Prof. M.S. Ramachandra Rao, *FInstP*
Department of Physics/NMMTC/MSRC/DSEHC

"Prof. R. Srinivasan Institute Chair Professorship"

Report

Date: 14.09.2020 (Monday); 03:00 pm

- **Introduction of the Chair Occupant:**

- **Name: Dr. M.S. Ramachandra Rao, *FInstP***
- **Designation: Professor**
- **Education Background: M.Sc. (Physics), IIT Kharagpur;**
  Ph.D. (Experimental Solid State Physics), IIT Kharagpur

Experience:

→ After Master's and Ph.D. at IIT Kharagpur, MSR pursued Postdoctoral Research work, at CNRS, Bellevue, France in the area of high temperature superconductivity.

→ He was then a visiting fellow at the Tata Institute of Fundamental Research (TIFR) before joining IIT Madras in 1995 as Asst. professor.

→ He was awarded the Alexander von Humboldt Fellowship (1999) at the University of Cologne, Germany where he worked on GMR/TMR aspects that are the backbone for present-day hard-drive technology. He was also a JSPS fellow and JST fellow at Kyushu University, Japan.

→ He has been a part of the Erasmus Mundus Master's program since 2007. He teaches in that program and about 25 students (M.Sc. And B.Tech.) from IIT Madras were sent as Master's students. Because of his involvement in teaching and research in this program, IIT Madras has been made a non-European partner Institute.

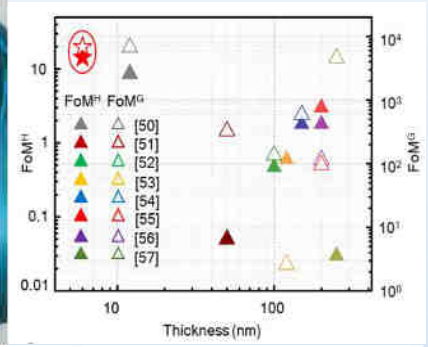
→ Prof. MSR Rao is a long-serving board member (since 2005) and section editor (Condensed Matter: Advanced and Quantum Materials) of J.Phys.D. Appl. Phys, Institute of Physics Publishing, UK.

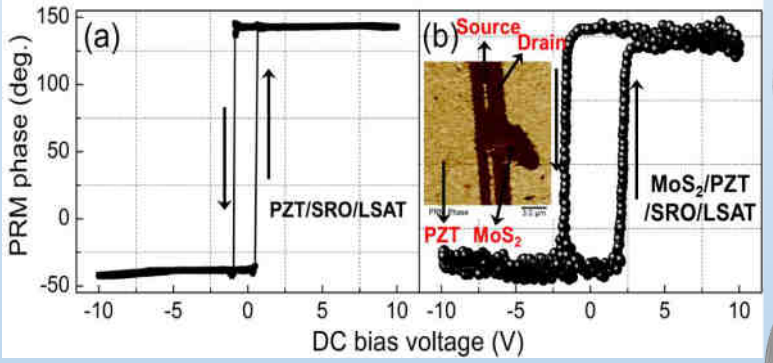
***Link to webpage**: www.physics.iitm.ac.in/~msrrao*

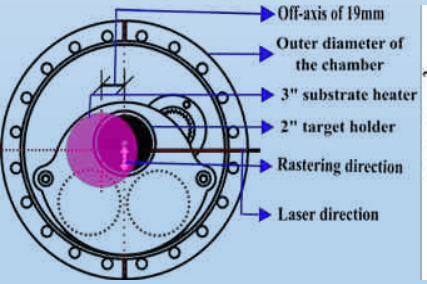
Broad Area of Research

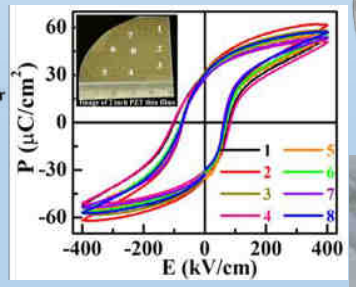
Overview of your Research:

Direct growth of large area, transparent rGO by Pulsed Laser Deposition





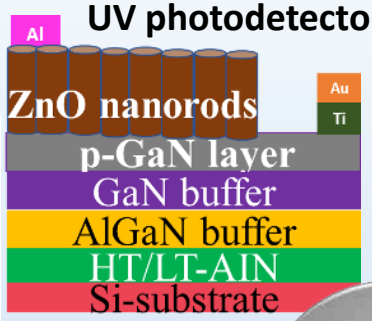


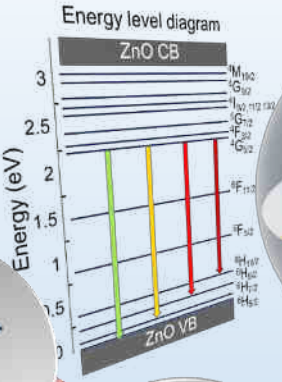


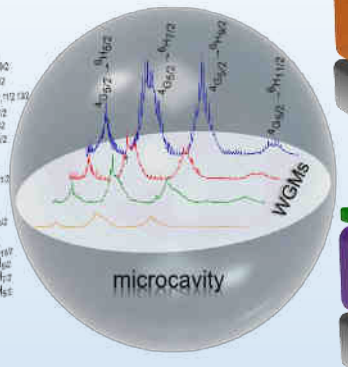
Schematic of raster scanning mechanism for large area PZT thin film

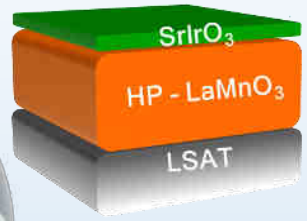
Making diamond n-type: Highly conducting phosphorus implanted diamond

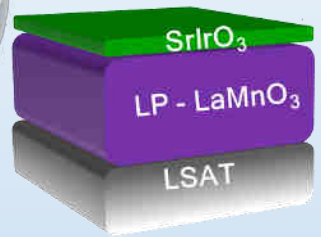
UV photodetector based on ZnO/ p-GaN heterojunction

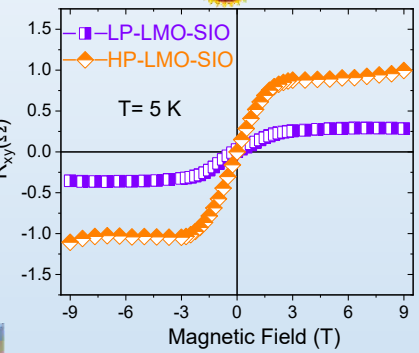


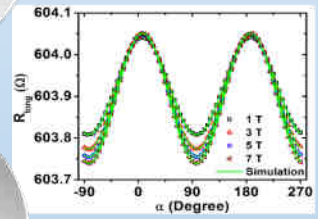


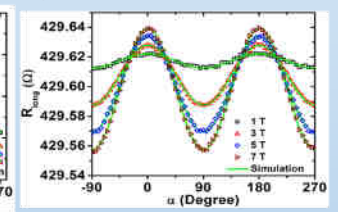




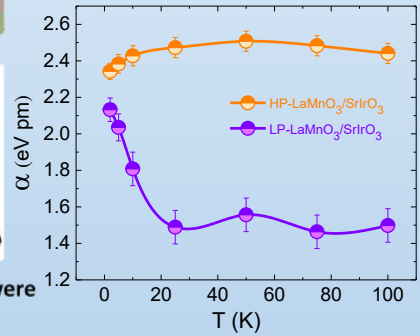




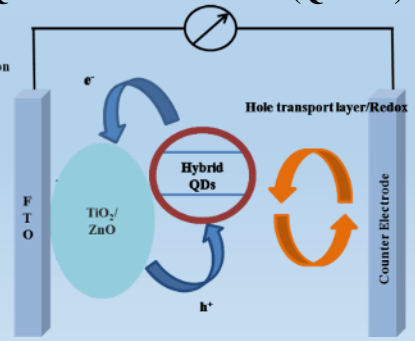


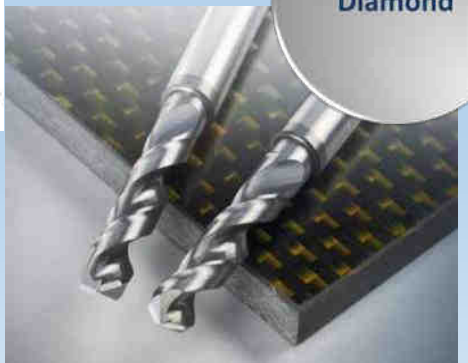


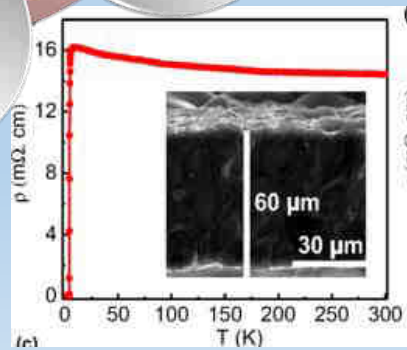
➢ Bi:YIG/Ga:ZnO/Pt trilayers and Bi:YIG/Ga:ZnO bilayers were investigated using ADMR measurements.

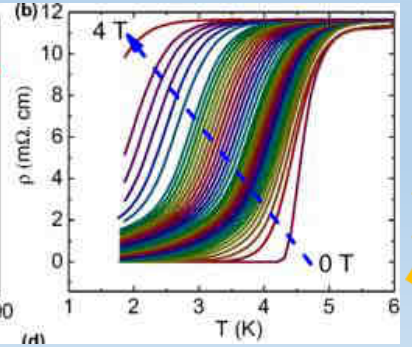


Schematic diagram of Quantum dot solar cells (QDSCs)









High-pressure behavior of superconducting boron-doped diamond

Specific Research Areas

- **Motivation for my research:** It has always been a passion for me to teach through the learning gained from advanced level research - I have always believed in doing experiments and implement ideas for useful applications (Industry and societal), at the same time contributing immensely to basic research.
- **Contribution to the societal problems** (if any)

➢ Development of high performance and low-cost boron-doped diamond electrodes for waste-water treatment (Imprint project) – in the process of research on BDD electrodes, we have realized that ozonated water can be produced as a disinfectant liquid (a product will come out within 6 month).

➢ Mechanical coatings with diamond for Defence applications. (1st prize National Award in the DRDO Date-to-Dream contest (PM's initiative).

➢ Large area PZT for underwater SONAR devices in collaboration with NPOL Kochi (DRDO).

➢ Nanoparticle synthesis and hyperthermia studies for cancer treatment in collaboration with Sree Chitra Tirunal Institute for Medical Sciences and Technology, Trivandrum).

Papers: 250+

Specific Research Areas:

MSR's i10 Index: 98

- Research impact (in general)

✓ After Ph.D., one of the highlights of MSR's work was that Pr-ion had no additional effect on the T_c suppression unlike Pr in Y-123 system (*Phys.Rev.B. 50 (1994) 6929)* and not Abrikosov-Gorkov pair breaking was responsible for T_c suppression.

✓ He also contributed immensely to the microwave applications of high T_c films (*Appl.Phys.Lett. 68 (1996) 1720)*. Prof. Rao as a faculty at IIT Madras has established a full fledged thin film growth laboratory and performed commendable work on correlated effects in manganites by demonstrating the effect of internal field due to Ho^{3+} substitution in LCMO (*Philosophical Magazine 83 (2003) 1631).*

✓ He also showed the importance of using an alternative insulating barrier in the study of magnetic tunnel junctions (*J.Phys.D. Appl.Phys. 35 (2002) 287*). In recent years, Prof. Rao has done some pioneering work on the correlation effects and stabilization of p-type conductivity in ZnO (*Phys.Rev.B. 80 (2009) 45210 & APL 96 (2010) 232504*).

✓ He has established a nanotechnology centre that also deals with industry related problems using nanocrystalline diamond coatings (*Diamond Rel. Mater. 44 (2014) 71*). His recent work involves observation of superconductivity in boron doped diamond.

- Current happenings/status of this research

- **Our Diamond research has achieved tremendous expertise in the growth of high quality microcrystalline diamond (MCD) and nanocrystalline diamond (NCD) films using hot filament chemical deposition (HFCVD) technique. During a span of 10 years, this group has been able to demonstrate their capability in so many ways that could benefit Industry requiring diamond coating applications on complex shaped tools, dealing with factors such as uniformity, adhesion and surface smoothness of the coatings. This work has led to the incubation of a company in IITM research work.**

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IIT Madras-incubated Start-up Kapindra develops Novel Diamond Coatings

Based on a technology developed by an IITM Research Group, this diamond coating technology has applications in Aerospace, Defence, Medical & Electronics industries; Kapindra was adjudged '#1 Start-up' in 'DRDO Dare to Dream Innovation Contest'.

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New Delhi February 10, 2020 UPDATED: February 11, 2020 12:05 IST

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IIT Madras-incubated start-up develops diamon coatings

Defence establishments of many countries have been working on heat dissipation issues, which pose a major hurdle stability of missiles upon re-entry.

EDUCATION Updated: Feb 13, 2020 11:47 IST

HT Correspondent
Hindustan Times, Madras

Representative photo(Bloomberg)

Indian Institute of Techn
Engineering has develop
dissipation (thermal mar
into earth's atmosphere

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IIT-M's diamond coatings to aid missiles entry into earth

CHENNAI: The Indian Institute of Technology-Madras (IIT-M) incubated deep-tech start-up Kapindra Precision Engineering has developed diamond coatings that could aid Indian scientists working on heat dissipation (thermal management), a major issue for hypersonic missiles during their re-entry into earth's atmosphere where they experience destructive high temperatures (more than 2,400 Deg C).

Defence establishments of many countries have been working on heat dissipation issues, which pose a major hurdle to aero-dynamic stability of missiles upon re-entry. Based on their technology, Kapindra, a deep-tech start-up, was adjudged as the '#1 Start-up' in the 'DRDO Dare to Dream Innovation Contest' for its specialised product offering.

The start-up came from technology developed at IIT Madras' Nano Functional Materials Technology Centre (NFMTC) and Materials Science Research Center (MSRC) led by Prof M S Ramachandra Rao, Department of Physics, IIT M. Kapindra Precision Engineering works on development and application of specialized coatings for components used in strategic products that demand extreme tribological performances to reduce friction, wear and promote heat dissipation at contacting surfaces, a release from IIT-M said on Monday.

High quality thin film coatings were required for UV and IR detection/sensing, underwater SONAR devices, surface acoustic wave devices, pressure sensors and actuators, among others.

Prof Ramachandra Rao said, "Stronger adhesion to tools and components is required to transmit larger loads and enhance coating/tool life. Currently this comes at a cost of functional performance in the form of higher friction and wear. So how can the coating adhesion to the substrate be improved, while ensuring required tribological performance of low friction and wear?–this is the problem we are trying to solve."

CHENNAI BASED START-UP USES DIAMOND TO HELP HYPERSONIC MISSILE RE-ENTRY

WEDNESDAY, FEBRUARY 12, 2020 **BY** INDIAN DEFENCE NEWS

based tech start-up has developed a technology that can be used in Indian
missiles during their re-entry into Earth's atmosphere

A Chennai based tech start-up has developed a technology that can be used in
rsonic missiles during their re-entry into Earth's atmosphere. Hypersonic missiles,
of Physics, IIT Madras.

'Diamond an ultimate material for space tech'

Rao termed diamond as an ultimate engineering material with a plethora of application prospects and states that it is the material to explore for 'quantum computing' with the creation of 'N-V centres in diamond' – a very challenging and futuristic area of research.

Kapindra Precision Engineering works on development and application of specialized coatings for components used in strategic products that demand reduction of friction, wear and tear, and promote heat dissipation.

Kapindra's unique diamond coating technology through its special patented microstructure, offers better surface adhesion on the substrate-side while providing lesser friction and wear on the functional-side on various types of substrate materials and shapes.

Heat dissipation made effective

Start-up uses diamond to help missile re-entry

EXPRESS NEWS SERVICE
Chennai

A Chennai based tech start-up has developed a technology that can be used in Indian hypersonic missiles during their re-entry into Earth's atmosphere. Hypersonic missiles, which travel at speeds greater than the speed of sound waves, face destructively high temperatures (>2,400oC) during their re-entry into earth's atmosphere.

Kapindra Precision Engineering, a tech start-up incubated by Indian Institute of Technology, Madras (IIT-M), developed diamond coatings that can aid effective heat dissipation in such scenarios, said a statement issued by IIT-M on Monday.

The technology proposed in this involves growing a protective layer (few microns thick) consisting of thin films of diamond. It is interesting to note that even though diamond is electrically insulating, its thermal conductivity (2,000 Wm-1K-1) is 5 times that of copper. So, diamond coatings act as heat-spreaders in electronic devices and find applications in space technology.

Heat dissipation made effective

The usage of diamond is substantiated by its thermal conduction property, which is 5 times that of copper. Diamond coatings can act as heat spreaders in electronic devices and in space technology applications.

Defence establishments of many countries have been working on heat dissipation issues, which pose a major hurdle to aero-dynamic stability of missiles upon re-entry. Usually, improper and inadequate dissipation of heat, during re-entry of missiles, leads to its intense wear and tear.

Based on their technology, Kapindra was adjudged as the '#1 Start-up' in the 'DRDO Dare to Dream Innovation Contest' for its specialised product offering. The start-up came from technology developed at IIT Madras' Nano Functional Materials Technology Centre (NFMTC) and Materials Science Research Center (MSRC), led by Prof MS Ramachandra Rao, Department of Physics, IIT Madras. P3

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Chennai based start-up uses diamond to help hypersonic missile re-entry

A Chennai based tech start-up has developed a technology that can be used in Indian hyper-sonic missiles during their re-entry into Earth's atmosphere.

Published: 11th February 2020 06:22 AM | Last Updated: 11th February 2020 08:10 AM

For representational purposes

By Express News Service

CHENNAI: A Chennai based tech start-up has developed a technology that can be used in Indian hypersonic missiles during their re-entry into Earth's atmosphere

Students contributions (who were involved in Research)

Maneesh Chandran
Assistant Professor, NIT Calicut

Brajesh Tiwari
Assistant Professor, Physics, IITRAM Ahmedabad

Pius augustine
Assistant Professor, S. H. College, KERALA

Shubra singh
Assistant professor, Crystal Growth Centre,Anna University

E.Senthil kumar
Assistant Professor, SRM University, Chennai

K.Mohankant
Assistant Professor, VNIT Nagpur

Ravikumar Dumpala
Assistant Professor, VNIT Nagpur

P.Thiyagarajan
Assistant Professor of Physics, Anna University

Dinesh kumar
Postdoctoral fellow at TIFR Mumbai

Muvvala Krishna surendra
Senior Research Engineer at Saint Gobain Research

Joy Narayan Mukherjee
Postdoctoral fellow at TIFR Hyderabad

Martando rath
Post Doctoral fellow CNRS, France

Kapil gupta
PDF, National Cheng Kung University, Tainan City, Taiwan

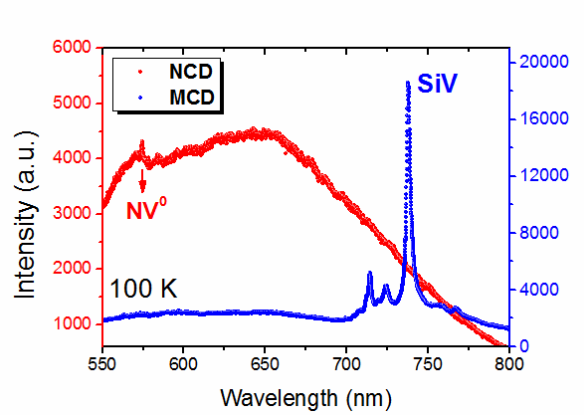
B.Ramachandran
Postdoctoral Researcher, National Dong Hwa University,Taiwan

AV radhamani
postdoctoral fellow, NUS

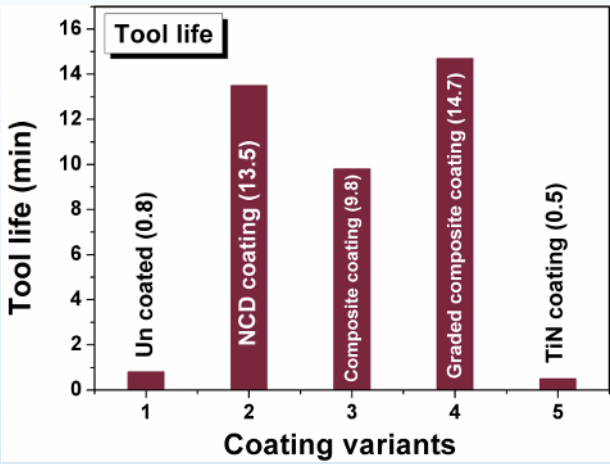
Plans for the year 20-21

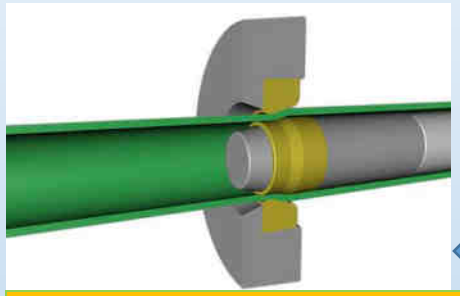
- **Go full-steam on diamond research: Diamond membranes, coatings for space, defence and societal applications.**

- **On the physics front – doping studies in diamond are very important to realize NV-centres for quantum computing.**



Cutting tools





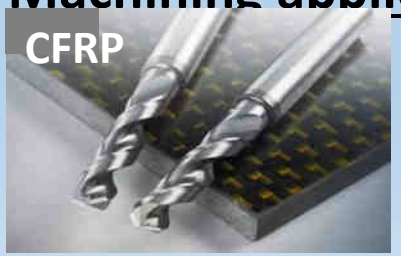
Tube drawing dies

CVD Diamond for mechanical application

Mechanical seals

Metal forming applications

Machining applications



Drilling of CFRP

Milling of CFRP

Societal impact

Diamond (Free-standing/ membranes)

- Radiation detectors for cancer treatment (5-10 Y)
- Surgical Knives (0-2 Y)
- Heat spreader in electronic chips (3-5 Y)

Doped Diamond

- Electrodes for Water purification, biomolecule sensing etc. (0-2 Y)
- Superconducting devices (SQUID) (3-5 Y)
- High power and radiation hard electronic devices (5-10 Y)

Diamond with NV-Centres

- Ultra-sensitive, high-resolution magnetometers (3-5 Y)
- Superconducting devices (SQUID) (3-5 Y)
- Nanoscale Magnetic resonance imaging (nano-MRI) (10-15 Y)

Diamond-based Devices

- Deep UV detectors (3-5 Y)
- Radiation hard nano-scale multi-colour LEDs (5-10 Y)
- Cantilevers for MEMS applications (5-10 Y)

Thank you note from Chair Occupant

- **I would like to thank the Institute for awarding me the 'Institute Chair Professorship' in 2018.**
- **I was extremely happy when Shri. V. Shankar, Founder CAMS Pvt. Ltd., and Distinguished Alumni Awardee of IIT Madras Sponsored the chair that has come to be named as 'Professor R. Srinivasan Chair'. I am the first occupant of Prof. R. Srinivasan (Prof. RS) Chair in the department of Physics. Prof. RS is a venerable teacher and a great researcher. We all emulate him in many ways and for me, to be called a 'Prof. R. Srinivasan Chair Professor' is more than just a honour.**
- **I thank Shri. Shankar for the sponsorship money provided to create Prof. RS Chair. Without this generosity of the donor, the tag would be just an Institute Chair Professor after my name, however now it is Prof. M.S. Ramachandra Rao, *Prof. R. Srinivasan Chair Professor*.**

I wholeheartedly thank Shri. Shankar once again for being the donor for this Prestigious Chair.

Thank you,

Shri. Shankar

DAA, IIT Madras
Founder @ CAMS Pvt. Ltd.

Link to my web-page:

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