THE SILVERINSTITUTE

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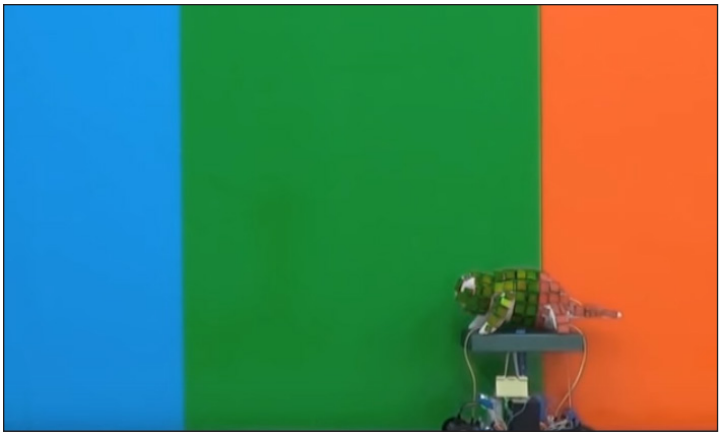
Silver News

Silver Helps 'Chameleon Robot' Change Colors

Military Applications Envisioned



NEW SCIENTIST

A rapid color-changing display has let researchers mimic a chameleon, and could one day be used for adaptive camouflage. Click for animation.

A team of scientists has developed a 'chameleon robot' that can change hue when placed next to a primary color, and silver ions make it possible.

One of the important characteristics of the lizard-like robot is that it can change colors almost instantaneously, offering applications for military use, according to researchers from the United States and China.

Scientists have used the properties of silver before in their quest for camouflage, especially by studying how animals like octopi and squid change colors. (See *Silver Helps Camouflage Researchers Mimic Octopi, Squids and Cuttlefish; Silver News*, October, 2014.)

The robot is a 3-D printed model that is covered in plasmonic displays, similar to plasma TVs in which light interacts with electricity to produce images. The model is produced from a sheet of glass with a tiny grid of holes, each only 50 nanometers across. Gold is deposited on the sheet, forming gold domes inside each hole. The sheet then is placed inside a casing filled with an electrolyte gel containing silver ions.

When the sheet is hit with light, it produces plasmons which are waves of electrons, and the sheet turns red. However, when an electric field is applied some of the silver ions are deposited to the gold domes and produce different colors. The colors change based on how much electricity is applied.

The researchers used sensors that detected the surrounding background colors, which in turn produced different amounts of electricity, which was then applied to the glass sheet. The robot's sensors calibrated each background color to a different electrical field which turned the sheet the same color.

For now, the robot can only recognize primary colors -- red, green and blue – but researchers are experimenting with methods of discerning other colors.

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The development team included researchers from the State Key Laboratory for Optoelectronics Materials and Technology and School of Physics and Engineering, Guangzhou; Sun Yat-Sen University, Guangzhou; School of Power and Mechanical Engineering, Wuhan University, Wuhan, both in the People's Republic of China and the School of Materials Science and Engineering, Georgia Institute of Technology, Atlanta, Georgia, United States.

Silver Pastes Allow More Precise Laser Etching for Artists and Engineers

Lasers are often used to mark metal and glass because of their precision and indelibility. Now, with the help of silver, lasers are being used to produce a wider range of markings, some extremely intricate, that would not be possible with lasers alone.

One of the advantages of using lasers on glass or other clear materials is that designs can be produced inside the object without marking the surface. In one process, tested at the University of Dundee in Scotland, silver paste is applied to one side of a thin glass plate. When the glass is heated while electricity is being applied, the electric field pulls the alkali metal ions that are common in everyday soda glass and replaces them with silver ions. After the glass cools, the paste yields a transparent plate.

When a laser is aimed at the glass, the silver ions produce silver atoms which in turn become silver nanoparticles. Because of their extremely small size, these nanoparticles offer the opportunity to produce detailed and elaborate designs.

The technique also has enormous potential for the manufacture of microelectronic devices by allowing engineers to lay down three-dimensional lines of electrically-conducting silver which are the backbone of circuits and semiconductors.

Similar techniques from the Amin Abdolvand laboratory have produced laser etching of metal surfaces and colored designs.

AMIN ABDOLVAND

Extremely precise etchings can be made on glass using a laser and silver paste.

Tiny Silver Switch Allows Gadgets to Shrink Even Smaller

As devices get smaller, and their components shrink to atomic sizes, the problem becomes how to control the digital signals with mechanical switches that are magnitudes too large.

Now, a Swiss-German scientific team is developing a technique to use a single silver atom as an on-off switch for controlling optical/digital signals. This can lay the foundation for a new optical atomic-scale technology with applications in communications for consumer products, as well as military and industrial uses.

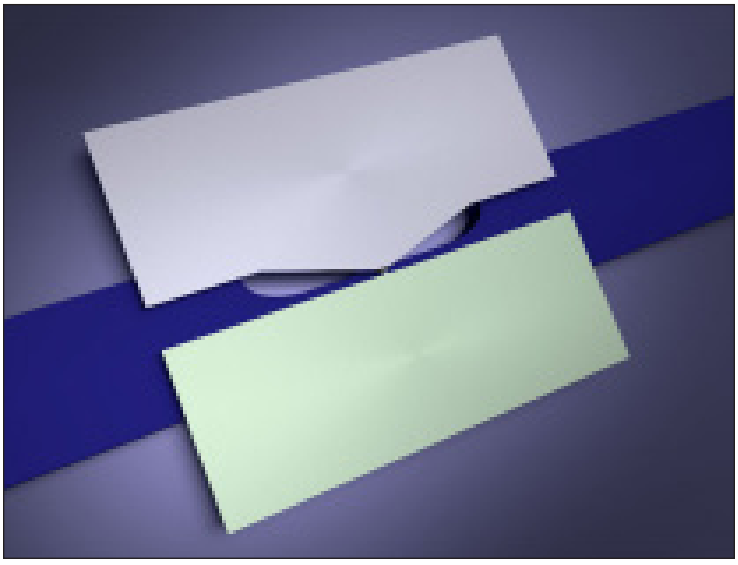
Although engineers have had some success with extremely small switches, they often required cryogenic (low temperature) laboratory conditions or complicated set-ups to work, conditions that are not practical for everyday applications.

By using plasmonic techniques (story on page 1), which rely on the interaction of light and metal surfaces, the team fashioned a tiny waveguide – a tunnel-like structure that channels waves, such as electromagnetic waves or sound waves – with a slot made of silver on one side and platinum on the other. The silver slot was tapered on one side and a 20 nanometer gap separated the two metals at the tip.

By applying a voltage differential between the two metals, silver ions jumped into the narrow gap short-circuiting the system and shutting off the flow of electrons through the waveguide. By removing the voltage, the electricity flowed again.

In essence, the scientists produced a switch that could turn on and off at room temperature, and with little battery consumption.

The device still needs development, according to Professor Juerg Leuthold of ETH Zurich, a Swiss university. The switch is relatively slow, for instance, but he believes that it can be commercialized within a few years.



GRAPHICS: A. EMBORAS/ETH ZURICH

Tiny plates made of silver (light grey) and platinum (mint) are placed on an optical waveguide (blue), allowing electricity to be controlled by a switch composed of a single silver atom.

2016 Silver Market Trends

Silver is prized primarily for its dual role as a monetary asset as well as an important industrial metal utilized in a wide-range of existing and growing applications. Factors driving the silver market include supply and demand fundamentals, global economic performance, geopolitical issues, interest rates, currency fluctuations and investor sentiment, among others. Against this backdrop, the Silver Institute offers the following thoughts on this year's silver market trends.

Silver Demand

Silver industrial demand, the largest component of total silver offtake, is set to increase its share of total demand in 2016. Silver is incorporated into a variety of industrial applications and is generally price-insensitive given the small quantities that are used in some applications and its critical contribution to these applications' functionality. In 2015, industrial fabrication demand accounted for an estimated 54 percent of total physical silver demand.

Silver's use in photovoltaics for solar energy is projected to rise in 2016 and surpass the previous peak of 75.8 Moz (million ounces) set in 2011, as global solar panel installations are expected to grow at a high single-digit pace. Moreover, silver's use in this application may account for more than 13 percent of total silver industrial demand in 2016, up from 1.4 percent a decade ago.

Silver demand from ethylene oxide (EO) producers is expected to jump to over 10 Moz this year, a more than 25 percent increase over 2015. Ethylene oxide is critical in the production of plastics, solvents and detergents. This growth comes off a very robust 2015, when demand grew by well over 40 percent. The bulk of demand is expected to continue to come from new EO plants and expansions at existing ones located in China. China is expected to account for an estimated 80 percent of silver requirements for new EO capacity in 2016.

Jewelry fabrication is expected to increase by 5 percent in 2016, in contrast to a modest contraction last year. While the market will likely see a decline in Chinese silver jewelry demand, which accounted for around 16 percent of the 2015 total for silver jewelry fabrication, growth in other countries should more than offset China's slippage in demand.

Coin demand is expected to be robust once again in 2016, following a record 130 Moz of demand last year. Demand will remain elevated this year as investors take advantage of relatively lower metal prices in the first few months of the year. Increased interest in safe haven assets, as already seen in the first few weeks of the year, will also be positive for physical silver investment demand. In 2015, coin demand made up an estimated 12 percent of total physical demand.

Silver exchange-traded-funds (ETF) holdings fell by 2.8 percent by the end of 2015 compared to year-end 2014. Notably, the decline in silver ETF holdings was smaller against gold's 8 percent contraction. Silver ETF holdings should continue to remain in stickier hands than those of gold's investors, partly a reflection that silver ETF holdings have a larger proportion of retail investors.

Indian silver demand in 2016 is expected to grow on the back of increased investor interest and growth in jewelry, decorative items and silverware fabrication. India, long a mainstay of global silver demand, imported a record high 228 Moz of silver bullion in 2015. Imports rose largely due to a decrease in scrap flows, necessitating new supply to meet annual fabrication requirements, a trend projected to continue.

Silver Supply

Global mine supply production is projected to fall in 2016 by as much as 5 percent year-on-year. This would represent the first reduction to global silver mine production since 2002. The lower price environment provided little incentive for producers to invest in expanding capacity at existing operations. Looking further ahead, many analysts expect global silver mine production to fall through 2019 as primary silver production from more mature operations begins to drop.

Scrap supply, which has been on the decline for several years, should further weaken in 2016. This outlook is based on additional losses in photographic scrap, a depleted pool of near-market silverware, jewelry and coins, and slowed scrap flows from industrial sources. Industrial scrap such as electronics cost more to recycle and the current price environment has weighed on the profitability of recovering silver from these end-of-life items.

Silver Market Deficit

The silver market deficit (total supply less total demand) is expected to widen in 2016, drawing down on above-ground stocks. The larger deficit is expected to be driven by a contraction in supply.

Silver Price

The silver price is expected to find solid ground this year. As of January 26th, silver prices are up 3.7 percent from the end of last year. This price appreciation is on the back of increased safe haven demand amid volatile and weakening equity markets across the globe.

PVC Wall Cladding Uses Silver Ions for Bacteria Protection

BioClad, a British manufacturer of wall cladding, has begun marketing what it claims is the first PVC (polyvinyl chloride) wall cladding technology and panels, which it recently displayed at the Arab Health show in Dubai, UAE. Wall cladding is a covering intended to make a wall look like it is made of a different sort of material than it actually is.

Antimicrobial silver ions are imbedded into the cladding panels at the time of manufacture. Company officials say this stops the growth of bacteria and mold and works continuously for the lifetime of the panels, reducing levels of bacteria such as MRSA, E Coli, Legionella, Salmonella and mould (including Aspergillus Niger) by up to 99.99%. The panels don't flake or corrode, officials say, and come with a 20-year guarantee.

California Hygienists Association Supports Silver Diamine Fluoride Use

The California Dental Hygienist's Association is promoting the use of Silver Diamine Fluoride (SDF) as a means to halt tooth decay and treat sensitivity. It is delivered topically.

"One of the great things about SDF is that hygienists can apply it under their current licensed duties, once a dentist provides the cavity diagnosis," said Association President Lygia Jolley. (See *Thirty-Eight Percent of a Silver Compound May Be the Magic Number for Preventing Cavities*, *Silver News*, April, 2013.) "Silver Diamine Fluoride has the excellent benefit of allowing the clinician to halt cavities at the initial diagnostic or exam appointment." With the exception of restorative dentistry such as implants or drilling out the bacteria and filling the hole, there is no other option in the United States to stop the progression of dental decay, she said.

Silver Diamine Fluoride was approved by the U.S. Food and Drug Administration in August of 2014, and the first products were available in April 2015. However, SDF has been used in other countries for decades, including an 80-year clinical history in Japan.

SDF offers a two-pronged approached to dental care. The silver acts as an antimicrobial against the decay-causing bacteria, while the fluoride remineralizes the enamel structure of the tooth.

Another benefit is that after application to a decayed tooth, the silver will remain in the dead bacteria of the tooth. If future bacteria attacks occur, the silver will 'reactivate,' preventing decay from starting again.

Jolley noted that SDF treatment allows clinicians to handle all decayed areas in a patient in one appointment as opposed to restoration or implants that would require multiple visits. "Think of traveling to a remote location where you only had time to examine and educate patients. SDF would allow the clinician to stop dental decay during that same one-time visit."

Silver Keeps Industrial Sensors Grime Free

Sensors operating in high humidity industrial environments, like food processing facilities, tend to attract a biofilm coating which we would call grime. A Spanish engineer is experimenting with coating these sensors with silver ions to keep the bacterial grime from forming, and it's working in real world applications.

On some devices or machine parts, grime is not a problem. However, biofilm formations – also known as biofouling – on sensors can lead to physical deterioration as well as incorrect readings.

"Right now, the costs arising out of biofouling are very high mainly because of the maintenance work or replacement of equipment," said engineer Aitor Urrutia from Spain's Universidad Pablica de Navarra (UPNA) in a public statement.

By coating the optical structure of the sensor with silver nanoparticles, less than one micron thick, biofilms do not have the opportunity to build. Moreover, the sensors are biocompatible and immune to electromagnetic interference. They are also inexpensive, compact and lightweight, said Urrutia.

Kwikset Introduces Home Locks with Silver Protection

Residential lock maker Kwikset and built-in antimicrobial product protection company Microban have joined to produce a silver-based antibacterial residential lock.

Because of their 'high-touch' nature, door locks collect bacteria, according to Kwikset officials. Microban 'silver-glass' technology is incorporated during the manufacturing process and permanently binds the silver ions to the coating, say Kwikset officials.

"At no extra cost, Kwikset hardware with Microban Technology provides homeowners with a lifetime peace of mind and security," notes Michelle Gangi, Senior Product Manager, Kwikset.

The product will be available in the spring. Retail price has not yet been announced.

Can Ancient Bacteria and Silver Help Protect Poultry?

Since 2009, when bacteria was found in the Siberian permafrost – microbes which may be 3.5 million years old – Russian scientists have been trying to figure out what practical applications these old germs may offer.

Silver may hold the answer to one use.

In testing, Bacullius F, as it's called, is being combined with colloidal silver (silver particles suspended in liquid) and put on chicken feed with the hope of reducing the amount of antibiotics currently fed to poultry.

Tests on laboratory mice and preliminary tests on chickens look promising, says Andrei Subbotin, leading researcher for Tyumen Scientific Center, quoted in World Poultry, He says that the drug will be tested in a large-scale study at several poultry farms by the Ural Federal Districts of Russia in the coming years.

Subbotin says that while he cannot be entirely certain that the bacteria are millions of years old, they were found in the depths of Mammoth Mountain in Yakutia, on the right bank of the river Chara, where the maximum age of the rocks from which they are extracted reaches 3.5 million years. "We are not 100% sure that this is an ancient, relict bacteria we are dealing with. Because the frozen ground is permeable, it could be of more recent date. Our hypothesis is that the bacteria in the permafrost are not in suspended animation, but are in a so-called state of hypometabolism. This means they continue to function," he noted.

It is widely known that this type of bacteria can survive in permafrost for hundreds of years, and is activated by higher temperatures.

So far, tests show that the injection of Bacillius F and silver has spurred weight gain and raised the ability of trial animals to fend off pathogens such as salmonella or MRSA.

Commenting on the ongoing tests, a project representative stated: "We expect a decrease of antibiotics use in poultry by 30-40% compared to the current amount. This will be a substantial contribution to the fight of modern medicine against growing microbial resistance."

Russian scientists have been experimenting with the bacteria for several years with the aim of learning how it has survived under such brutal conditions.

A bacteria thought to be 3.5 million years old was found in the Mammoth Mountain in Yakutia. Scientists hope that combining it with silver may allow poultry farmers to use fewer antibiotics.

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