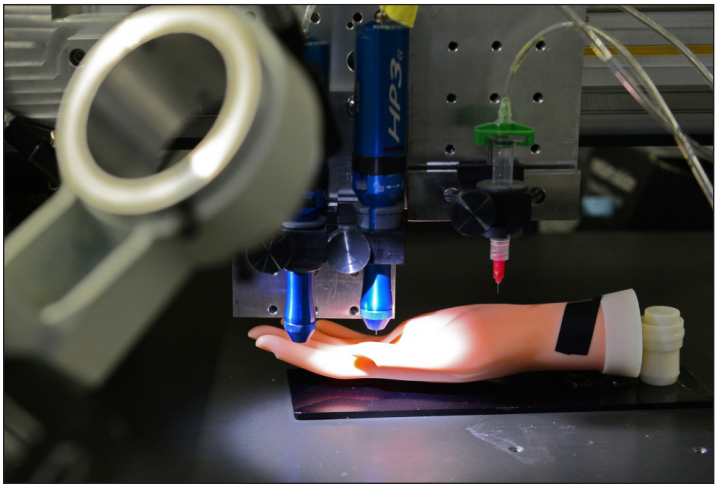
THE SILVER INSTITUTE

June 2017

Silver News

Silver-Silicone 'Fingertips' Allow Greater Touch

May Help Surgeons, Burn Victims, Bomb Experts Increase Skin Sensitivity



SHUANG-ZHUANG GUO AND MICHAEL MCALPINE

Click the image to watch how a 3-D printer makes a pressure sensor on an artificial hand.

Engineers at the University of Minnesota have developed a 3-D printed sensory device that can be printed on fingertips to increase their touch sensitivity. This could allow surgeons to have greater control over surgical procedures, offer bomb disposal experts increased 'feel' to better disarm explosive devices and even give burn victims back their touch sensitivity.

"This stretchable electronic fabric we developed has many practical uses," Michael McAlpine, Ph.D., a University of Minnesota mechanical engineering associate professor and lead researcher on the study, said in a public statement. "Putting this type of 'bionic skin' on surgical robots would give surgeons the ability to actually feel during minimally invasive surgeries, which would make surgery easier instead of just using cameras like they do now. These sensors could also make it easier for other robots to walk and interact with their environment."

The device, which is mainly composed of layers of stretchy, silver-silicone gel, has already been tested on artificial fingers and can be produced under everyday conditions because a special laboratory or 'clean room' is not necessary. When the silicone containing tiny silver particles is compressed, as when touch occurs, it conducts electricity. The sensor 'knows' how hard the finger is touching by how much electricity is flowing.

Not only could these sensors be printed on fingertips but also on tools such as those used in surgery which would give doctors 'extended bionic fingertips,' says McAlpine.

For people who have lost their sense of touch altogether, the sensors could provide sensitivity by connecting the device to a neural feedback system which would amplify the touch sensation.

More work needs to be done, McAlpine notes in his study *3D Printed Stretchable Tactile Sensors published by the journal Advanced Materials*. For example, how to distinguish between touching done on purpose and the natural, almost imperceptible twitches of the human hand.

McAlpine is widely known for his 2013 work in which he announced that he had produced a bionic ear.

Silver-Paste on Rubber Allows Wire to Stretch Five Times Its Length

Holds Promise for Improved Wearables, Robots

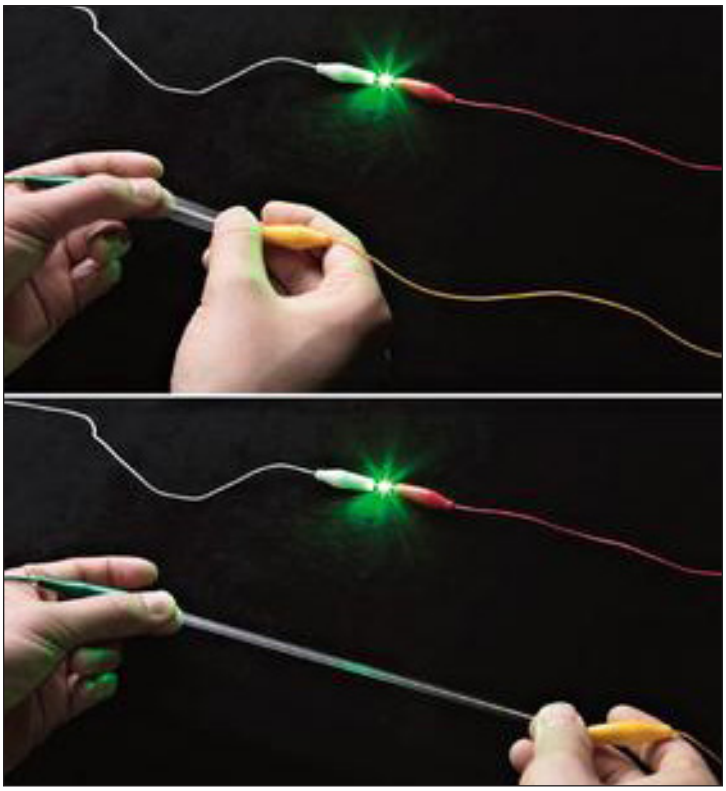
What if an electrical wire could stretch five times its original length? Such a wire could increase the versatility and usability of wearables and help robots move more like people.

Such a wire is already here and silver makes it possible.

University of Tokyo researchers have developed a mixture of silver powder, fluorine-containing rubber, fluorosurfactants (organic compounds that contain the carbon–fluorine atomic bond) and organic solvents. This paste-like brew can be printed on rubber sheets and textiles making it highly flexible and able to stretch without breaking the electrical connection allowed by the silver powder. Silver is the world's best electrical conductor, and the researchers, using an electron microscope, found that the silver powder (having mixed with air to become silver oxide) formed flakes 8 nanometers long that were evenly distributed. Even when twisted or stretched, the substance allowed electricity to flow through it.

The work, done in conjunction with the Japan Science and Technology Agency and published online by the British scientific journal *Nature Materials*, will find applications in sportswear wearables that collect biological data about wearers such as blood pressure and heart rate and transmit this information through a smartphone or other device. This helps athletes to improve their performance. Wearables are also used by people with medical issues to keep track of their physical health.

The researchers will now focus on increasing the wire's toughness and durability.



UNIVERSITY OF TOKYO

These wires can maintain conductivity even when stretched to five times their original length.

Silver Moves Data Closer to Light Speed

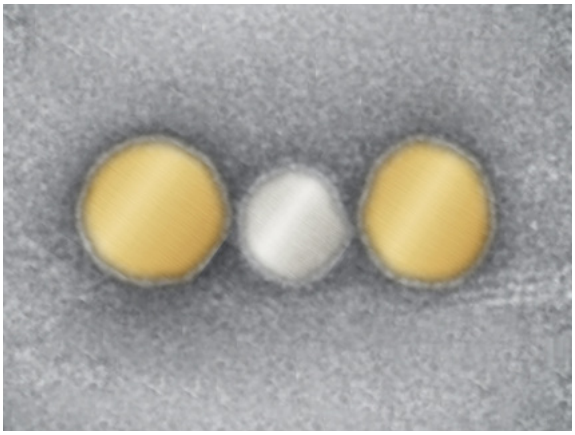
Light travels much faster than electricity so when scientists want the fastest-known computing speeds, they send information through fiber optic wires. There's a glitch, however.

As wires becomes microscopically thin, the wavelength of the light comes close to the diameter of the optic fibers and the light has trouble oscillating (producing waves) which means it can't carry data. This problem can be mitigated by adding gold nanoparticles, which excite the light particles and allow oscillation. But there's another problem. Although the gold allows information to travel at about 10 percent of the speed of light, it also produces heat almost as high as transistors.

This is where silver enters the picture.

Researchers at Ludwig-Maximilians-Universitaet (LMU) in Munich have shown that by placing one gold nanoparticle at each end of a 100 nanometer wire with a silver nanoparticle in the middle, the energy consumption significantly drops with no loss of speed. The silver acts as a kind of a bridge between the gold particles.

Tim Liedl, Ph.D., Professor of Physics at LMU, and colleagues from Ohio University, published an article in the journal *Nature Physics*, in which they describe their findings and how energy flows 'around' the silver particles. "Transport is mediated via the coupling of the electromagnetic fields around the so-called hot spots which are created between each of the two gold particles and the silver particle," explains Liedl in a prepared statement. "This allows the energy to be transported with almost no loss, and on a femtosecond (one quadrillionth of a second) time scale."



LIEDL/HOHMANN (NIM)

The silver serves as an intermediary between the gold particles without dissipating energy.

Global Silver Mine Production Drops in 2016 for First Time in 14 Years: *World Silver Survey 2017*

Global silver mine production in 2016 recorded its first decline since 2002. When added to declining silver scrap supply, which posted its lowest level since 1996, and a contraction in producer hedging, total silver supply decreased by 32.6 million ounces in 2016.

New highs were recorded for silver's growing use in the photovoltaic and ethylene oxide sectors, which are significant industrial applications for silver. These findings, and other key components of the silver market, are discussed in *World Silver Survey 2017* released May 11 by the Silver Institute and produced on its behalf by the GFMS Team at Thomson Reuters (GFMS).

Other highlights from the *World Silver Survey 2017* include:

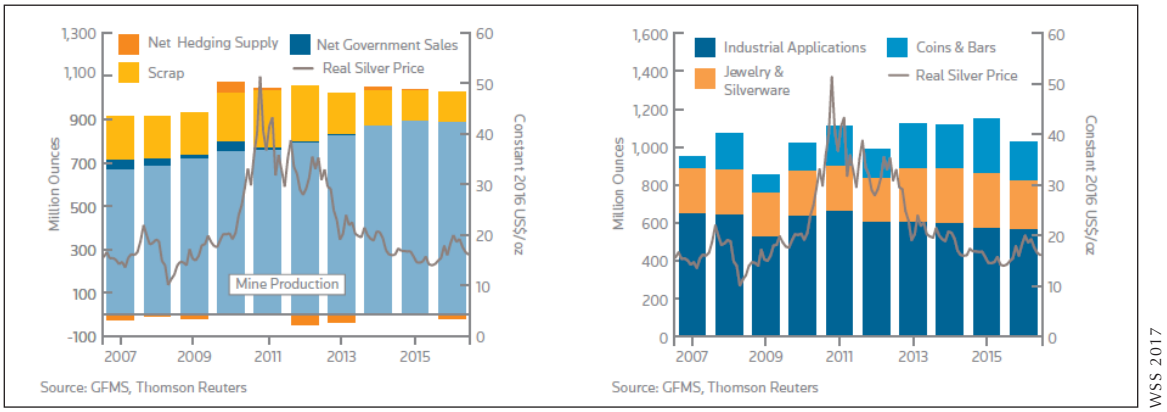
Supply: The total silver mined in 2016 dropped by 0.6 percent to 885.8 million ounces. A large proportion of the drop was attributable to the lower output from the lead/zinc and gold sectors. Mexico was again the world's largest silver producing country, followed by Peru, China, Chile and Russia.

Silver scrap supply fell to 139.7 million ounces in 2016, despite higher silver prices. The contraction was largely driven by lower Asian flows, due in part to lower industrial fabrication volumes.

Demand: Total silver physical demand fell by 11 percent in 2016 due to weaker offtake for jewelry, silverware and retail investment. Industrial applications, the largest component of physical silver demand, accounted for 55 percent of total physical silver demand last year, and was marginally lower by just 1 percent. That said, the United States experienced another healthy rise in this sector, the second in succession, jumping 9 percent over 2015 volumes, while Japan posted a 6 percent rise in silver industrial fabrication. Elsewhere, demand was dragged lower by softer economic conditions with declines in China, Africa, South America and Europe.

Silver demand for photovoltaic applications posted an impressive 34 percent rise. This growth was the strongest since 2010 and driven by a 49 percent increase in global solar panel installations. Silver's use in the ethylene oxide industry grew by 6 percent. Silver's use in electrical and electronic applications, as well as its use in brazing alloys, fell last year due to a sluggish global economy.

To download a free PDF copy of the report visit the Silver Institute website.



Silver Plus Graphene May Lead to Stronger Weapons Against Bacteria

Silver ions kill bacteria by attacking and disrupting the microbe's cell wall structure leaving it weakened and unable to reproduce. But what if this germ-destroying property could be made even more efficient?

Indian researchers are experimenting with a derivate of graphene, which by itself has the ability to damage cell membranes with its atomic-sized sharp edges. (Graphene is a single atom thick sheet of carbon atoms structured in a lattice. The material is about 200 times stronger than the strongest steel, conducts heat and electricity and is nearly transparent.) By combining the graphene derivate and silver nanoparticles -- producing a nanocomposite -- scientists believe that the graphene derivate cuts into the cell membrane while silver nanoparticles disrupt the bacteria's respiratory and energy generating pathways. The cumulative effect is enhanced efficacy and a higher activity rate as compared to the two components studied individually, the researchers say.

The tests were conducted with laboratory-grown bacteria by a team from Anna University, Chennai, India, along with Australian researchers from Queensland University of Technology, Commonwealth Scientific and Industrial Research Organisation, Queensland University of Technology and University of Southern Australia. The nanocomposite was effective against multi-drug resistant variants of *E.coli*, *P.mirabilis* and *S.aureus* commonly found in lungs, skin, urinary tracts and intestines. The work was published in the journal Scientific Reports.

Four-in-One Catalyst Uses Silver to Get the Job Done

Catalysts are substances that help speed up chemical reactions, usually for industrial manufacturing processes. While silver is often used as a catalyst, especially to produce ethylene oxide, a widely-used industrial compound, some scientists are using silver to produce a catalyst that helps spur not just one chemical process but four – in sequence.

Brown University researchers believe that the new catalyst could be very useful in producing pharmaceuticals, because they often require a chain of chemical reactions requiring catalysts. "It normally takes multiple catalysts to carry out all of the steps of this reaction," said Chao Yu, a post-doctoral researcher at Brown who co-led the work. In a prepared statement, he added: "We found a single nanocatalyst that can perform this multistep reaction by itself."

Professor Christopher Seto, a co-author with Prof. Shouheng Sun of the research paper detailing their finding, believes that using a 4-in-1 catalyst instead of four steps, each using a different catalyst, is environmentally beneficial. "If you're running four different reactions separately, then you've got four different steps that require solvents and starting materials, and they each leave behind waste contaminated with byproducts from the reaction," Seto said. "But if you can do it all in one pot, you can use less solvent and reduce waste."

The catalyst is composed of silver-palladium nanoparticles placed on the surface of nanorods made of oxygen-tungsten-oxide (with a few of its oxygen atoms missing). The team found that they could catalyze a series of reactions needed to convert common precursor materials like formic acid, nitrobenzene and an aldehyde into a benzoxazole, which can be used to make antibacterials, antifungals and NSAID painkillers. The catalyst could also create quinazoline, a chemical used in anti-cancer drugs.

The end products were made with little loss of the starting materials and at lower temperatures than many chemical reactions require. "The temperature we used to synthesize this product is around 80 degrees Celsius," said graduate student Xuefeng Guo, who also worked on the project. "Normally the reaction happens around 130 degrees and you need to run the reaction for one or two days. But we can get a similar yield at 80 degrees in eight hours."

They realized another benefit of the new catalyst. It could be used up to five times without any diminishing of the end product. Although catalysts are not consumed by the reactions they help to occur, they do lose their ability to spur the process by becoming deactivated or destroyed by secondary processes.

The work was supported in part by the U.S. Army Research Laboratory and the U.S. Army Research Office and was published in the Journal of the American Chemical Society.

Can Crabs and Silver Kill Dangerous Mosquitoes?

An unlikely mixture of crushed crab shells and silver particles may be a non-toxic way to kill mosquitoes that carry diseases such as malaria, yellow fever, dengue fever, Zika and West Nile viruses without resorting to environmentally harmful or dangerous chemicals, according to a team from National Taiwan Ocean University.

Chitosan, a derivative of chitin, which is found in the exoskeletons of arthropods such as crabs, lobsters and shrimps, among other places in nature, has properties similar to the protein keratin which is the main structural material in the outer layer of human skin. Chitosan is often used to produce compounds that help plants fight off diseases, as a fertilizer, as a food additive to thicken and keep foods from deteriorating and in drugs that help heal wounds.

To produce the mosquito killing substance, researchers crushed the shells of crabs that inhabit ocean areas near hydrothermal vents and mixed them with silver nitrate solution. They sprayed the solution around water reservoirs in India and observed that the mixture killed mosquito larva, the worm-like creatures that come from the egg and are the first stage of insect life, as well as the second stage of life known as the pupa.

The researchers tested the solution on fish and found that it did not harm them or any other underwater animals. They also found an unexpected benefit; the chitosan silver-nitrate mixture increased the appetite of fish that feed on mosquito larvae. Still another benefit is that the solution inhibited the growth of some water-borne pathogens such as *Bacillus subtilis*, *Escherichia coli*, *Klebsiella pneumoniae* and *Proteus vulgaris*.

Authors of the study, published in the journal *Hydrobiologia*, suggest that the nanosized particles pierce the insect's cuticles, travel into cells and interfere with the life-cycle process.

The authors, led by Professor Kadarkarai Murugan of Bharathiar University, Coimbatore, India, concluded: "This research highlighted that chitosan-fabricated AgNP (silver nanoparticles) are easy to produce, stable over time, and can be employed at low dosages to strongly reduce populations of the malaria vector *A. sundaicus* without detrimental effects on the predation of natural mosquito enemies, such as goldfish. It also effectively inhibits important bacterial pathogens of public health relevance."

Hydrothermal vent crabs living by heat-producing fissures in the ocean floor near volcanically active places may hold promise in the fight against mosquitoes that carry diseases.

Upcoming Events

Silver Industrial Conference

Registration is open for the 3rd Silver Industrial Conference, which will be held in Washington, D.C. on October 26-27.

The theme of this year's Conference is: "Silver's Evolving Role in Science and Technology."

Silver's use as a chemical catalyst and as a growing component in photovoltaics and the automotive industry will be examined. Emerging uses in areas such as advanced electronics and silver's role in health care will also be discussed.

The Conference program on October 27 will include a variety of presentations and will provide a unique opportunity to exchange viewpoints and experiences with other industry participants during the program and the accompanying networking events.

For more information on the conference, see this announcement from the Silver Institute: Silver Industrial Conference Press Release

To register for the conference, please click this link: Silver Industrial Conference Registration

Silver Industrial Conference attendees are offered discounted room rates of US$299 + taxes/night at the Embassy Suites Convention Center. To book your room, please go the Conference event registration site at: Embassy Suites Hotel Convention Center.

Speakers, panelists, and additional program details will be announced shortly.

We look forward to seeing you in October in Washington, D.C.

Larry Kahaner
Editor

www.silverinstitute.org
@SilverInstitute on Twitter

THE SILVERINSTITUTE
1400 I Street, NW, Suite 550
Washington, DC 20005
T 202.835 0185
F 202.835 0155