

Better managing the sun's energy

A WINDOW THAT LETS IN THE LIGHT BUT SENDS BACK THE HEAT MAY HELP SOLAR CELLS BECOME MORE EFFICIENT, WRITES S ANANTHANARAYAN

The last few months have seen a series of devices to step up the performance of solar cells. While new designs like organic or dye sensitised solar cells or alternatives to silicon are making an entry, an area of advance has been in making better use of the light that falls on the solar cell. One discovery is of nano-patterns that help focus diffused light of a range of frequencies, or colours, on to the cell surface. Yet another has been materials that receive light energy in the ultra violet part of sunlight and convert it to the frequencies that a solar cell can use. This not only helps the cell make use of more of the energy in sunlight but also reduces the damage and heat that direct UV light is responsible for.

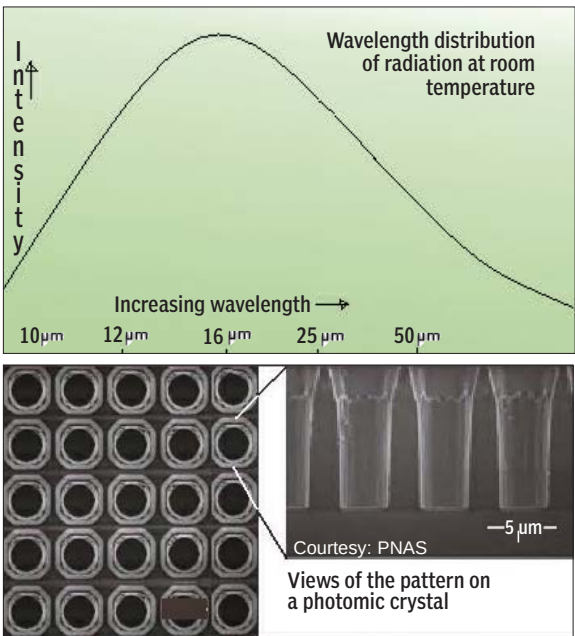
The latest in the list is the current work of Linxiao Zhua, Aswath P Raman and Shanhui Fan at Stanford University, an arrangement that cools and helps the solar cell stay at its best working temperature and also lets in the light energy that the cell needs to function. This same group, with two others, recently developed a "near total reflector" that gives off heat waves at infra red frequencies that can pass through the atmosphere to help things cool while standing in the sunshine. The present development, which the researchers report in the journal *Proceedings of the National Academy of Sciences*, goes a step further in being transparent so that light energy can be

used even while the heat is being sent away. This can be useful in many areas of working, beyond just solar cells. A greenhouse for warmer climes that cuts the heat but lets photosynthesis continue may be one such.

The principle of the action is that outer space is a region of extreme coldness — about 270° Celsius below freezing. If an object to be cooled could be connected to this area, it would chill without the need for refrigeration or airconditioning! Even without a physical connection, all warm bodies radiate heat and should cool, if only they did not gain heat by the radiation of the surroundings. But the earth's atmosphere acts like a warm blanket, which is not a bad thing, and keeps things comfortably warm even when the sun is not shining. The heat that objects radiate is thus absorbed by the air immediately around the object and radiated straight back.

Fortunately, however, there is a range of wavelengths, eight to 13 micrometres, in the infra red, where the atmosphere does not absorb radiation. This is to say that the atmosphere is transparent to radiation in this range of frequencies. If an object radiates a lot of heat in the form of IR radiation in this range, this heat would head out to space.

The trouble is that natural objects radiate heat at a wide range of frequencies, peaking at a particular temperature, no doubt, but largely spread over many frequencies. The bulk of thermal radiation is hence not in the narrow "transparent window" of the atmosphere and objects do not naturally cool down. This is in respect of the normal heat radiation of all objects. But there is another kind of emission of energy that comes from a resonance, or the matching of frequencies of IR waves and atom-



scale components of certain materials, in given dimensions, an intermediate between electrical and optical effects of radiation on materials.

One such material is silica, which is nothing but purified, ordinary sand. The structure of silica is such that high frequency waves are set up by radiation that falls upon it and it is able to emit strongly at the same wavelengths as the "window" in the atmosphere. A sliver of silica placed over a solar cell unit should hence act as both a transparent path for light energy to reach the solar cell as well as an arrangement that would emit heat at the wavelength that can escape from the earth through the atmosphere.

minium mirror. The silicon was also "doped" with the correct additives so that it behaved exactly like real solar cell material. While this was the "bare structure", two more assemblies were with the addition of a "photonic cooling" structure and the efficiency of absorption of light and warming behaviour of all three were assessed. Of the two "cooling structures" added, the first was just a half millimetre-thick layer of silica, while the second was a half millimetre-thick polished silica crystal with a lattice pattern of holes 10 microns deep and six microns apart. Silica is transparent to light of all wavelengths in sunlight and while it shows strong emission in the IR, its electric properties also create a "dip" in the absorption and, hence, emission just at the "atmospheric window" wavelength, which reduces its effectiveness. But the physical pattern created in the second kind of "cooling structure" was able to overcome this limitation and allow high emission, which should lead to effective cooling.

The measurements of how well the arrangement absorbs light in the shorter wavelengths of sunlight is shown in the first of the graphs. We can see that a high level of absorption for the "bare structure" is almost unchanged with the silica layer and actually increased with the photonic crystal layer, an effect caused by its greater anti-reflection and light-capture ability.

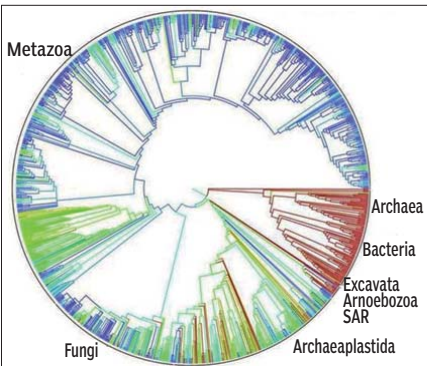
The second graph shows the level of emission, in the IR region. We can see that the "bare structure" has low emission and, in the case of the simple silica layer, there are dips at the eight to 13 micron and the 20-30 micron ranges. With the photonic crystal layer, however, the emission stays high at all wavelengths.

While these results show that the photonic crystal structure has the characteristics required, field trials were carried out with the three assemblies actually exposed to the winter sun on a Stanford rooftop for a three-hour period. The bare structure was found to warm up in the sun by 50° Celsius above the surroundings. The assembly with the simple silica layer warmed 12° Celsius less, while the assembly with the photonic crystal was 13° Celsius cooler. This greater coolness of the third structure becomes more important when we consider that this arrangement also absorbs the most energy, as we see in the first graph.

While the experiment shows a general method of cooling devices or surfaces that need to be exposed to sunlight for their function, the case of solar cells is one where there is a direct effect on efficiency. Solar cells drop efficiency by about 0.45 per cent for every one degree Celsius rise in temperature. Keeping the temperature down by 13° Celsius thus means a nominal increase of efficiency by about five per cent and considering that solar cells work at about 20 per cent efficiency, this is a gain of a whole percentage point.

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PLUS POINTS



Tree of life

Scientists have released a new version of the tree of life, showing everything we know about how the living things of earth are related to one another. With 2.3 million species and counting, it's the most complete model of its kind — but there's a lot more work to do.

Everything that lives or ever lived on earth is somehow related to everything else. But figuring out just how all those critters and plants and pond scum fit together has posed a bit of a challenge. There are a lot of earthlings, after all, and with around 15,000 species discovered each year, our family tree keeps getting bigger and more complicated all the time. That's why the researchers, who reported their new tree on 18 September in the *Proceedings of the National Academy of Sciences*, have open-sourced the model, making it free to download online. This is simply version 1.0, and they're going to need help with revisions. The first draft combined around 500 existing trees to come close to true completion. But close is a relative term here.

One popular study estimated a staggering 8.7 million species on earth today, let alone in the planet's entire history. There are a lot of gaps we've yet to fill in. And the relationships between different species aren't always easy to pin down, so some are controversial or just totally mysterious.

"As important as showing what we do know about relationships, this first tree of life is also important in revealing what we don't know," co-author Douglas Soltis of the University of Florida said in a statement.

The researchers hope that other scientists will help finish the job by uploading their own data.

RACHEL FELTMAN/THE INDEPENDENT

Musical scales

Several years ago, ichthyologist Eric Parmentier met French marine biologist and filmmaker Laurent Ballesta, who was organising an expedition to South Africa to produce a documentary film on the coelacanth. This ancient fish — one whose fossil record dates back to at least 350 million years — has an almost mythical legacy. Although it was widely assumed to have gone extinct 65 million years ago, a live specimen was found in 1938, and scientists have identified two extant



species. Both move in a peculiar way waggling four lobe-like fins in an alternating pattern, as we do our arms and legs. Their anatomy is also unusual: a tiny brain, a joint at the back of the head that allows the animal to open its jaws widely, and only rudimentary vertebrae. Ballesta's trip inspired Parmentier, who studies fish acoustics, to collaborate with the team. "I hoped to be the first guy to record (sounds of) the coelacanth."

Parmentier, a morphologist at the University of Liège in Belgium, has travelled the world to understand fish sounds. For the South African expedition, the divers successfully planted a hydrophone inside a cave and also shot video footage of a coelacanth. (The resulting documentary by Ballesta is available on YouTube. Although it is in French, the footage obviates the need for fluency to enjoy the film.) Day and night, for weeks, the hydrophone dutifully recorded the sounds within the cave. When Parmentier retrieved the files and went to analyse the recordings, there was one big problem: it was filled with dozens of different fish calls. "Maybe the coelacanth is in these sound files, but it's completely masked by the other sounds," he says.

Nonetheless, the tape captured ceaseless, never-before-heard chatter among the aquatic organisms within the cave. To make some sense of it, Parmentier's team undertook the laborious task of characterising the sounds recorded over 19 non-consecutive days (to make this feasible, the group pared down its analysis to the first nine minutes of every hour). The researchers assigned more than 2,700 sounds to 17 groups, most of which sounded to Parmentier like fish (one group was clearly dolphin, based on its high frequency, he says). These included frog-like croaks, grunts that sounded like a creaking door, a moan, and one that sounded like a whistle blown under water. "It's fair to say, based on the characteristics of the sounds they were hearing, they are probably fish sounds," says Erica Staaterman, a postdoc at the Smithsonian who studies fish acoustic communication.



cides in them increases. Some plants and all animals are capable of accumulating and retaining organo-chlorine poisonous chemicals in their organism for a long time. Research shows that the path along which the residues of pesticides reach human beings is through food. For this reason, a safe barrier must be erected between man and his food. The tolerance levels of pesticides in food products are the officially allowed harmless amounts in milligrams per kilogram of the relevant product. All the procedures followed in storing, processing, and preparing food products facilitate the diminishing of the pesticide residues in the food.

To understand correctly how pesticides affect the environment, we must consider their behaviour in separate ecosystems and their influence on the most important objects of those systems.

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THE ACCURACY QUOTIENT

DOES INDIA REQUIRE ITS OWN GOOGLE? MORE THAN 15 SEARCH ENGINES HAVE BEEN LAUNCHED SINCE LAST YEAR BUT THERE REMAIN STUMBLING BLOCKS THAT NEED REMOVAL, SAYS RAHUL JALAN

To the average Indian Internet user, Google is God — an omnipresent and easily accessible free service. We can normally see people around us completely engrossed in their mobiles or smartphones, searching for something. Whether searching the net, reading blogs, using GPS navigation, watching a video or just simply emailing, the presence of Google seems everywhere.

Google's success in India and across the world is testimony of its carefully designed, prompt and reliable results. Some experts believe the appeal of its products makes it an undisputed leader in the online world. Some feel Google is a monopoly whereas others strongly disapprove the suggestion. Obviously, it is not possible to hold and lock people in any particular Internet service because it is completely up to them to continue with the same service or switch to another — with just a click without spending a penny.

During the past few years, Google has gained a firm foothold in the Indian online market by reaching Internet users across geographic and economic barriers. The Internet's popularity in India can be measured by the constantly increasing number of its users in this country.

According to global digital measurement and analytics firm comScore, India has bypassed Japan to have the world's third largest Internet user population after China and the USA. And as per the report of a US-based firm, the number of online users in India is expected to touch 283.8 million by the end of 2016, outdoing the USA at 264.9 million in the same time.

Some big Internet players in India feel Google is willfully intervening in their business turf. They think of Google as a "Frenemy" — a portmanteau of friend and enemy, a rival in the disguise of a friend who infuses himself between their clients and themselves and charges what they see. According to a company that runs Bharat Matrimony website, search giant Google purposely sold its website keywords to its competitors like jeevansathi.com and shadi.com. Another fairly similar complaint has been lodged by CCI (CUTS), a Jaipur-based consumer rights organisation.

- Tough competition from established global players;
- Poor launch timing;
- Wrong target audience;
- Incapability to scale;
- No successful revenue model;
- Poor technology adaptability of local lingos;
- Lack of sources of monetisation;
- Low Internet penetration in tier II and tier III cities and rural areas;
- Lack or poor quality of Indian content;
- Difficulty of server space;
- Problem of advanced algorithms to give better results;
- Irrelevant search results; and
- Inability to grab attention.



nated by Google, which claims 81 per cent, while other popular search engines like Yahoo and Bing have 9.4 per cent and 1.7 per cent. Localised search engines have less than a five per cent share. Large amounts of money are needed to run a largescale search operation like that of Google's and very few Indian search engines, even when supported by other technology firms, have pockets of that depth. However, we have a few flourishing online search engines like Just Dial and Sulekha who cater to a very local audience.

There is one more thing that distinguishes any search engine: the number of documents indexed. Google still leads in this field with some 4.2 billion pages indexed. Search engines are designed as guides that point one in the right direction to one's destination. And whichever site gets one to that destination faster, no matter how complex the question is, proves extremely helpful. Therefore, localised search engines need to ensure accuracy as per users' satisfaction. Only this would prompt their moving away from their existing preferred search engine.

About 180 million users access the Internet through mobiles right now, which opens a new window of opportunity for localised and genre-specific search engines and these, in turn, must adapt to the changing search landscape and concentrate on segments that are most browsed for education, reviews-movies, books, jobs, etc.

There is also the need to make native languages a part of business, just like the Chinese companies do. They became the first in this area, having a large population working in their mother language. Availability of local language keyboards and safety policies will help Indian business record a strong presence in the online market.

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