as a postdoctoral research fellow, studying with Yi Cui, a Stanford professor in the department of materials science and engineering. During his time at Stanford, Chen worked on nanoporous polyethylene (nanoPE) microfibers, showing in a co-authored paper published in *Nature Sustainability* that nanoPE microfibers, compared with commercial cotton fabrics, have a strong cooling power capable of lowering human skin temperature by 2.3 degrees Celsius. This works because cotton absorbs

infrared radiation (IR) wavelengths from seven to 14 micrometers; humans at normal body temperature radiate at wavelengths around 9.5 micrometers, so human heat does not easily escape. Polyethylene, a thermoplastic polymer, on the other hand, is transparent to those IR wavelengths, which means they can irradiate out without fabric absorption, or trapped heat. "Instead of setting your air conditioning to 22 degrees Celsius, you can wear this fabric and set the air conditioning to 25 degrees," said Chen. "Those three degrees represent a big temperature difference and could save a lot of energy used for cooling."

Wearable Bioelectronics and Smart Textiles

In 2019, Chen joined UCLA Bioengineering Department as a tenure track assistant professor, and started up his lab. Chen's research leans in various directions – from using textiles as a soft power bank to the invention of a machine learning-enabled glove that can translate sign language to audible speech, in real-time. Chen has already filed 14 US patents, published two books and 160 journal articles to date. His works have been selected as research highlights by the journals *Nature* and *Science*, and have been cited widely in mainstream media outlets. Chen also serves as associate editor of the journal *Biosensors and Bioelectronics*.

'I just want to keep discovering something new.'

The research projects and potential applications of Chen's research are too numerous to list, but two more recent developments are especially noteworthy. The first is a "photo-rechargeable fabric" or smart textile that captures solar energy to power clothing laced with bioelectronics, which can be used to monitor vital signs and other bodily processes.

According to a paper co-authored by Chen and published in Matter on 6 May, 2020, the group's photo-rechargeable fabrics are capable of delivering constant electric power for 10 minutes at 0.1 milliampere after one minute under standard sun conditions. The electricity generated could be used to power "on-body sensor networks" interwoven in the fabric, for use in personalized health care. This fabric, too, compares favorably with cotton, in terms of look, feel and durability, and holds stored energy for over 60 days without voltage loss, according to the paper. The polymer fibres are also low-cost, a theme that runs across many of Chen's projects. Chen's contribution to the field led to a review paper in the journal *Chemical Reviews*, titled "Smart Textiles for Electricity Generation." The review discussed energy harvesting textiles as sustainable power sources for wearable bioelectronics, in the era of IoT.

A second project, one that Chen hopes will be available commercially in five to 10 years, is a "sign-to-speech" translation device, which translates sign language to audible speech in real-time using a glove packed with sensors, and a mobile phone app. "You just wear a pair of gloves and then perform standard American Sign Language," explained Chen. The signing is then displayed as a voice using a mobile application. Using a custom machine learning algorithm, sign language gestures are turned into letters, numbers and words; the system analyzed 660 sign language hand gesture recognition patterns and demonstrated a recognition rate over 98%, and a recognition time of less than one second, according to a paper published by *Nature Electronics* last June.

Chen said he gets a lot of emails from parents who tell him about their children's hearing disorders, and their desire to communicate with them more effectively. Chen is passionate about personalized healthcare, and was invited to give an iCANX lecture titled "Smart Textiles for Personalized Healthcare" on 4 December, 2020, part of the American Chemical Society (ACS) Nano Rising Stars Lectureship Award. Like Chen's smart textiles work, the translation glove is also designed with lightweight – and inexpensive – stretchable polymers. The electronic

sensors are also inexpensive. Access and sustainability emerge as pillars of the research Chen pursues, which he hopes to commercialize in the future.

Campus Life And Future Plans

For now, Chen is content working toward a tenured position as a professor. He enjoys working with students, having a somewhat flexible schedule, and the fact that making new discoveries is in his job description: "I just want to keep discovering something new," he said. Working with a younger generation of researchers was inspiring, he said, and being able to share experiences and knowledge with students "is a good part of being a professor."

In selecting students to join his lab, Chen said he looked for strong character: integrity, honesty and courage, and a willingness to work hard. "Being persistent is very important, especially when you're doing experiments, when you're doing something new. Nobody did it before, so it is very easy to get frustrated," said Chen. "Working hard and being persistent may be what I look for the most in students who want to join my lab."

Beyond professorship, Chen wants to become a well-established scholar, and to open up new fields to further develop his research identity. Sustainable energy and personalized health care are two areas he hopes to impact – especially with the use of smart textiles, since they have the potential to improve daily living, without any additional burden, said Chen. He hopes to bring those technologies forward, and make them available for public use.

In 10 or 20 years, it might be time to make a play for the industry, said Chen. "I want to start some companies to commercialize my invented technologies…that's the second stage of life. In order to do that, I need to become a well-established scholar with a strong research identity." Chen appears to have several pathways available to make that wish a reality.