THE SILVERINSTITUTE

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Silver News

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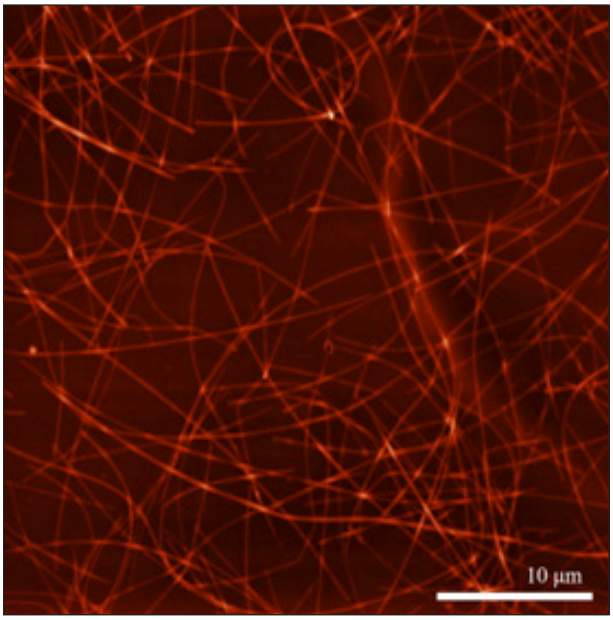
Silver and Next Generation Touch Screens

Trevor Keel, PhD. Technical Consultant to The Silver Institute



MATTHEW LARGE, UNIVERSITY OF SURREY, U.K.

An Atomic Force Microscope (AFM) image of an array of silver nanowires. The scale bar of 10µm equals 1/100 of a millimeter.

In 2016, touch screens are ubiquitous. The idea of a smartphone or tablet not equipped with a touch-sensitive, 'swipeable' screen is almost unthinkable. While the technology itself is well-established and reliable, there are a couple of issues that may limit future iterations of the much-used touch screen.

The most common touch screens operate via a capacitive system, which relies on a layer of material capable of storing electrical charge coated onto the glass panel. When the glass is touched, the charge within the material changes and this is sensed by software, which pinpoints exactly where the touch occurred, and responds accordingly. The material most commonly used as the coating is Indium Tin Oxide (ITO) because of two key properties – its electrical conductivity and optical transparency.

However, ITO does have limitations. Indium is relatively expensive and has some high supply risk elements, which makes for a costly and somewhat uncertain component for manufacturers. Additionally, while ITO performs well on a rigid glass screen, it is relatively brittle and is known to have performance issues on flexible displays, which is an area predicted to see significant growth in the coming years within the electronics industry.

Silver has long been recognized as a potential replacement for ITO. It has excellent electrical conductivity and, if manufactured as nanoparticles or nanowires, good optical transparency. It also has advantages from a manufacturing perspective, such as room temperature processing. Indeed, the combination of these properties has already seen the technology gain traction in the electronics sector. Large consumer electronics companies such as LG, HP and Lenovo are already using silver nanowires in some of their products.

But, what next? One of the strengths of silver nanowire coatings lies within the performance they offer on flexible substrates. (See *New Technology for Easier Fabrication of Touch Panel Sensors Uses Nanosilver Ink*, in this issue.) According to Michael Chung, CEO of Korean touch screen manufacturer TPK, his company has generated 200 patents focused on replacing ITO with alternative materials, primarily silver nanowires. There is a clear expectation within the industry that the next generation of devices will demand flexibility, so technologies are being developed to enable this. A recent report in the Nature Journal *Scientific Reports* by U.K. researchers

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compared alternatives to ITO, including graphene, carbon nanotubes and various metallic nanowires. According to the authors, silver nanowire films emerged as the strongest competitor, thanks to light transmittances and conductivity that can match and readily exceed those of ITO. In addition to the strong performance characteristics, the fabrication process itself was less energy-intensive meaning the next generation of touch screens and displays may be 'greener' than their predecessors.

Matthew Large, a research fellow at the University of Surrey and lead author of the research, said: "Films of silver nanowires have great potential for applications in displays technology. Our work has demonstrated that the important functional properties of these films exceed those of standard materials used in displays and touch sensors. However, unlike traditional materials the behavior of silver nanowire films changes when you want to make a device with very small features like LCD pixels in a smartphone display.

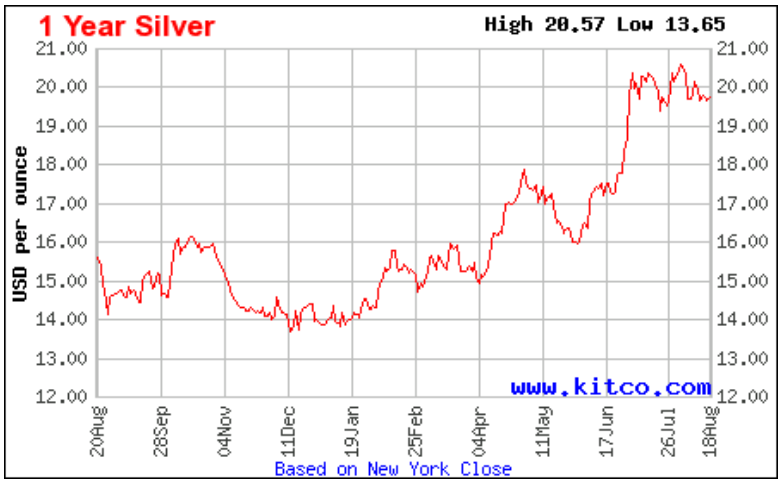
Silver Soars in 2016

Silver's price performance soared in the first half of 2016, fueled by increased investor interest in silver as a safe haven asset and as leveraged exposure to gold's price rally. In the period January 4 – August 5, silver's price increased 44 percent, based on the LBMA Silver Price, significantly outpacing all of the other precious metals.

Investors accumulated silver in the first six months of the year, including both the physical and paper markets. Exchange traded product holdings rose by 44.3 million ounces, or 7.2%, to a record high of 662.2 million ounces. Investors have also raised their net long positions in COMEX silver futures and options to a record high of 80,522 contracts as of July 5th. Net longs have been trending higher all year, starting from 6,282 contracts at the end of 2015.

Coming on the heels of record global silver coin demand in 2015, silver coin sales increased in the first quarter of 2016 by 29 percent globally, according to the GFMS Thomson Reuters Quarterly Coin Sales Survey. Regionally, North America has continued to be the bright spot in silver investment product demand. In the coin market, coin sales grew at double-digit paces in all the major regions (North America, Europe, Japan, Asia, Africa, & Other), as coin demand has remained elevated since the second half of last year.

For more information click here.



The silver price has risen 44 % in the period since January 4.

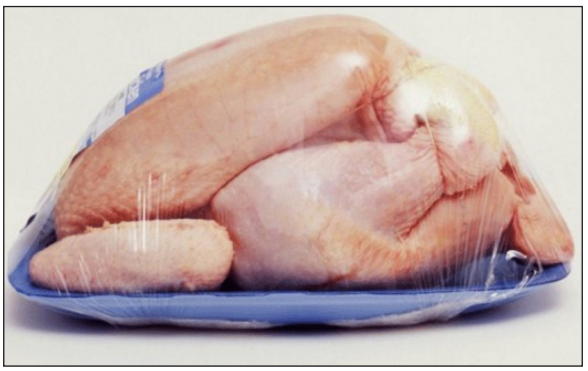
Silver Helps U.K. Poultry Packager Take Aim at Bacteria

Specialty U.K. packaging manufacturer Parkside has developed flexible packaging with a built-in silver-based antimicrobial to reduce bacteria growth on the outer packaging of fresh poultry. The protection is aimed especially at the deadly *campylobacter* bacteria, a widely-recognized challenge for the poultry packing industry's ongoing battle against cross-contamination.

According to officials of the U.K. Food Standards Agency, an independent government department, many consumers know that they should wash their hands after touching raw chicken, but recently-published research notes that over 70% of U.K. consumers are unaware that *campylobacter* is also present on the outside of chicken packaging, including cook-in-the-bag chickens. Moreover, other studies by the FSA show that 7% of chickens found on supermarket shelves are contaminated on the outside of the packaging, yet the agency found that 52% of consumers don't wash their hands after handling packaged chicken in supermarkets or pack chicken in a separate bag.

In a prepared statement, Paula Birch, sales director at Parkside, said: "The demand for ready-to-eat, fresh and easily prepared food is increasing. Initially the packaging of these foods was simply to provide protective and barrier functions. However, the growth of bacteria on packaged foodstuffs continues to cause problems regarding consumer food safety and of course, product quality. To deal with this issue, Parkside has designed and developed a range of flexible packaging solutions which incorporate antimicrobial technology to improve pack functionality."

Campylobacter is the most common cause of food poisoning in the UK and is an increasing concern for the entire food supply chain, she said. Preventing cross-contamination during preparation, processing, packing and distribution is key in reducing the risk to consumers. "The technology used by Parkside incorporates silver ions into coatings and is aimed specifically at the poultry category and other protein markets where *campylobacter* is a major issue," Birch added.



ADDMASTER

Poultry is prone to bacterial contamination on the outside of packaging.

London Metal Exchange and World Gold Council Announce Precious Metals Trading Products

The London Metal Exchange (LME) and the World Gold Council, and several financial institutions, plan to introduce a suite of exchange-traded and centrally-cleared precious metals products including silver.

LMEprecious, the umbrella name for the new products, will comprise spot, daily and monthly futures, options and calendar spread contracts for silver and gold. All trading will be centrally cleared on LME Clear, the LME's real-time clearing house, and leverage the London market's existing delivery infrastructure. The new product suite will complement the bilateral over-the-counter (OTC) market, offering market participants similar levels of execution flexibility, including the ability to bring bilaterally negotiated (phone-based) trades into clearing. Market participants will also benefit from tight on-exchange price discovery and a product model designed to maximize capital efficiencies, according to participants, which includes Goldman Sachs, ICBC Standard Bank, Morgan Stanley, Natixis, OSTC and Societe Generale. Banks participating in this initiative will act as liquidity providers for the precious contracts to ensure price discovery and establish market depth.

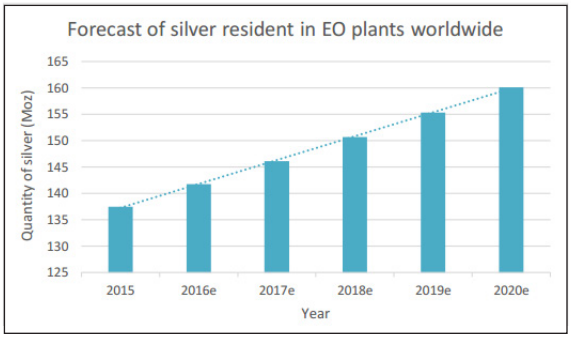
LMEprecious is targeting a launch in the first half of 2017, following testing and regulatory approvals.

Silver Catalysts: A Backgrounder

Catalysts are used in many industrial applications to speed along processes, such as the production of chemical compounds, and silver is often the catalyst of choice.

For example, Ethylene Oxide (EO) is one of the most important and commonly used chemicals and is the building block for a range of plastics including polyester, the textile used in both mainstream fashion and specialty clothing. EO is an ingredient in various molded plastic items such as insulating handles for stoves, key tops for computers, electrical control knobs, domestic appliance components and electrical connector housings. Silver catalysts make the efficient and economical production of EO possible because of the metal's unique properties.

In 2015, about 137.5 million ounces of silver resided in EO plants around the world, which was equivalent to more than half of the world's entire demand for silver jewelry. Moreover, 2015 saw a 103% increase in the amount of silver entering the world's EO plants compared with 2014. This number is expected to rise, with 160 million ounces forecast to reside in the world's EO plants by the year 2020, a 3.1% Compound Annual Growth Rate.



GFMS; THOMSON REUTERS

Forecast of silver resident in EO plants worldwide.

To learn more about why silver is so important to industrial processes industry read this catalyst backgrounder prepared by The Silver Institute.

No Socks, No Stink, No Problem

Although wearing shoes without socks is fashionable for the summer, it suffers from one major problem that most people won't discuss in public: Foot sweat can make shoes damp and smelly.

One company, Gekks, has produced shoe liners made from silver-based antimicrobial yarn. The owner of the company, brothers Justin and Christian Arquilla, created the liners not only to keep shoes odor free for non-sock wearers but also for increased comfort. The liners also have 'grips' that keep the liner from sliding around in the shoe.

The liners are 72% StayCool polyester, 21% nylon, 4% silver coated nylon and 3% elastane, a synthetic fiber similar to Lycra or Spandex.

The liners are produced in the United States and sell for about US$25.

GEKKS

Gekks silver-based liners keep shoes odor free

Another Environmental Friendly Way to Produce Silver Nanoparticles: Mung Beans

In their quest to find eco-friendly ways to produce silver nanoparticles for use in basic experimentation, and industrial and medical applications, scientists in India are using mung beans.

Researchers from Guru Nanak National College, the Institute of Microbial Technology, Mata Gujri College and Punjab University are synthesizing silver nanoparticles (AgNPs) from seed extracts of *Vigna radiata*, commonly known as the mung bean or green gram, by mixing it with a solution of silver nitrate. Although employing a mung bean may be new, scientists have previously used strawberry leaves and pomegranates to extract silver nanoparticles. (See, *First Pomegranates; Now Strawberry Tree Leaves Used to Produce SilverNanoparticles*, August, 2012 *Silver News*.)

Using vegetation to help produce nanoparticles makes unnecessary the usual chemical, photochemical and electrochemical extraction techniques that involve high temperatures, electrical energy and toxic chemicals. These methods are also more expensive and take longer.

By adding an aqueous seed extract of mung beans to silver nitrate, nanoparticles were broken out of the solution and stabilized. The spherically-shaped particles ranged in size from 5 to 30 nanometers and remained stable at room temperature even after five months. Moreover, the particles were tested for their antibacterial powers against *Escherichia coli* (E-Coli) and *Staphylococcus aureus* (Staph germ) and found to be as effective as silver nanoparticles produced by traditional methods.

The group's research was published in the journal Applied Nanoscience. "In the present paper, we report a simple, eco-friendly and cost-effective synthesis method of AgNPs at ambient conditions using seed extract of *Vigna radiata* as a reducing and stabilizing agent," wrote Manoj Kumar Choudhary and his team. "The AgNPs synthesized by this method have efficient antimicrobial activity against pathogenic bacteria."

Mung beans are a major edible legume seed in Asia as well as Southern Europe and the Southern United States, said Choudhary. The beans for the experiments were obtained from a local market of Patiala, Punjab, India. All of the solutions were prepared in deionized water.

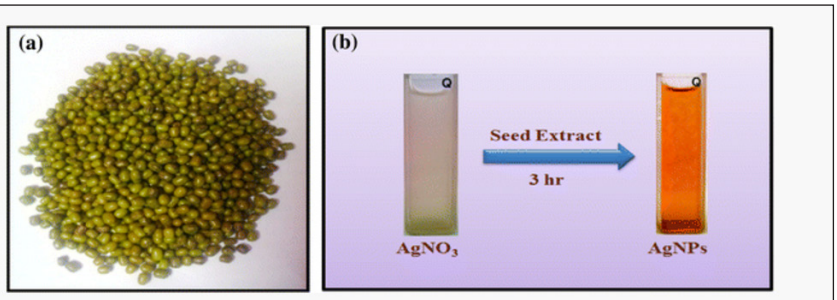


Fig. 1
a *Vigna radiata* seeds. **b** *Reddish brown* solution of silver nanoparticles formed after 3 h due to reduction of silver ions

NANOSCIENCE

Mung beans are the latest fruit or vegetable to be used for extracting silver from silver iodide in an environmentally safe way.

First Luxury Vinyl Flooring With Silver Antibacterial Protection

Loose Lay vinyl flooring from Decoline Australia claims to be the first luxury vinyl flooring that employs silver nanoparticles for antibacterial protection.

Loose Lay comes in a dozen designs including antique pine, antique walnut, charcoal, Tasmanian oak and ash brown. The top polyurethane layers of the flooring contain the nanoparticles.

Company official says their products contain a minimum of 67% and as much as 75% of post-consumer recycled material. They also say that their floors are 100% recyclable and every month Decoria's reclamation program keeps over 1,600 tons of waste from landfills.

DECORIA

Loose Lay luxury vinyl flooring contains antibacterial silver ions to ward off bacteria, mold and fungus.

New Technology for Easier Fabrication of Touch Panel Sensors Uses Nanosilver Ink

Tanaka Kikinzoku Kogyo K.K., the manufacturing business of Tanaka Precious Metals and a member company of the Silver Institute, has announced that it is working with several technology research institutes in Japan to commercialize a new printing technology that allows for the production of small, flexible touch panel sensors using nanosilver ink.

"Flexible printed circuit boards that are bendable and foldable have only been able to use wires as thin as about 30 microns wide, and in most cases they must rely upon wiring of 100 microns or thicker," said Takao Enomoto, Director of Chemical Materials Development at Tanaka. "Until now, this made the idea of practical applications using flexible circuit technology on printed electronics unrealistic. This new technology enables ultrafine wires of 1 micron to be formed on flexible plastic film (PET resin)."

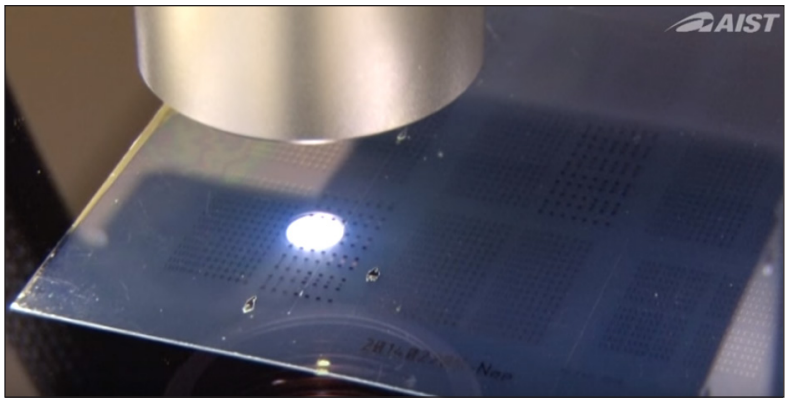
The technology, called 'SuPR-NaP' (Surface Photo-Reactive Nanometal Printing), which produces ultrafine silver wiring patterns for electronic circuit boards, will be used in flexible sensor pads like those used in wearable consumer electronics (See, *Smart Contact Lenses Rely on 'Invisible' Silver Wires*, Silver News, April, 2016). Said Enomoto: "This technology will lead to an expansion of applications using these sensors because it can be applied to small touch panel sensors, rather than just applied to large or medium-sized sensors. One of those applications is print formation onto PET film and similar applications, and there are great expectations for its application to the new wearable products industry. It can be also used in PV (photovoltaic) biosensors used as transparent electrodes."

While printable silver metal mesh wiring has extremely low electrical resistance, the problem was that hardly any light could pass through the metal areas, according to Tanaka officials. The solution is electronic circuit patterns with wires so thin as to be invisible to the naked eye, on the order of a few microns wide. However, until now producing these ultra thin wires on a plastic film has been slow and expensive, mainly because it had to be done at high temperatures and in a vacuum.

The new process can be done at normal temperatures and atmospheric pressures without the need for etching equipment for indium tin oxide or metal film that was previously required. This will allow for more efficient and precise mass production in the workplace.

SuPR-NaP technology uses selective chemisorption (adsorption in which the adsorbed substance is held by chemical bonds) of silver nanoparticles by means of ultraviolet irradiation. This is followed by a self-fusion reaction among nanoparticles that gives low-resistance silver wiring.

The research team includes members from Japan's Flexible Electronics Research Center, University of Tokyo, Yamagata University and National Institute of Advanced Industrial Science and Technology (AIST). The team plans to have a sample shipment of the flexible touch screen sensor sheet using the new technique by January 2017.



AIST

A new printing technology produces small, flexible touch panel sensors using nanosilver ink. (Click the image to watch a video.)

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