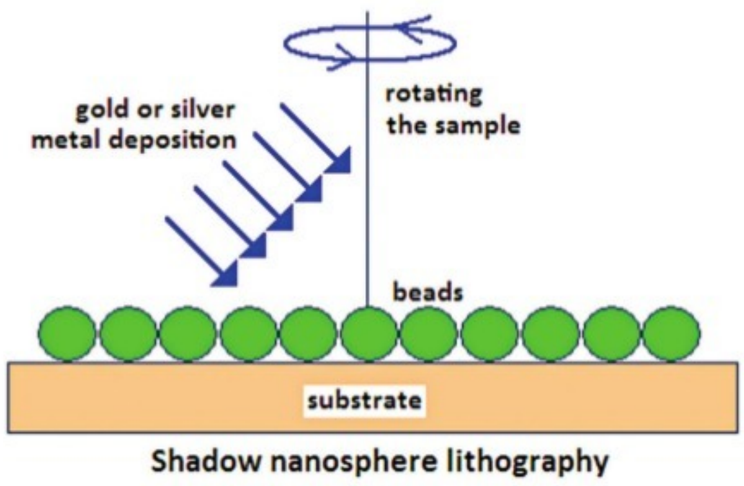
New ways of travelling light

Zero gravity would reduce many loads but it has its downside



Shadow nanosphere lithography

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Long distance space flight has a huge challenge of load. As there is a limit to the quantity of supplies that can be carried, resources need to be recycled. Doing this with the help of the Sun's energy or starlight would conserve fuel. We now have the technology to use light energy to split water into hydrogen and oxygen. The method that is available and which works here, on the surface of the Earth, however, makes use of the force of gravity to be effective.

Katharina Brinkert, Matthias H Richter, Omer Akay, Janine Liedtke, Michael Giersig, Katharine T Fountaine and Hans Joachim Lewerenz from Caltech, ESA in the Netherlands, Brandenberg University, Freie University in Berlin, South China Normal University and the Northrop Grumman Corpn, California, report in the journal, Nature Communications, a method of artificial photosynthesis, where light gets water to split into hydrogen and oxygen, to provide both a fuel and oxygen for the crew, in zero gravity conditions. The group has then tested the method in a capsule that experienced near weightlessness when it was launched into a 9.3 second-long free fall in a special facility in Germany.

All the stored energy on Earth is what green plants have captured from sunlight and converted into carbohydrates. The process, called photosynthesis, is how plants grow and produce fruit and grain. Our fossil fuels of coal and petroleum contain the same plant matter preserved since ages. Green plants, with the help of chlorophyll, are able to extract carbon and hydrogen from carbon dioxide and water, to form carbohydrates and release oxygen. The process has now been understood as a two-step process — the first when the photon of light splits water into ionised hydrogen atoms and an oxygen atom, and the second where the hydrogen ions and carbon dioxide combine as carbohydrates.

The process has been replicated and we now have artificial photosynthesis. Carbon dioxide from sources like power plants can now be converted to other forms, with the release of oxygen. The energy that is necessary to separate the carbon and the oxygen, in the artificial method, is provided by light and silicon-based photocells. The same process can also split water to provide hydrogen and oxygen alone. This is the process that is of interest for space travel.

The problem with the use of photocells in conditions of zero gravity is that for the silicon surfaces, which bring about the splitting of water to be effective, the hydrogen that is generated needs to be swept away. In an Earth-based system, in a water medium, the hydrogen rapidly bubbles to the surface. This happens because of the pressure of the surrounding water, or buoyancy, which arises because of the Earth's gravity. In outer space, there is no gravity, there would be nothing to push the hydrogen away and hydrogen would crowd the silicon surface as "froth". The generation of hydrogen and oxygen would then stop as soon as it starts!

It is similar to the condition in the simple electric cell and the vacuum tube valves that were used in early radio sets. In the electric cell, there is a zinc plate and a copper plate immersed in a dilute acid and connected outside the acid with a metal wire. Hydrogen ions, with a positive charge, are released from the water in the dilute acid at the zinc end. Zinc metal moves into the solution and leaves behind a negative charge, which travels through the wire to the copper end as the electric current.

The problem with the simple cell is that the hydrogen released at the zinc end stays put, to cover the zinc plate, and the reaction stops. The more complex electric cells, like the dry cell that we use in portable devices, have arrangements to clear the negative end and keep the cell going for longer.

In the vacuum tube valve, again, there was a negative end, the cathode, where free electrons were generated by heating a coil. The electrons then flowed to the opposite, positive end. But if the poles were reversed, there was no current. This was because the positive end, the anode, was not heated and there were no free electrons.

In addition to this "one-way" effect, the strength of the current could be controlled by a small voltage applied to a mesh, or grid, between the two electrodes. This made the device useful in many ways, the main one being to amplify a feeble signal applied at the grid. But the trouble with the device was that the negative charges released by the heated cathode would collect around it and prevent more charges from moving towards the anode. This collection, which was called the space charge, then needed an arrangement to sweep it away.

In the case of the photocell, when it is used to generate hydrogen in weightless space, again, we need to eliminate the so-called "gas bubble froth", which covers the active surface. The group writing in Nature Communications provides an answer — architecture for the photocathode that gets the hydrogen bubbles to be released from the surface even without help from any surrounding buoyancy.

The key process is to build a special pattern of nanometre dimensions on the surface. This was done by a printing process called shadow nanosphere lithography — one that has been used elsewhere to generate nanometre surface features. As can be seen in the picture, the electrode surface is covered with nanometre size polystyrene beads. Gold or silver ions attach to the surface in a pattern that has nanometre dimensions. The nature of the pattern can be varied by changing the angle at which the ions are sprayed or by rotating the grid of polystyrene beads. The second picture shows how the shape generated on the electrode surface keeps the hydrogen from smothering the electrode.

Having found a way that should make the photocathode effective in zero gravity, there was a need to test it. This was done by arranging a sufficiently long spell of freefall. While we all experience gravity by the resistance we feel, when we stand on any surface, we would be weightless if the surface below us was to give way. We would have experienced this when we start the descent in the elevator from the upper floors of a building. Even astronauts are trained to experience weightlessness by spending time in an aircraft that goes into "free fall" descent.

The authors of the paper tested their device in a free fall facility that has been provided for researchers in the town of Bremen in Germany. It consists of a tall tower, 146 metres high, with a 120 metre free fall cavity. The device whose working is to be tested is tossed up using a powerful catapult. As soon as the device leaves the catapult, it is in free fall and weightless, first moving upwards, and then descending. The period of zero gravity is 9.3 seconds.

The device that was flung up has arrangements to test the effectiveness of hydrogen generation from water, using light energy. The test was started as soon as the free fall started and carried on till it ended. The result was that the special electrode surface did allow efficient hydrogen generation despite there being no buoyancy to clear the hydrogen away, the paper reports.

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Homo sapiens to homo digitalis

Contactless cards inside your body may sound like something from a dystopian future but not for bio-hackers in Sweden

The microchip between the thumb and index finger

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Thousands of people in Sweden have inserted microchips, which can function as contactless credit cards, key cards and even rail cards, into their bodies. Once the chip is underneath your skin, there is no longer any need to worry about misplacing a card or carrying a heavy wallet. But for many people, the idea of carrying a microchip in their body feels more dystopian than practical.

Some have suggested that Sweden's strong welfare state may be the cause of this recent trend. But actually, the factors behind why roughly 3,500 Swedes have had microchips implanted in them are more complex than you might expect.

This phenomenon reflects Sweden's unique bio-hacking scene. If you look underneath the surface, Sweden's love affair with all things digital goes much deeper than these microchips.

The term bio-hackers refers to those amateur biologists who conduct experiments in biomedicine, but do so outside of traditional institutions — such as universities, medical companies and other scientifically controlled environments. Just as computer hackers hack computers, bio-hackers hack anything biological.

Bio-hacking is also a culture and a diverse one, with many different subgroups — all with different types of interests, goals and ideologies. But within this diversity there are two main groups — "wetware hackers" and trans-humanists.

Wetware hackers are citizen science hobby biologists who build laboratory equipment from household utensils. They conduct so-called "frugal science", where they find inexpensive solutions that will improve the living standards for people in developing countries. But they also do more playful experiments where plants are genetically modified to become fluorescent or algae is used to make new types of beer!

The other group is the trans-humanists, who focus on enhancing and improving the human body — with the aim, in the long run, of improving the human race. Only through bettering ourselves — and escaping biological boundaries — will humans be able to compete with AI in the future.

Often, different bio-hacking scenes reflect the different societies and cultures in which they develop. So, for example, European bio-hackers generally differ from their North American counterparts. North American groups are concerned with developing alternatives to the established healthcare practices. European groups, meanwhile, are more focused on finding ways of helping people in developing countries or engaging in artistic bio-projects.

But Swedish bio-hacking culture actually differs from the rest of Europe. Swedish bio-hackers are generally part of the trans-humanist movement. And it is the trans-humanists — or more specifically the subgroup "grinders" — who have been inserting NFC chips somewhere between the thumb and the index finger of thousands of Swedes. These are the same microchips that have been used for decades to track animals and packages.

So why are Swedes so happy to put microchips into their body? One theory put forward is that Swedes are more prone to sharing their personal details because of the way the Swedish social security system is structured. This myth of the "naive Swede", who innocently trusts the government and Sweden's national institutions, is an exaggeration, which has even been noted by the Swedish Ministry of Foreign Affairs.

If it is part of the explanation, it is certainly not the whole truth. More convincing is the fact that in Sweden, people have a strong faith in all things digital. Swedish people have a deep belief in the positive potential of technology. Over the last two decades, the Swedish government has invested heavily in technology infrastructure — and it shows. The Swedish economy is now largely based on digital export, digital services and digital tech innovations. And Sweden has become one of the most successful countries in the world at creating and exporting digital products. Notable companies, such as Skype and Spotify, were founded in Sweden.

A belief in digital technology and a trust in its potential have strongly affected Swedish culture. And the trans-humanist movement has built upon this. In fact, Sweden played an important part in the formation of the trans-humanist ideology. The global trans-humanist foundation, Humanity+, was co-founded by the Swede Nick Bostrom in 1998. Since then, many Swedes have become convinced that they should be trying to enhance and improve their biological bodies.

So as the world expresses shock at the number of people being microchipped in Sweden, we should use this opportunity to delve deeper into Sweden's remarkable relationship with all things digital. After all, this latest phenomenon is just one manifestation of an underlying faith in technology that makes Sweden quite unique.

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The independent

PLUS POINTS

Birth of stars

Scientists have released a stunning image of stars forming deep in space.

The picture shows the usually hidden wonder of a star cluster known as RCW 38, which is usually shrouded in dust. It allows astronomers to peer into that cluster and see the stars forming inside. The picture shows a cluster made up of hundreds of young, hot, massive stars and lies 5,500 light-years away.

Usually, scientists see something very different when they look towards this star cluster. Previous images are much emptier of stars because they are covered by dust and gas.

But by looking using infrared imaging, the scientists were able to see the vast cluster of stars that light up the gas and dust that surrounds them. The darker parts of the images are shown glowing gently in dark shades of red and orange, and are parts where cooler gases flow through the region.

The image was taken by peering through that dust using the latest telescopes and imaging technology. It was taken using an infrared imager mounted on the European Space Observatory's Very Large Telescope in Chile.

That imaging technology fired four laser beams into the night sky, which can be used as artificial reference stars. Using those, scientists are able to correct for the atmospheric turbulence that normally smudge such pictures, allowing this one to be much sharper.

The independent

Worth the money

The programme to vaccinate 27 million newborn babies in India against pneumococcus could prevent approximately 35,000 under-five pneumonia deaths, say researchers.

The Union Government is rolling out a pneumococcal conjugate vaccine across the country to tackle the disease, which claimed the lives of an estimated 105,000 children under the age of five in 2010. However, the vaccine is significantly more expensive than others included in the Universal Immunisation Programme. In addition, its effectiveness in low and middle-income countries is uncertain.

The Global Alliance for Vaccines and Immunization is currently helping to fund PCV provision until 2021 after which the Union Government will have to bear the full costs.

To predict the potential outcome and cost-effectiveness of India's PCV programme, researchers at the University of Strathclyde in the UK and the Center for Disease Dynamics Economics and Policy in the US and New Delhi, used a model they had previously developed and validated called IndiaSim, which is representative of the Indian population and health system.

The analysis considered the distribution of the dominant strains of the disease in India and the characteristics and behaviour of the host population within the country's health system. The study, published in the journal BMJ Global Health, concludes the programme could prevent 34,800 under-five deaths, cost $240m but save families $48.7 million in treatment costs annually.

This outcome assumed vaccination coverage levels similar to those achieved by the diphtheria, pertussis and tetanus immunisation programme — approximately 77 per cent. Increasing the coverage level to 90 per cent was found to be the most cost-effective outcome in over 95 per cent of simulated outcomes.

Lead author Itamar Megiddo, assistant professor and chancellor s fellow in Strathclyde Business School, said, "PCV is expensive and its efficacy is uncertain for a number of reasons. These include a lack of information on the distribution of the disease-causing strains in India and lack of contextualised information on the efficacy of the vaccine and other low and middle-income countries. The affordability and cost effectiveness for a country like India is especially ? important.

"Although our study had limitations, and there are data gaps that need to be filled, even with conservative assumptions we believe the vaccination would avert a significant number of deaths."