PHYSICS *Alumni-News*

Alumni of Department of Physics, Cochin University Volume 3, December 2010

Editorial

Alumni of Physics Department, Cochin University of Science and Technology is very proud to release this third edition of the news letter. This is a medium for students to express their views as well as the activities of the Department. Valuable suggestions from your side are invited to improve the quality of the news letter. Many helping hands were there, behind the work of this news letter, especially the students of Nanophotonic & Optoelectronic Devices Laboratory. I wish to thank them all.

Navaneeeth

From Secretary

The third volume of alumni news letter is being released now. It has been delayed for many reasons. Though late, the students of optoelectronics laboratory took the initiative to release this volume. It is in a hurry this volume being released before the dawn of 2011 and was not able to incorporate all the articles which we received late. This news letter is to create a common platform for discussion and interaction. It also provides an opportunity to walk down the memory lane to those good old times and to get updated with events in the Department. The news letter though the third volume is still in its infancy. We hope your contributions to future news letter will make it really worthy and take to greater heights. The news letter will be shortly available on our web page. The department web page is currently being modified and will be available soon

We wish all Alumni and their family members a prosperous and happy new year 2011.

Dr. M.K. Jayaraj

Contents of the volume

Dr. Ramachandran Thekkedath appointed as new Vice Chancellor of Cochin University of Science and Technology

Dr. Ramachandran Thekkedath took charge as the 12th Vice-Chancellor of the Cochin University of Science and Technology (CUSAT). He is an alumnus of Physics Department. He completed his PhD from Department of Physics CUSAT in laser physics in the year 1987. He joined the University of Utah in 1997. He worked in two companies of the University before associating with the artificial heart programme of the University. He had worked as a scientist in the Sree Chitra Thirunal Institute of Medical Sciences, Dr. Thekkedath hails from Pattambi.

National Academy of Science Award to Prof. K.G Nair

Prof. K.G.Nair, a former faculty of the Department of Physics, CUSAT has been honored by the National Academy of Science Allahabad through their special award in recognition of his innovative and outstanding individual contributions to the scientific society along with Dr. K Radhakrishan, the Chairman of ISRO. Now he is active in the position of the distinguished Director of Centre for Science in Society (C-Sis) Cochin University of Science and Technology.

Scope and Awareness Programme for School children.

Students with the telescopes they made

Department conducted "Physics scope and awareness programme" for school children. This ten day programme include the classes by faculties of the Department and the visit of the students to various laboratories in the Department. "Physics scope and awareness programme" was inaugurated by Vice Chancellor Dr. Ramachandran Thekkedath. The students were introduced to the topics like Theory of Relativity, Solar Cells, Elementary Particles and Astrophysics. As part of the Programme a telescope making workshop was also arranged for the students, in association with IUCAA Resouce Centre.

Quiz and Seminar Competition as part of IYA celebrations.

Dr. N.Shaji conducting the quiz

As part of the International Year of Astronomy, a state level quiz and seminar competition on "Contribution of Kerala Astronomers in Astrophysics" were conducted in February 2010. More than forty students from various colleges were participated. The programme was co-ordinated by Dr.Titus K. Mathew.

Open House Programme

Open house programme of this year was conducted on April 19, and 20, 2010. More than eight hundred students from various colleges and schools participated in this programme. Students visited different laboratories of the Department and classes on recent developments in physics were arranged for the visting students. The programme was co coordinated by Dr.S Jayalekshmi. The Open House for the year 2011 is being held on January 14th and 15th. We welcome you all to this programme.

Researcher explaining the LASER

Students Scholarship Programme (SSP)

The student scholarship programme was initiated by M Sc 2006-2008 batch for financial support to needy students of the ongoing M.Sc batch. This year scholarship (Rs.4000/per annum- each) have been awarded to 4 M. Sc students. Now the scholarship programme is being undertaken by physics alumni association. To sustain and continue this programme we need to mobilize corpus fund. A separate joint account is being opened for this purpose. Those wishing to support this programme may donate to this fund. very shortly, we will update you on this programme.

Nobel Prize in Physics 2010

Geim Novoselov

Andre Konstantinovich Geim, a Dutch physicist, was awarded the 2010 Nobel Prize in Physics jointly with Konstantin for their work on graphene. A thin flake of ordinary carbon, just one atom thick, lies behind this year's Nobel Prize in Physics. Andre Geim and Konstantin Novoselov have shown that carbon in such a flat form has exceptional properties that originate from the remarkable world of quantum physics.

Inauguration of Facilities funded by DST-NSTI scheme

The facilities funded by Deparment of Science and Ttechnolgy under Nanoscience and Technology Initiative (DST- NSTI) scheme were inaugurated by Prof. C. N. R. Rao, FRS, Chairman of Scientific Advisory Council to Prime Minister, Honorary President and Linus Pauling Research Professor JNCASR, Bangalore on 15/01/2011 at Nanophotonic and Optoelectronic Devices Laboratory, Department of Physics. Dr. Ramachandran Thekkedath, Vice chancellor, Cochin University of Science and Technolgy belssed the occasion. High resolution XRD, atomic force microscope, micro Raman spectrophotometer, semiconductor analyser and microprobe station obtaineed through the DST-NSTI scheme were explained by Prof. M. K. Jayaraj.

Graphene- An Experimental Realization of Carbon Flatland

T. N. Narayanan, Rice University, TX, USA.

"It brings lots of surprise to the science community, it happened so soon"; this was a common reaction to the news regarding the 2010 Nobel Prize in Physics. Prof. Geim and Prof. Novoselov of University of Manchester are now becoming the part of the history for their groundbreaking experiments on single layer (thinnest material in our Universe) carbon film known as 'Graphene'. They awarded the Nobel Prize for the first successful identification (unlike 1D systems, real 2D crystals have no clear signatures in transmission electron microscopy), isolation, experiments and foreseen applications of this 'truly' 2D system. The fame for a discovery should goes to those persons who correctly identify the real potential of the material. People were using the scotch tape peeling of HOPG for STM/AFM studies even years before 2004 and they could not identify/isolate the single atomic layers of graphitic carbon, that is what Geim and his team did in 2004. Of course there are some citations to argue the earlier identifications of Graphene (like that happened to many other discoveries) and the first such report was from Dr. John W. May's work published in 1969 Surface Science about 'Platinum Surface LEED rings'.

It is not just the discovery but the impact of graphene research (first paper, Ref[1] already got more than 3000 citation) that brings the Nobel Prize in Physics of this year to this 2D system. The beauty of this system gives an excellent opportunity to understand the high energy physics from a lab level synthesized material. In past, any real flatland must have a finite thickness. In the case of semiconductors, the thickness typically extends from 10 to a 100 atomic layers and the system can accurately be described as 2-D only when the quantum size effects that makes the degree of freedom for electron motion in the short direction is relevant (otherwise it is quasi 2D). In 2004, Prof. Geim succeeded in isolating and studying the ultimate flatland – graphene, a one-atom layer thick sheet of carbon atoms arranged laterally in a honeycomb lattice (first truly atomic 2D crystalline matter). This material is so charming in its properties that it had already been the object of theoretical study for more than half a century before it at least available for experimental realization [3].

The notion of engineering the nanostructures for applications was so prevalent after the discovery and subsequent bulk production of single and multiwalled carbon nanotubes, after 1990. The 'groundbreaking' of their discovery in Graphene is that they could 'fool the Nature'. The nascent 2D crystallites try to minimize their surface energy and morph in to one of the rich verity of stable 3D structures. Otherwise, interactions with 3D structures can stabilize 2D crystals (conventional thin films) and in that respect graphene already exists within graphite in the form of layers stuck together by Vander Waals-like attraction. Fundamental forces place the barriers in the way of creating a true flat land and conventional crystal growth techniques are also little help to form these finite flat lands as the

thermal fluctuations easily fold the 2D planes to 3D. Graphene was there like CNTs and fullerenes even before their discovery, but the biggest challenge was, as mentioned earlier, to identify them in the haystack of thicker flakes. It is now believed that the intrinsic microscopic roughening on the scale of 1 nm could be important for the stability of purely 2D crystals, and that will explain the stability/existence of isolated Graphene or Graphene like other 2D crystals.

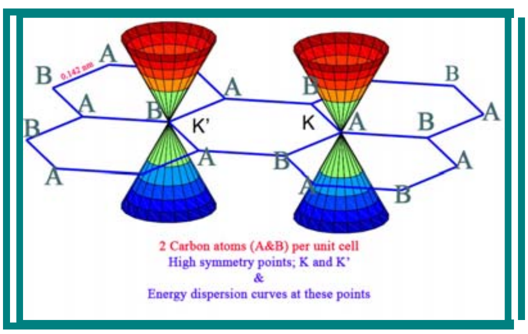

Figure 1. Honeycomb lattice of Graphene and energy dispersion curve.

The beauty of graphene is its crystal structure. The lattice consists of 2 carbon atoms per unit cell with a honeycomb lattice in the form of two interpenetrating triangular sub-lattices (figure 1).

This honeycomb lattice structure gives relativistic behavior to Graphene. Graphene is a gapless (zero gap) semiconductor (energy dispersion curves are like 2 inverted conic touching each other (figure 1), though for 1-D systems also have similar dispersion curves, but in that case not all of the point touches each other) in which valence and conduction band energies are linear functions of momentum (if you go back to the Dirac's description of electronic states). This implies that the speed of electrons in graphene is a constant (as like speed of light is c, but much lesser than c, at least 2 order), independent of momentum. Quantum mechanics of Graphene's electrons is identical to that of relativistic particles having vanishingly small mass or in other words, electrons in Graphene are 'neutrino-like particles'.

This opened new avenues for testing some of the predictions of relativistic quantum mechanics or QED; those were not having been observed yet in any of the particle physics experiments. Klein paradox (relativistic particles can penetrate any potential barrier of any height 'without' any reflection component) is supposed to be the reason for the enhanced Graphene's conductivity and reflectionless tunneling (hopping from A to B) of Dirac fermions through the potential barriers of Graphene's lattice. But, the electrons in Graphene are many ways different from the fermions in QED. The physics of electron-electron interaction in Graphene is different and is not a photon assisted one. Moreover, unlike 2D QED, the interaction between electrons in Graphene is not a Lorentz invariant. Hence, Graphene depicts a new system and platform, where its particle move relativistically but interact non-relativistically. Further, it also contradicts the notion of localized electrons in 2D systems, where it assumes to follow the argument of Dirac fermions that 'it always remains delocalized'. Quantum Hall effects (in that, opening of additional Landau levels in sufficiently high magnetic fields) and other transport properties, zero bias photocurrent in Graphene-metal contacts (due to band bending), wide range optical absorption, optical transparency, and mechanical stability are some examples of the present research scenarios in Graphene system. The applications of Graphene and their hybrid systems (with nanoparticles/ nanotubes/other Graphene) in the fields of energy storage, electronic devices and solar cells are also being the other hot topic of research.

Now comes the real and intriguing competition between theory and experiment (or science and technology); the real properties of Graphene in a substrate are far from the isolated one. For practical purposes, we need to synthesize these structures in a substrate. The superior properties derived for Graphene are applicable to the freestanding ones. Once the interaction with environment comes, these outstanding properties seem to be faded (that is not only the case of Graphene but many other nanosystems, and there comes the real role and challenge of Nanoscience and Nanotechnology). Another property which isolate Graphene from other nanosystems is that one layered (single layered)/ two layered/ three layered….Graphene are different entities. Or in other words, it is hard to compare a single layered Graphene properties with a double layered and so on and generalization is almost impossible (though a few people believe this exist in certain properties such as capacitance, it is hard to generalize them). Many methods have been successfully experimented for the synthesis of Graphene. Other than the mechanical exfoliation (ex: scotch tape method, as synthesized by Novoselov et al. Science 2004), ultrasound cleavage of graphite (in solution), CVD processes over a verity of metal and non-metal surfaces, reduction of graphene oxide (after exfoliation and complete oxidation of graphitic flakes (powders), for ex: modified Hummer method) and cutting of nanotubes/cages by metallic nanoparticles (nano ribbons) are some of the general methods (there are many sub routes in each of these methods) successfully adopted for the synthesis of Graphene in laboratories. Successful synthesis of identical bulks of Graphene sheets still remains as a challenge and efforts are underway, though they can be easily characterized (to find whether it is a single layered or multilayered) using established techniques such as Raman spectroscopy (of course, AFM is there, but AFM is too difficult for a bulk analysis compared to Raman).

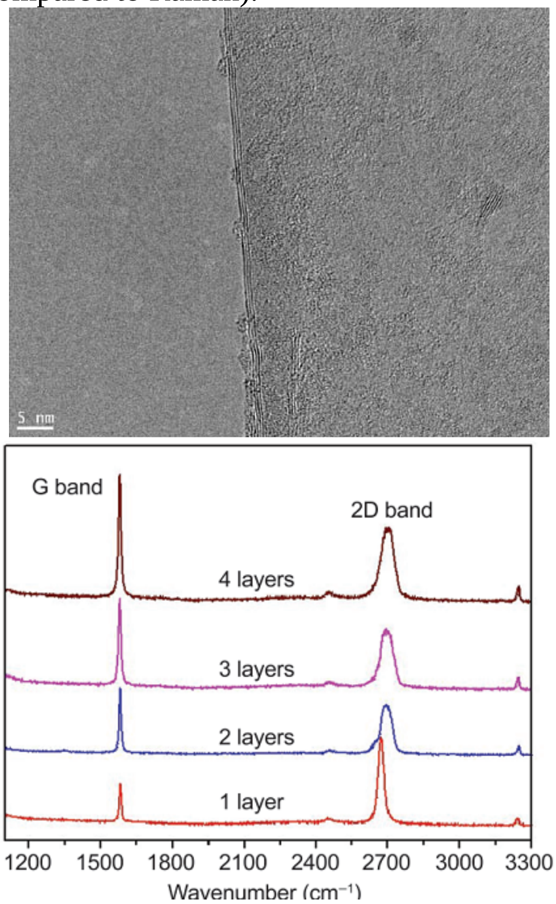

Figure 2: (a) TEM image of 3 layered Graphene, (b) Raman spectroscopy studies on various layered Graphene (comparison of 2D and G peak intensity ratio will give evidence for number of layers). [Though according to latest IUPAC naming; the term 'Graphene' denotes for single layer, people are using this term upto 7-10 layers- since then only the Raman spectrum will 'fade' into that of Graphite (other words, ABAB stacking re-enter)].

It may be a mere coincidence that Carbon Nanotechnology again appreciated via Nobel Prize during the 25th celebration of Fullerene discovery, this year. It gives me pleasure to sit in the Hall of Fame of Smalley Research Institute (Rice University) along with the big names and pioneers in Carbon nanotechnology such as Prof. Kroto, Prof. Curl, Dr. James Heath, Prof. Endo, Prof. Huffman, Prof. Geim, Prof. Dresselhaus, Prof. Ajayan and so on. Moreover, as a beginner, it brings more encouragement on hearing Prof. Geim that 'it is only the beginning and a lot can still achieved from these nanostructures'.

The technology driven society always asks the question, what are the uses of these materials?!! I wish to quote the words of famous scientist Michael Faraday, "I don't know, but someday you will tax it".

References: (*a few*)

1. K S Novoselov et al. *Science* 306 666-669 (2004).
2. A K Geim et al. *Nature Mater.* 6 183-190 (2007).
3. P K Wallace *Phys. Rev.* 71 622 (1947).
4. K S Novoselov et al. *PNAS* 102 30 10451-10453 (2005).
5. A K Geim (Review) *Science* 324 1530-1534 (2009).
6. A K Geim et al. *Scientific American* (www.sciAM.com) 93-97 (2008).
7. W Gao et al.*Nature Chem.*1 403-408 (2009).
8. L E Ana et al. *Nano Lett.* 10 2 366-372 (2010).

Plasma Actuators in Aerodynamic Air Flow Control

M.P.Revathy, 3rd semester MSc Physics, Department of Physics, CUSAT

With the vision of improving aircraft performances such that the environmental impacts are reduced, studies are being carried out to find novel solutions to influence air flow using simple actuators. If the aerodynamic configuration of future aircraft could be modified in real time in flight, then the performance of the aircraft can be made to correlate with the optimum characteristics which would lead to reduced fuel burn through improved lift and less drag. This can also be used to reduce the speed for shorter and steeper landing and take-off paths thereby reducing ground noise. This could provide faster cruise speeds at higher altitudes. Since the current wing designs and the complex control surfaces on them lead to major gain in weight of the aircraft, the active actuators would make a more simple and efficient replacement.

Of the many proposals for active actuators, plasma based technology is seen to be very promising. Such an actuator is seen to excel both from a performance point of view and in terms of the diversity in potential applications from external and internal flow control, combustion, enhancement and noise attenuation. The main advantages of plasmas devices are their manufacturing and integration simplicity, low power consumption, ability for real-time control at high frequency and their robustness.

In an experiment conducted by Malik et al, in 1983, ion wind on a flat plate was used for a small reduction in the drag (of approximately 5%) in the turbulent boundary layer for longitudinal Reynolds numbers of the order of 10^6. For lower Reynolds numbers (10^5), it became possible to reduce the viscous drag of flow by 50% using a corona discharge between spaced fine wires on a flat surface for both a direct current and an alternate current of low frequency (60 Hz)(El-Khabiry and G. M. Colver, in 1997). Based on the experiments conducted by Roth et al, in 1998, it was found that Spark discharges could reduce aerodynamic drag in glow discharges up to 6 % and slight changes in filamentary discharges. In the year 2003 J.R. Roth invented glow discharge plasma actuators that can produce sufficient quantities of glow discharge plasma in the atmosphere pressure air helps to yield an increase in flow control performance.

Plasma actuators can be created on the basis of different atmospheric-pressure discharges: a corona discharge, a dielectric barrier discharge, and a homogeneous glow discharge. The use of plasma actuators makes it possible to ensure a purely electrodynamic linkage between the electric field in the plasma and the neutral gas in the boundary layer. This linkage is sufficiently strong to produce aerodynamically important effects, including the increase or decrease in the aerodynamic drag on a flat plate, rearrangement of the flow near the wing at high angles of attack, and peristaltic induction of a neutral gas flow by a moving electrostatic wave on the surface in flow.

A high-frequency barrier discharge formed near the surface in flow can successfully be used in technical devices intended to reduce the aerodynamic drag of aircraft. The gas-discharge plasma is fairly rigidly bound to the electrodes and is virtually not blown away by the incident flow. The formation of filamentary structures in the discharge leads to a limitation of the maximum velocity of the induced flow and a reduction in the operating efficiency of the device. This effect can be gap. Furthermore, minimized by selection of the appropriate dielectric and the size of the inter-electrode the formation of filamentary structures the discharge is prevented by the presence of the external flow; therefore, in the case of blowing of the discharge gap its operating efficiency is considerably improved.Therefore, active actuators based on plasma technology can revolutionize the aviation arena by improving the aerodynamic performance in the most environment-friendly fashion.

NANOMACHINES

M.Junaid Bushiri, Reader
Department of Physics, Cochin University of Science and Technology, Kochi

Technology based on nanostructured materials is promising one and advancing very fast and expected to replace conventional technologies in coming years. Nanomachines (nanite) are one of the important products of this new technology, which can perform mechanical or electromechanical functions. Nanomachines are similar to ordinary machines in terms power utilization and resultant mechanical work. These motors will work by using energy from external or internal sources and do mechanical work. As compared to its bulk or micro sized counterparts, nanomachines are built by individual atoms and miniature in size ranging from 1.5 to 100 nm. In some cases these may contain many nano machines self assembled or intentialy aligned in a specific pattern to do certain functions.

Nature has made several hundreds of nanomachines, before the origin of the idea of nanomachines in human brain. These machines are working very efficiently and safeguarding living organisms in the universe. Living cells have miniaturized machines which play active role in synthesis of proteins which draws energy from living cells metabolic activities. At the same time man made nanomachines can be used for various applications such as treatment of cancer, counting of a specific molecule in a sample, as mechanical lubricants, gear system, muscle and bone growth stimulators etc. But the design, development and specific application oriented production of nano machines are only in the budding stage of the technology.

Moving parts of synthetic nanomachines are made of carbon nanotubes, metals, or semiconductor nanowires, and mainly driven by an electrical source of energy. Some of the nanomotors derive on-board or off-board power from in-situ chemical reactions[1]. Nanites work faster because of smaller size and require a little space for installation or fixing. Another major advantage of these machines is it requires less amount of energy for it functions. These machines are more durable than ordinary machines. The development of new nanomachines will advance in future with the growth of nanoscience with combined efforts of scientists working in basic science.

For Further Reading

G. A. Ozin,* I.Manners,S.Fournier-Bidoz, and A. Arsena; Adv. Mater. 2005, 17, 3011–3018.

Condolence Message

Prof.G.Aruldas

Our distinguished alumnus member and a profound academician Prof.G Aruldas passed away on 16th July 2010**.** He was a former faculty of our Department and he retired as a Professor from University of Kerala. We have lost one of the great teachers of our times. We express our heartfelt condolences in his demise**.**

Dr. Ravindran

We, the Alumni of Physics, CUSAT express our profound grief on the very unfortunate and shocking demise of Dr. Ravindran, Chairman ISNT Trivandrum and his wife Dr. Suda Ravindran in an accident on 19/05/2010. Dr. Ravindran was former student of our Department (1976-78). He joined in VSSC in 1978 as young scientist. He was bestowed with many awards including National NDT Award 2003 for his contribution to the developments in space vehicles.

Ph.D Awarded During the Year 2009-2010

Name of the Scholars	Title of the Thesis	Guide	Year
Saji K. J.	Amorphous Oxide Transparent Thin Films; Growth, Characterisation and Application to Thin Film Transistor	Dr.M.K Jayaraj	2009
Mini Krishna K.	Synthesis and Characterisation of Zinc Gallate based Phosphors for Thin Film Electroluminescent Devices	Dr.M.K Jayaraj	2009
Anoop G	Synthesis, Growth and Characterization of Oxide Phosphors for Thin Film Electroluminescent Devices	Dr.M.K Jayaraj	2009
Tina Sebastian	Automation of chemical spray pyrolysis unit and fabrication of sprayed $CuInS_2/In_2S_3$ solar cell	Dr. C Sudha Kartha	2009
Deepa K G	Preparation of sub-micrometer thick CuInSe,films using sequential evaporation technique for device fabrication	Dr. C Sudha Kartha	2009
V C Kishore	Development of photorefractive polymers: evaluation of photoconducting and electro-optic properties.	Dr. C Sudha Kartha	2009
Vijutha Sunny	On the synthesis and characterization of magnetic metal and metal oxide nanostructures	Dr.M.R Anantharaman	2010
T N Narayanan	Template assisted fabrication of 1-D nanostructures of Nickel, Cobalt, Iron Oxide and Carbon nanotubes and a study on their structural, magnetic and nonlinear optical properties for applications	Dr.M.R Anantharaman	2010
E Muhammad Abdul jamal	Preparation and characterization of magnetic and non-magnetic nanosized spinel oxides, Nickel nanoparticles and Nickel polymer nanocomposites	Dr.M.R Anantharaman	2010
KRaveendranadh (PhD awarded postmously)	Lithium containing complex metal Oxides and metal phosphides ; Investigation on their synthesis and various characterization for rechargeable Lithium battery applications	Dr. S. Jayelekshmi	2010
Amirthesh M	Investigations on some selected conducting polymer and polymer composites for possible optoelectronic applications	Dr. S. Jayelekshmi	2010

Arun K J	Investigations on growth and characterization of some technologically important single crystals for Non- linear optics applications	Dr. S. Jayelekshmi	2010
Senoy Thomas	Fabrication of thin films and nano columnar structures of Fe-Ni amorphous alloys and modification of its surface properties by thermal annealing and swift heavy ion irradiation for tailoring the magnetic properties	Dr.M.R Anantharaman	2010
Meril Mathew	Engineering the properties of indium sulphide for thin film solar cells by doping	Dr.C Sudha kartha	2010
Veena Gopalan E	On the synthesis and multifunctional properties of some nanocrystalline spinel ferrites and magnetic nanocomposites	Dr.M.R Anantharaman	2010