Sparklers point the way

The diamond's lustre is helping to trace nano-magnets in bacteria, says s ananthanarayanan

THE diamond has a very high index for dispersing light, which makes it glint in different colours and explains why it is celebrated as a gemstone. It also has an unparalleled hardness, which makes it valuable in industry and research. Again, it is a form of everyday carbon so removed from charcoal at one end, or all things living, at the other, that it is a marvel to study — just for itself. Among other things, it has a face-centered cubic crystal structure and is the best conductor of heat among bulk materials.

D Le Sage, K Arai, DR Glenn1, SJ DeVience, LM Pham, L Rahn-Lee, MD Lukin, A Yacoby, A Komeili and L Walsworth, of the institutes in Massachusetts and in California report in the journal, *Nature*, an application of using the diamond crystal to detect magnetic effects within living tissue — with good resolution of detail and while the tissue is still alive — qualities that existing method do not have.

Living things are known to mineralise and create minute magnetic particles within themselves. It is thought that these help some animals "sense" the direction of a magnetic field, like the earth's field, and navigate or orient themselves. A simpler instance is of bacteria that form magnetic bodies within themselves, whose effect is to turn the bacteria along an applied magnetic axis.

These bacteria develop bodies called *magnetosomes*, which contain nanoparticles, or chains of *iron oxide* or *iron sulphide*. These bacteria can survive only in a near-total lack of oxygen and it is thought that the magnetic guidance system has evolved to help them simplify navigation while trying to reach favourable conditions.

The work of Le Sage and others, of imaging magnetic structures within cells, would also enable investigation of similar formations in more complex organisms. The technique developed to spot magnetic cells in different kinds of tissue could be useful in biology and medicine. The genetics of magnetic cells, how non-magnetic, mutant cells could arise and how nanoparticles are shared during cell division, could be studied. The presence of magnetic nanoparticles in cells could also lead to a clearer imaging of organs, in methods like Magnetic Resonance Imaging, and such presence has also been linked with diseases of degeneration of nerve tissue.

The diamond has a rigid crystal structure and does not allow any contaminants in its composition, except atoms of boron and nitrogen. This makes for diamonds, which are transparent, to appear clear and colourless. Small quantities, one part in a million, of boron impurity give diamonds a blue tinge and nitrogen impurities lead to yellow diamonds. Nitrogen atoms in the lattice create a change in the otherwise uniform crystal structure. The diamond atom, being carbon, has four electrons in its outer shell.

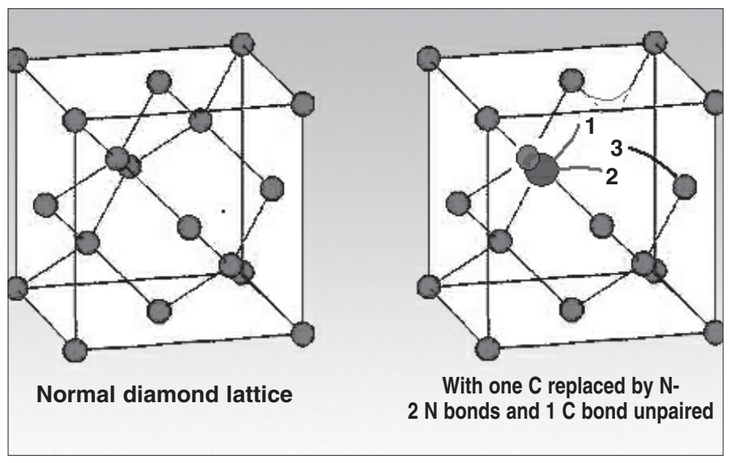
Each atom can, hence, share its outer shell electron with a neighbouring carbon atom to form a stable framework of fully balanced carbon atoms. The nitrogen atom, however, has five outer shell electrons. In the condition called the *Nitrogen-Vacancy* — where one carbon atom is replaced by a nitrogen atom — three of the five outer shell electrons form bonds with carbon atoms, leaving two unpaired electrons called a *lone pair*. The electrons from three neigbouring carbon atoms are also unpaired. Two of these get together to form a bond and that leaves one unpaired electron, in addition to the pair from the nitrogen atom.

The energy levels of the three electrons at a place where there is an NV, which are called *NV colour centres*, are easily excited by visible light and the centres emit a bright red light. The nature of this luminescence is again sensitive to magnetic fields, as such fields affect the splitting of energy levels at the NV.

This effect, which allows very fine resolution detection of magnetic fields, hence promises a means to detect the magnetic effects of intracellular magnetic material. The technique has already been applied to measure things of very fine detail, as fine as the spin of a single electron, but these results were within a neighbouring diamond crystal. Imaging of nanoparticles outside the crystal is a different question, which Le Sage and colleagues addressed.

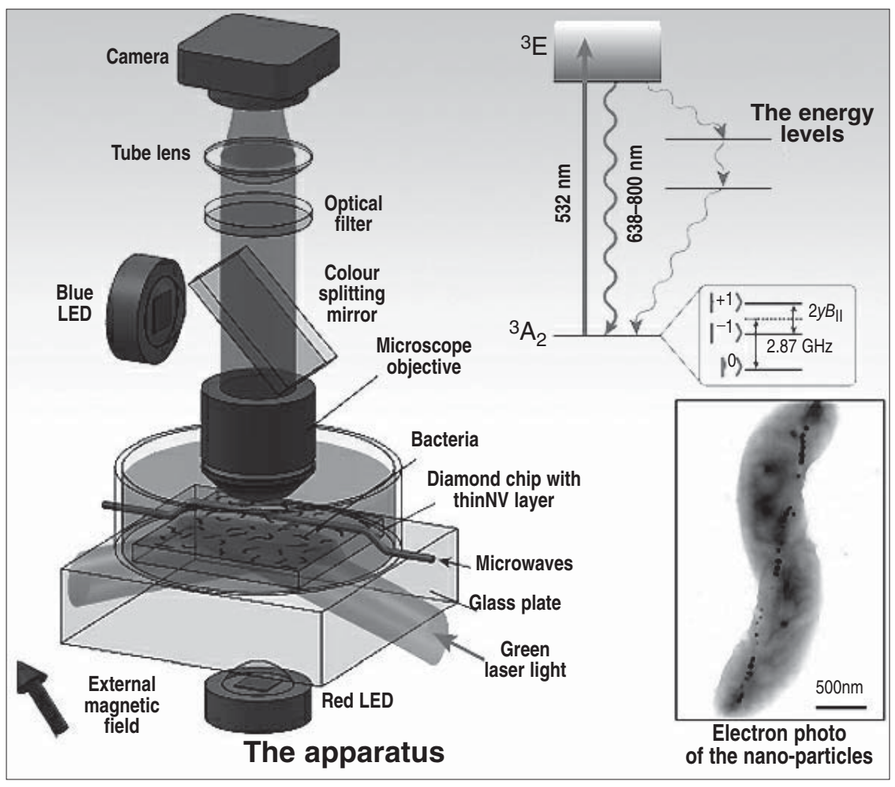
They used a pure diamond chip doped with a 10 nanometre (100 millionths of a millimeter) deep surface layer of NV centres. The NV energy levels were made uniform with the help of a green laser light and then manipulated using microwaves and detected with the help of the fluorescent light emitted.

The frequencies of fluorescence get affected by external magnetic fields, and this was the property used for detecting the magnetic field of the bacteria. And for each imaging NV spot (pixel), imaging was done with four orientations of the fields so that the exact orientation of the magnetic organelles could be found out.



Normal diamond lattice

With one C replaced by N-
2 N bonds and 1 C bond unpaired



The apparatus

Electron photo of the nano-particles

The experiment was done with two kinds of samples — dried bacteria placed directly on the diamond chip and also with live samples in a liquid medium, with suitable changes in the way the beams were shone. The magnetic scan provided a picture of the magnetic fields created by the nanoparticldes, down to sub-cellular resolution. The same apparatus also created optical images of the bacteria.

Electron microscope pictures then proved that the magnetic imaging correctly localised the *magnetosomes* in the bacteria. "Our results provide a new capability for imaging biomagnetic structures in living cells under ambient conditions with high spatial resolution, and will enable the mapping of a wide range of magnetic signals within cells and cellular networks," say the authors in their paper.

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Infectious diseases

tapan kumar maitra **dwells on the many forms of manifestation**

TO gauge from manifestations, infections are subdivided into acute and chronic, obvious and latent, mixed and secondary. Acute infections are characterised by a sudden onset and a comparatively short course (influenza, measles, scarlet fever, typhus fever and relapsing fever). Disease with chronic or protracted courses include malaria, tuberculosis, syphilis, leprosy, brucellosis, amoebiasis, toxoplasmosis, etc.

Some infectious disease can occur atypically, and latently without typical clinical manifestations. These forms of infection are called latent or silent, during which the causative agent for a long period of time can be found in tissues or organs not causing clinically marked response reactions of the macro-organism. Most frequently, tuberculosis occurs in the latent form. Infection with the *tubercle bacilli* is many times greater than the disease incidence itself.

During unfavourable effects of the factors related to the external or social environment, the latent form changes into the obvious typical form. In some cases, herpes, malaria, meningitis, poliomyelitis, etc, may occur latently.

The asymptomatic form of infection was named inapparent by C Ni-colle, in which clinical signs are absent, although, at the same time, multiplication of the causative agent takes place. Inapparent infection is an acute disease that terminates in convalescence after a certain period or in the disappearance of the causative agent.

Persistence is related to a special category of latent infection. It is characterised by the causative agent being preserved in the human organism for a long period of time (the viruses of serum hepatitis, herpes and rubella, arboviruses, Mycobacterium tuberculosis, loxo-plasma organisms, the plasmodia of malaria, etc). Persisting viruses cause the most severe forms of diseases of the central nervous system and post-vaccinal complications. Long-term persistence of the influenza virus in the human organism, for instance, may cause the development of the gravest complication of Parkinson's disease resembling shaking palsy. The persistence of many pathogenic agents is linked with deficient immunity.

The production of L forms of many causative agents as well as other changes leads to a decrease in their pathogenicity and virulence, an increase of their allergic effect and resistance to antibiotics and other drugs. Diseases caused by atypical forms of the causative agents are characterised by a latent and chronic course and are attended with recurrences and exacerbations.

One of the forms of inter-relationship that occurs between the pathogenic micro-organism and a human or animal body without manifesting an obvious disease is carrier state. The ability of the causative agent to carry infectious diseases has been confirmed only in a relatively immune organism. Regarding specificity of action, the carrier state has much in common with the infectious process. In some infectious diseases, an intense and prolonged post-infectious immunity is produced which excludes the carrier state (measles, smallpox, chickenpox. etc). In other diseases, during the period of convalescence a carrier state may be prominent that is different in frequency and duration (cholera, enteric fever, paratyphoid, dysentery, amoebiasis, scarlet fever, diphtheria, meningitis, malaria, encephalitis, poliomyelitis, etc).

The carrier state may be found in healthy persons who have come into contact with diphtheria, meningitis, enteric fever, cholera, amoebiasis, encephalitis and poliomyelitis. This state, with a duration of three months, is considered acute, while that for longer periods is considered chronic. A prolonged carrier state (years and decades) has been described in enteric fever.

When infection occurs not with one species of causative agent but with two or more, one speaks of mixed infection (measles and scarlet fever, measles and tuberculosis). If the infectious process is caused by micro-organisms changed under the influence of one or several co-members of the parasite coenosis, then this state is known as para-infection.

In some cases, infection causes a weakening of the body, which then becomes susceptible to other diseases. Thus, for example, after influenza or measles, pneumonia occurs. This is known as secondary infection.

There are also focal and generalised infections. For example, during infection with staphylococcus, the process causes furunculosis, and if the causative agent penetrates the blood, sepsis will develop. An alternate occurrence of focal and generalised infections is observed during tuberculosis and syphilis.

Reinfection is a repeated infection by the same species of microbe responsible for the disease which terminated in convalescence (gonorrhoea, syphilis, etc). Superinfection is a fresh infection of the body in which the main disease has not ended. Superinfection occurs in many infectious diseases in their acute and chronic forms.

Relapse is a return of the symptoms of the same disease (relapsing fever, paratyphoid fevers, etc). Of certain significance in the occurrences of relapses is the low level of immunological activity of the organism during illness and convalescence.

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Wither avenues for small wind turbines?

aritra bhattacharya **concludes his series on the wind energy sector with a look at the possible problems plaguing the segment**

BACK in 2005, Sujay Shah was grappling with a teething crisis: the health of his numerous plants seemed to be in jeopardy as they were not receiving their daily dose of instrumental music. "Music is critical to plant and human health," says the owner of Sarup Bonsai and Garden — "among the largest bonsai gardens in the world" spread over four acres, located on the outskirts of Mumbai in Panvel, which was then witnessing three-four hours of load-shedding on a daily basis; and this was hampering the "music therapy" for his plants at the assigned time. He was looking for ways to work around the crisis till someone suggested he give wind power a go.

"I was, in any case, keen on natural resources and the idea of harnessing wind for electricity seemed to fit in with the overall principle of the farm, centred on reduce, reuse and recycle," says Shah. Through a friend, he got in touch with an indigenous wind turbine company and, following talks with the turbine makers, installed a 10-kilowatt turbine in his garden at a cost of "Rs 1.8-2 lakh". There has been no looking back since, he says. The facility generates enough electricity to power his daily doses of music therapy, and the fire and safety alarms, in addition to running household appliances on the farm. "We run our lights, fans and refrigerator with the power generated by the contraption," he says. "It's really been a boon for us, since we spend long durations on the farm, away from our home (in Mumbai's Andheri area)."

Like Shah, Vadodara-based businessman Kirit Amin is also reaping the benefits of harnessing renewable energy. He installed seven wind-solar hybrid power generators atop the roof of his cold storage more as a way of participating in "the fight against global warming". At the time in 2008, he was not too sure of the power the facility would actually generate, although Supernova Technologies, the manufacturers of the hybrid turbines, promised he would be able to recover his investment through a reduction in power bills within six years.

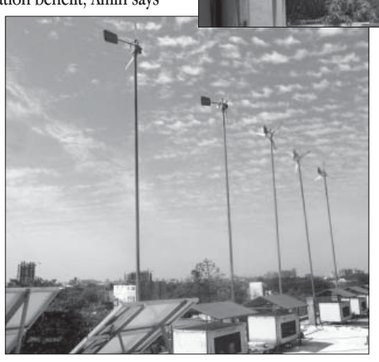
However, within a year's time, he noticed a considerable difference in his electricity bills — though the refrigeration unit in his cold storage was still running on conventional electricity, the lights and other electrical appliances in the storage facility were powered by electricity generated by the hybrid turbines. "Since cold storages are closed spaces, they need to be lit up through the day, and lighting them through the turbines really helped cut down on my power bill," says Amin. He was so impressed with the results that he installed three more hybrid turbines from Supernova Technologies and three wind-operated pumps from the Gujarat Energy Development Agency in his 50-acre farming plot off the Mahi river.

"Wind was going past our compound all year round, and yet we were not using it," Amin rues. He says that despite Gujarat chief minister Narendra Modi's promises of round the clock electricity, the reality on the ground is harsh. In addition to power cuts, the cost of conventional electricity is also escalating sharply. Keeping in mind all these factors and availing of the 80 per cent accelerated depreciation benefit, Amin says he has been able to reap the investment cost within three years.

Yet, stories like these are few and far between, for when one thinks of wind energy what comes to mind are large, almost industrial grade wind farms operated by companies like Suzlon. These farms have their attendant problems and often operate in contravention of laws — something that earlier articles in this series have explored.

The small windmills that Amin installed are different from large windmills in big farms, says Shreelal Jha, who designed the turbines Supernova manufactures. "The windmills from large companies, even the small ones, operate at wind speeds of 25 kmph and above. That makes them unsuitable for use in our cities, where the average wind speed for most of the year is between five-seven kmph. The windmills that I designed have the ability to operate at a minimum wind speed of three kmph," says Jha, director-technical (SFRCI), under the Department of Physics in Gujarat's Sardar Patel University, which gets a three per cent royalty for every turbine Supernova Technologies sells.

He says the cost of turbines Supernova and other indigenous companies make is far cheaper and better than the ones manufactured by foreign companies or their licensees in India. Despite this, the cheapest wind turbine from Supernova costs Rs 35,000. This means the turbines are accessible to those populating the upper echelons of the economy and owning large mansions, or small businesses with some capital. In addition to this, there is the problem of actual power generation — the installed capacity does not translate into actual power generated, as wind speeds vary through the year and the output is often only a portion of the potential. This lag between installed capacity and actual generation is one of the main criticisms of large wind farms, but afflicts small turbines as well.



Windmills atop Kirit Amin's cold storage and a windmill (top) at Sujay Saha's garden.

In order to work around this, most small turbine makers compliment the turbines with solar panels. Jha, in fact, says the ratio of wind-solar hybrid in Supernova's turbines is determined on the basis of the place of installation. "For instance, in coastal areas with a wind:solar ratio of 70:30, the ratio in many areas that are inside is 60:40," he says. Despite these measures, wind energy hasn't become hugely popular.

Subsidies from the Central government are available for those wishing to install small wind turbines, but industry insiders say it is often tedious to claim these. Besides, they also point out that small wind turbines have drawn a lot of NGOs — typically, those which, flush with money, have installed small wind turbines to claim the subsidies as also project themselves as champions of green energy. "I know of so many NGOs who installed such devices, but they have fallen into disrepair within a year or so," says Jha.

A Kolkata-based official of a small turbine manufacturing company, who did not wish to be named, also pointed this out and said that examples like the ones Jha was talking about abound in Maharashtra and Gujarat. With acquisition costs remaining high and the service record of companies manufacturing small turbines being inconsistent, the prospects for off-grid wind energy seem dicey. However, as a recent Union ministry of new and renewable energy document pointed out, the potential for small wind turbines is huge.

"Imagine the case of villages located along the coast of Bengal; they are far off from any power transmission lines and small wind turbines can help bring electricity to such villages," says Anupam Boral, managing director of Kolkata-based Gitanjali Solar Enterprises, which works on installation and maintenance of small wind turbines. His company recently equipped a railway level crossing with a wind-solar hybrid turbine and installed wind turbines in two schools in West Bengal's South 24-Parganas.

There is, however, a long way to go before such stories become the norm.