

Delhi Babu Prabhu

Scientist
Centre for Automotive Energy Materials (CAEM)
International Advanced Research Centre for Powder
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Education

July 2014 – till date	Scientist ‘C’ Centre for Automotive Energy Materials ARCI, Chennai 600 113
May 2012 – June 2014	Scientist (Contract) Centre for Automotive Energy Materials ARCI, Chennai 600 113
Oct 2010 – Mar 2012	Post Doctoral Fellow Magnetic Materials Centre National Institute of Materials Science Japan 305 0047
Jan 2009 – Sep 2010	Research Associate Department of Materials Engineering Indian Institute of Science Bangalore 560 012
Mar 2002 – Jan 2009	Research Scholar (Ph.D) Materials Science Centre, Department of Physics University of Madras, Chennai, India
Sep 1999 - June 2001	Masters Degree in Physics, Materials Science Centre, Department of Physics University of Madras, Chennai, India
July 1996 - June 1999	Undergraduate in Physics, Loyola College, Chennai, India (Affiliated to University of Madras, India)

Skills: Technical

- **Materials Preparation and Processing**
 - Jetmilling technique (powder micronizing technology)
 - Rapid solidification processing (melt spinning, suction and injection casting)
 - High Vacuum and UHV melting units
 - Arc metling
 - Induction melting
 - Quartz tube vacuum sealing
 - Ball milling
 - Soft chemical methods for synthesis of oxides and metallic nanoparticles
- **Characterization Techniques Handled**
 - BH Loop Tracer for Hard and Soft Magnetic Materials (Laboratorio Eletrofisico, Italy)
 - Pulse magnetizer (Laboratorio Eletrofisico, Italy)
 - Magnetic In-Field Press (Tamakawa, Japan)
 - Coercimeter (Laboratorio Eletrofisico, Italy)
 - Transmission Electron Microscopy (Tecnai20)
 - Scanning Electron Microscope (Carl Zeiss CrossBeam 1540EsB, Quanta)
 - X- Ray Diffractometer (Huber, Seifert ,JEOL JDX 8030, Panalytical XpertPro powder, Rigaku diffractomers).
 - Differential scanning calorimeters (Perkin elmer DSC-7 and Mettler Toledo 823e instruments)
 - Thermogravimetric analyzer (Perkin elmer TGA-7, Netzsch STA 409 and TA Q500 TGA)
 - SQUID VSM (Quantum Design)
 - Vibrating Sample Magnetometer (EG&G Parc, Model 4500 and Microsense EZ9)
 - Mössbauer Spectrometer (Wiessel, Germany and Nucleonix India)

Research Experience

Doctoral Thesis Title: “Magnetic and Electrical Properties of Nanocrystalline Magnetic Materials”

Summary of the Thesis

The thesis main focus is on the effect of Al substitution in enhancing the soft magnetic properties of the nanocrystalline soft magnetic materials namely FINEMET, NANOPERM and HITPERM. We have concluded from our results that Al is though dia-magnetic has an effect on the crystallization process where in it is found to enhance the number of crystallites and refine the grain size resulting in

better soft magnetic properties due to better averaging effect of the random anisotropy. The nature of exchange interaction in these alloys has also been explored and has been found to be of the Heisenberg type involving the next nearest neighbours.

The thesis has also one chapter on ferrites where we have explored the effect of grain size on the magnetic and electrical properties of CuFe_2O_4 and from these results determined that the tetragonal to cubic phase transition temperature decreases with grain size.

The thesis also discusses the design and construction of the indigenously built inert gas melt spinning unit which was used for the synthesis of all the amorphous alloys used in the thesis.

Other research interest: Synthesis and characterization of metallic and alloy magnetic nanoparticles with controlled grain size using environmental friendly soft chemical routes, synthesis and characterization of magnetic oxides in the nano domain with potential bio medical applications, exploring magnetic ion doped oxides for DMS applications, magnetic characterization of exchange spring magnets like NdFeB and magnetic and crystallization behaviour of rapidly quenched Fe based metallic alloys.

Current Research: Synthesis and microstructural characterization of ultra-high coercive hard magnetic materials for industrial application. Preparation of high coercive sintered SmFeN and Dy free NdFeB magnets using Spark Plasma Sintering.

Synthesis and microstructural characterization of Fe-P for motors in automotive applications.

Instruments Installed and Fabricated:

- Design and setting up of indigenously built Vacuum Melt Spinning unit
- Design and setting up of indigenously built Vacuum Injection Casting unit
- Design and setting up of in-house high temperature Seebeck coefficient measurement set up.
- Installation and commissioning of Nucleonix Mössbauer spectrometer
- Installation and commissioning of Heutinger TIG 20/300 induction furnace

Additional Skills Acquired

- 3 dimensional atom probe analysis using PoSAP software.
- Operation and maintenance of Vacuum systems.
- Operation and handling of low temperature cryostats.
- Vacuum sealing of quartz tubes for vacuum annealing purposes.
- Well versed in Mössbauer spectrum fitting routines [Bent program (fitting crystalline spectrum), Windows (fitting amorphous spectrum) and Le-caer (fitting crystalline and amorphous spectrum simultaneously)]

Fellowships / Scholarships

- Selected for Visiting Student Research Program (VSRP) of Tata Institute of Fundamental Research, India from May 2000 to July 2000
- Project Fellow in the DRDO project “Nanocrystalline Soft Magnetic Materials For High Temperature Applications” – July 2001 to March 2004

- Senior Research Fellow of the Council of Scientific and Industrial Research, India April 2006 to till date
- “Indian Institute of Science Research Associateship” of the Indian Institute of Science, Bangalore 1st April 2009 to 31st September 2010.

Awards and Honors

- **First prize** in the State level PG Technical Seminar competition conducted by Indian Spectrophysics Association
- **Best paper presentation** award in the National Seminar on Advances in Materials Science held at Manonmaniam Sundaranar University, Tirunelveli, 2006
- **Best paper presentation** award in the 20th Student Annual Symposium held at Indian Institute of Science, Bangalore 12, January 2007.
- **Best Micrograph** award in the 23rd Student Annual Symposium held at Indian Institute of Science, Bangalore 21-22, January 2010.
- **Best Poster** award in the International Conference on Multifunctional Nanomaterials and Nanocomposites held at Bharathiar University, Coimbatore 4-5 February 2010.

Editorial Experience

- ❖ **Reviewer** for Journal of Materials Science
- ❖ **Reviewer** for IEEE Transacation of Magnetics

Skills: Computer Related

Platforms	: Windows
Programming	: Fortran
Packages	: MS Office, Microcal Origin, Adobe Photoshop, Peakfit, XRDA, Traces, X-pert Pro, Mössbauer fitting routines namely Bent, Windows, Le-caer programmes,

List of Publications

Research works Accepted/published

- 1) Effect of iron on the enhancement of magnetic properties for cobalt based soft magnetic metallic glasses.
Medha Veligatta, Shravan Katakam, Santanu Das, Narendra Dahotre, R. Gopalan, **D. Prabhu**, Aravindh Babu, Haein Choi-Yim, Sundeep Mukherjee
Met. and Mat. Trans. (accepted 2015)
- 2) On the temperature dependent magnetic properties of as-spun Mn-Bi ribbons
S. Kavita, U.M.R. Seelam, **D. Prabhu**, R. Gopalan
Journal of Magnetism and Magnetic Materials **377** (2015) 485
- 3) AC magnetic properties and core loss behaviour of FeP soft magnetic sheets
S. Manna, **D. Prabhu**, V. Srinivas, R. Gopalan
IEEE Transactions on Magnetics **50** (2014) 2008604

- 4) Facile in situ growth of Fe₃O₄ nanoparticles on hydroxyapatite nanorods for pH dependent adsorption and controlled release of proteins†
G. Bharath, **D. Prabhu**, D. Mangalaraj, C. Viswanathan and N. Ponpandian
RSC Adv., **4** (2014) 50510
- 5) Mn²⁺ ion influenced optical and photocatalytic behaviour of Mn–ZnS quantum dots prepared by a microwave assisted technique†
S. Joicy, R. Saravanan, **D. Prabhu**, N. Ponpandian and P. Thangadurai
RSC Adv., **4** (2014) 44592
- 6) High saturation magnetization in Fe-0.4 wt.% P alloy processed by a two-step heat treatment
S. B. Chandrasekhar, D. Prabhu, M. Gopinath, V. Chandrasekaran, M. Ramakrishna, V. Uma and R. Gopalan
Journal of Magnetism and Magnetic Materials **345** (2013) 239.
- 7) Coercivity enhancement of rapidly solidified Nd-Fe-B magnet powders
H. Sepehri-Amin, D. Prabhu, M. Hayashi, T. Ohkubo, K. Hioki, A. Hattori and K. Hono
Scripta Materialia **68** (2013) 167.
- 8) Enhanced coercivity of spark plasma sintered Zn-bonded Sm-Fe-N magnet
D. Prabhu, H. Sepehri-Amin, C.L. Mendis, T. Ohkubo, K. Hono and S. Sugimoto
Scripta Materialia **67** (2012) 153.
- 9) Effect of addition of aluminum on the evolution of microstructure in HITPERM class Fe₄₄Co₄₄Zr₇B₄Cu₁ alloy
D. Prabhu, R. Veerababu, R. Balamuralikrishnan, A. Narayanasamy, K. Chattopadhyay
Materials Science Engineering B **177** (2012) 791.
- 10) Grain size effect on the phase transformation temperature of nanostructured CuFe₂O₄
D. Prabhu^a, A. Narayanasamy^{b,*}, K. Shinoda^c, B. Jeyadeven^c, J-M. Greneche^d and K. Chattopadhyay^a
Journal of Applied Physics **109** (2011) 013532
- 11) Magnetic, electric and dielectric properties of FeCo alloy nanoparticles dispersed in amorphous matrix
E. Thirumal, D. Prabhu, K. Chattopadhyay, V. Ravichandran
Physica status solidi (a), **207** (2010) 2505-2510
- 12) Synthesis, Magnetic and Electrical Properties of Fe-containing SiO₂ nanocomposite,
E. Thirumal, **D. Prabhu** and V. Ravichandran,
Journal of Alloys and Compounds **502** (2010) 169-175
- 13) Effect of Aluminum on the hyperfine field and crystallization behaviour of NANOPERM alloy
D. Prabhu, A. Narayanasamy and K. Chattopadhyay,
Hyperfine Interactions **183** (2008) 7-15.
- 14) Magnetic properties of amorphous Fe_{73.5}Cu₁Mo₃Si_{12.5}Al₁B₉ alloy
D. Prabhu, K. Ganesan, A. Narayanasamy, K. Chattopadhyay, and N. Ponpandian

- 15) Exchange field penetration in $\text{Fe}_{73.5}\text{Cu}_1\text{Mo}_3\text{Si}_{12.5}\text{Al}_1\text{B}_9$ alloy
D. Prabhu, A. Narayanasamy, K. Ganesan, N. Ponpandian and K. Chattopadhyay
Journal of Alloys and Compounds **438** (2007) 15-20.
- 16) Effect of Al substitution on the magnetic properties of amorphous $\text{Fe}_{73.5}\text{Cu}_1\text{Mo}_3\text{Si}_{13.5-x}\text{Al}_x\text{B}_9$ alloy
D. Prabhu, A. Narayanasamy and K. Chattopadhyay
Journal of Non Crystalline Solids **353** (2007) 1577–1581
- 17) Critical phenomena in FINEMET alloy
N. Ponpandian, A. Narayanasamy, **D. Prabhu**, K. Ganesan, M. Manivel Raja, K. Chattopadhyay
Journal of Magnetism and Magnetic Materials **296** (2006) 67–76
- 18) Dipolar and exchange couplings in $\text{Nd}_2\text{Fe}_{14}\text{B}/\alpha\text{-Fe}$ ribbons
R. Justin Joseyphus, A. Narayanasamy, **D. Prabhu**, L. K. Varga, B. Jeyadevan, C. N. Chinnasamy, K. Tohji, and N. Ponpandian
Physica Status Solidi (c) **1** (2004) 3489–3494

Manuscripts Communicated

- 1) Synthesis, structural and magnetic properties of nanocrystalline Fe, Co and $\text{Fe}_{100-x}\text{Co}_x$ alloy powders by a direct chemical method
E. Thirumal, **D. Prabhu**, K. Chattopadhyay, V. Ravichandran
Intermetallics, (Communicated)

Manuscripts Under Preparation:

- 1) Effect of Al substitution on the crystallization and magnetic properties of FINEMET type alloys
D. Prabhu, A. Narayanasamy, R. Balamuralikrishna, Veera Babu and K. Chattopadhyay
Materials Science and Engineering B (to be communicated)
- 2) Synthesis of phase pure HCP-Co by novel low temperature hydrothermal annealing process and thermomagnetic investigations
E. Thirumal, **D. Prabhu**, V. Ravichandran, and K. Chattopadhyay.
Appl. Phys. A (to be communicated)
- 3) Synthesis of $\text{Ni}_x\text{Fe}_{100-x}$ Alloy Nanocrystalline Powders by Novel Chemical Process in Aqueous Medium
E. Thirumal, **D. Prabhu** and V. Ravichandran.
Mater. Sci. Eng. B (to be communicated)

Research work presented in the International/National Conferences and Workshops Attended

- 1) **Oral** presentation of the paper entitled “Magnetic properties of amorphous $\text{Fe}_{73.5}\text{Cu}_1\text{Mo}_3\text{Si}_{12.5}\text{Al}_1\text{B}_9$ alloy”
D. Prabhu, K. Ganesan, A. Narayansamy, N. Ponpandian and K. Chattopadhyay

12th International Conference on Rapidly Quenched and Metastable Materials, Jeju, Korea, August 21-26, 2005

- 2) **Oral** presentation of the paper entitled “Effect of Al substitution on the magnetic properties of FINEMET alloy”
D. Prabhu, A. Narayansamy and K. Chattopadhyay, National Seminar on Advances in Materials Science, Manonmaniam Sundaranar University, Tirunelveli. March 27-28, 2006.
- 3) Attended the National Workshop on “Measurement & Characterization of Magnetic Materials” 20-21st April 2006 conducted by the Magnetics Society of India and Saha Institute of Physics at Saha Institute of Physics, Kolkatta
- 4) **Poster** presentation of the paper entitled “Exchange Field Penetration in $\text{Fe}_{73.5}\text{Cu}_1\text{Mo}_3\text{Si}_{12.5}\text{Al}_1\text{B}_9$ Alloy”
D. Prabhu, A. Narayanasamy, K. Ganesan, N. Ponpandian and K. Chattopadhyay
8th International Conference on Nanostructured Materials - 2006
Indian Institute of Science, Bangalore 560 012, 21st – 25th August 2006
- 5) **Poster** presentation of the paper entitled “Magnetic Properties of $\text{Fe}_{73.5}\text{Cu}_1\text{Mo}_3\text{Si}_{13.5-x}\text{Al}_x\text{B}_9$ ($x = 0, 1, 3 \text{ \& } 5$) Alloy”
D. Prabhu, A. Narayanasamy, and K. Chattopadhyay
8th International Conference on Nanostructured Materials -2006
Indian Institute of Science, Bangalore 560 012, 21st – 25th August 2006
- 6) **Poster** presentation of the paper entitled “Magnetic and Crystallization Studies on $\text{Fe}_{43}\text{Co}_{43}\text{X}_2\text{Zr}_7\text{B}_4\text{Cu}_1$ ($X=\text{Al, V, Ni}$)”
D. Prabhu, A. Narayanasamy, K. Chattopadhyay
International Conference on Nanoscience and Nanotechnology – 2006
University of Madras, Chennai 600 025, 26th -28th August 2006
- 7) **Oral** presentation of the paper entitled “Probing the amorphous phase magnetic transition in $\text{Fe}_{73.5}\text{Cu}_1\text{Mo}_3\text{Si}_{12.5}\text{Al}_1\text{B}_9$ alloy”
D. Prabhu, A. Narayanasamy, K. Chattopadhyay
20th Annual Student Symposium, Indian Institute of Science, Bangalore 560 012, 4-5th January 2007
- 8) Attended the International Workshop on Bulk Metallic Glasses: Science and Technology 12-16th January 2007, Department of Materials Engineering, Indian Institute of Science, Bangalore, India
- 9) **Oral** presentation of the paper entitled “Magnetic and Crystallization Behaviour of Rapidly Quenched $\text{Fe}_{73.5}\text{Si}_{13.5-x}\text{Al}_x\text{Mo}_3\text{B}_9\text{Cu}_1$ Alloys”
D. Prabhu, A. Narayanasamy, S. Chithra, K. Chattopadhyay
International Conference on Nanomaterials, Communication and Broadcasting Systems – 2007, Sastra University, Thanjavur - 613 402, 9th -10th February 2007
- 10) **Poster** presentation of the paper entitled “Effect of Al on the Magnetic and Crystallization Behaviour of NANOPERM Alloys”
D. Prabhu, A. Narayanasamy, K. Chattopadhyay

Diamond Jubilee Symposium on Advances in Materials Engineering
Indian Institute of Science, Bangalore 560 012, 4-6th July 2007

- 11) **Poster** presentation of the paper entitled “Magnetic Properties of the Nanocrystalline FINEMET Alloy”
D. Prabhu, K. Ganesan, N. Ponpandian, A. Narayanasamy and K. Chattopadhyay
Symposium on Advances in Materials Engineering
Indian Institute of Science, Bangalore 560 012, 4-6th July 2007
- 12) **Poster** presentation of the paper entitled “Effect of Al on the Hyperfine Field of Amorphous and Crystalline FINEMET Alloys”
D. Prabhu, A. Narayanasamy, K. Chattopadhyay
International Conference on Applications in Mossbauer Effect – ICAME 2007
Indian Institute of Technology, Kanpur, 14th - 19th October 2007
- 13) **Oral** presentation of the paper entitled “Effect of Aluminum on the Hyperfine field and Crystallization behaviour of NANOPERM Alloy”
D. Prabhu, A. Narayanasamy, K. Chattopadhyay
International Conference on Applications in Mossbauer Effect – ICAME 2007
Indian Institute of Technology, Kanpur, 14th - 19th October 2007
- 14) **Poster** presentation of the paper entitled “Structural and Magnetic Studies of Nanocrystalline Ni_xFe_{100-x} Alloy Synthesized by a Novel Chemical Route”
E. Thirumal, **D. Prabhu**, G. Dhanalakshmi, V. Ravichandran and K. Chattopadhyay
International Conference Magnetic Materials & their Applications for 21st Century [MMA21]
National Physical Laboratory, New Delhi, 21st – 23rd October 2008
- 15) **Poster** presentation of the paper entitled “Superparamagnetic Nanoparticles as MRI Contrast Agents”
R. Priya, S. Rajesh Kumar, D. Mangalaraj, N. Ponpandian, R. Justin and **D. Prabhu**
International Conference Magnetic Materials & their Applications for 21st Century [MMA21]
National Physical Laboratory, New Delhi, 21st – 23rd October 2008
- 16) **Oral** presentation of the paper entitled “Effect of post sinter annealing on magnetic properties of bulk $Sm_2Fe_{17}N_3$ sintered magnets”
D. Prabhu, H. Sepehri-Amin, C. L. Mendis, T. Ohkubo, K. Hono, S. Sugimoto
The 35th Annual Conference on Magnetic in Japan, Niigata Convention Centre, Niigata,
27th – 30th September 2011
- 17) **Oral** Presentation “Enhancement of coercivity in rapidly quenched Nd-Fe-B powders by the Nd-Cu diffusion process”
S. Hossein, **D. Prabhu**, M. Hayashi, T. Ohkubo, K. Hioki, A. Hattori, K. Hono
ICAUMS 2012, Nara Prefectural New Public Hall, Nara, Japan, 2nd-5th October 2012.4
- 18) **Poster** presentation “Thematic Unit of Excellence on “Nanomaterials based technologies for Automotive Applications”
D. Prabhu, D. Sivaprahasam, S. B. Chandrasekar, T. Rajappa and R. Gopalan
The 5th Bangalore Nano, The Lalit Ashok, Bangalore, 5th – 7th December 2012.

- 19) **Poster** presentation “Temperature dependent magnetic properties study of as-spun MnBi ribbons”
S. Kavita, **D. Prabhu**, R. Gopalan, S. Uma Maheswara Rao and K. Hono
58th Annual Conference on MMM, Denver, Colorado, USA, 4th-8th November 2013
- 20) **Poster** presentation “High saturation magnetization in Fe-P soft magnetic alloy achieved by two step heat treatment”
D. Prabhu, S. B. Chandrasekar, V. Chandrasekaran, R. Gopalan and K. Hono
58th Annual Conference on MMM, Denver, Colorado, USA, 4th-8th November 2013
- 21) **Oral** presentation “Development of Fe-P alloy with high saturation induction for automotive applications”
D. Prabhu, Ravi Gautam S. B. Chandrasekar, V. Chandrasekaran and R. Gopalan
NMD-ATM 2013, IIT (BHU), Varanasi, India, 12th - 15th November 2013
- 22) **Oral** presentation “High Coercivity and temperature dependent magnetic properties of as-spun MnBi ribbons”
S. Kavita, **D. Prabhu**, R. Gopalan, S. Uma Maheswara Rao and K. Hono
MagMa 2013, Department of Physics, IIT Guwahati, 05th – 07th December 2013.
- 23) **Invited Talk** “Microstructural Engineering of Magnetic Materials” International Conference on Magnetic Materials and Applications (ICMAGMA 2014) Department of Physics, Pondicherry University, Pondicherry, 15-17th September 2014.
- 24) **Poster** presentation “Synthesis of high Coercivity SrFe₁₂O₁₉ Powders”
R. Rajashekar, Ravi Gautam, **D. Prabhu**, R. Gopalan
International Conference on Magnetic Materials and Applications (ICMAGMA 2014)
Department of Physics, Pondicherry University, Pondicherry, 15-17th September 2014.
- 25) **Poster** presentation “Evolution and growth of LTP MnBi in Mn-Bi system”
V.V.Ramakrishna, S.Kavita, D.Siva Prahasam, D. Prabhu, Ravi Gautam and R.Gopalan
International Conference on Magnetic Materials and Applications (ICMAGMA 2014)
Department of Physics, Pondicherry University, Pondicherry, 15-17th September 2014.

Extracurricular Activities

- Oration
- Reading (special interest in autobiographies and biographies)
- Photography
- Cricket, Badminton

Personal

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