PRANABA KISHOR MUDULI

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OBJECTIVE

A scientific position in the field of condensed matter physics more specifically spintronics and/or magnetism that will use my research experiences and laboratory skills.

SUMMARY OF RESEARCH EXPERIENCES

Five Years of research experience in the field of experimental condensed matter physics during and as a part of the M.Tech (Materials Science and Engineering) and PhD (Ferromagnet-Semiconductor hybrid structures). Proficient at the growth and characterization of Ferromagnetic thin films by molecular beam Epitaxy (MBE), Expertise in characterization techniques like RHEED, XRD, AFM, SQUID, MOKE, and Magnetotransport.

PERSONAL DETAILS:

Nationality: INDIAN
Date of Birth: 01-11-1978
Place of birth: Orissa, India
Sex: Male
Marital status: Single

SCHOLARSHIPS AND ACHIEVEMENTS

- Doctoral fellowship granted by the Paul-Drude-Insitute for Solid State Electronics, Berlin, Germany
- Postgraduate scholarship during M.Tech at IIT Kharagpur, Govt. Of India
- Qualified the prestigious national level examination, Graduate Aptitude Test For engineering (GATE)-2000 with 97.84 *percentile*, All India Rank: 34 (out of 1600 students appeared)
- Qualified CSIR –NET JRF (Junior Research Fellowship in Physics) held during June 2000. I was among top 30 students in the National eligibility Test (NET), Approximately 9000 students appeared in this national test.
- Ranked 6th in Master of Science (Physics), from Utkal University, India ,1998-2000.
- National Scholarship by Government of India, for securing 6th rank (out of around 2000 students) in Bachelor of Science (B.Sc) with Physics.
- Qualified TOFEL (Test of English as a Foreign Language)-2002 with a score of 233/300

EDUCATION *(chronologically reversed)*

2002(Sept)—Present:

Graduate student at Paul drude Institute and Humboldt-Universität zu Berlin, Berlin, Germany.
Ph.D. Specialization: Experimental condensed matter physics,
Dissertation: Ferromagnetic thin films of Fe and Fe_3Si films on low-symmetric GaAs(113)A substrates (electronic copy available on request).
Advisor: Prof. Dr. Klaus. H. Ploog
Projected Graduation Date: Dec 2005, (thesis submitted)
My PhD thesis is a part of the Humboldt graduate school on "Fundamentals and functionality of size and interface controlled materials: spin-and optoelectronics"
Also see the non-official page at:
http://www.physik.hu-berlin.de/~pomraenk/graduate/index

2002(Jan)—2002(Aug):

Junior research fellow in the department of Physics, Indian Institute of Technology (I.I.T) Kharagpur.

2000(July)—2002(Jan):

M.Tech (Master of Technology) in Materials Science and Engineering with semiconductor technology as specialization from Indian Institute of Technology (I.I.T) Kharagpur, India.

Courses: Optoelectronics Materials and devices, Semiconductor devices and Modelling, Crystal Growth and Characterization, Semiconductor Technology, Thin Film Technology, CAD for VLSI

Project: "Study of Silicon carbide based Schottky junctions for hydrogen Gas sensor applications"

Duration: 8 months

Supervisors: Prof S Basu and Dr C Jacob

Over all GPA: 8.84/10

1998(July)—2000(July):

M.Sc (Master of Science) in Physics with Electronics and Instrumentation as Specialization from Utkal University, Bhubaneswar, Orissa, India.
Courses: Solid state physics, Quantum mechanics (Basic and Advanced), Electrodynamics, Electronics, Classical Mechanics, Optics (physical and geometrical), Mathematical methods, Nuclear and atomic physics
Marks obtained: 74 %, Rank: Six (in the University)

1995(July)—1998(July):

B.Sc (Bachelor of Science) in Physics as Honors from Sambalpur University, Sambalpur, Orissa, India.

Marks obtained: 71.625% Rank: Six (in the University, Out of around 2000 students)

RESEARCH EXPERIENCE

PRESENT RESEARCH

The present research leading to PhD involves the growth and properties of ferromagnets on semiconductor substrates. The work deals with three important aspects: (i) growth and structural characterization, (ii) magnetic properties, and (iii) magnetotransport properties of Fe and Fe_3Si films on low-symmetric GaAs(113)A substrates. These two ferromagnetic metals, namely Fe and Fe_3Si have cubic crystal structure and exhibit a close lattice match with GaAs. This allows to stabilize the [113]-orientation of the films on GaAs(113)A by using molecular-beam epitaxy (MBE). The structural properties of the Fe and Fe_3Si films are studied using techniques such as reflection high-energy electron diffraction (RHEED), high-resolution X-ray diffraction (HXRD), X-Ray Reflectivity (XRR), and Atomic force microscopy (AFM). The magnetic properties are studied by *in-situ* Magneto-optical Kerr effect, SQUID magnetometry, and different magnetotrantranport techniques such as anisotropic magnetoresistance, planar Hall effect (PHE) and anomalous Hall effect. The basic achievements of this work include the following: (i) establishment of the growth of Fe and Fe_3Si on the high-index surface of GaAs(113)A substrates by MBE, (ii) study of the magnetic properties on the low-symmetric surface, which also provide the understanding to the incompletely understood uniaxial magnetic anisotropy (UMA) of Fe/GaAs system, (iii) substantiate correlation between structural and magnetic properties, and (iv) an important finding of an antisymmetric component in the PHE due to the reduced symmetry of the [113] orientation, (v) development of a phenomenological model based on the symmetry of the crystal to understood the understand the observation of the antisymmetric component in PHE. The antisymmetric component in PHE is a completely new observation and to our knowledge is a first observation of the second-order Hall effect. For more details please see the following publications and the personal web page **at**
http://www.geocities.com/pranab_muduli

LIST OF PUBLICATIONS

- J. Herfort, H.-P. Schönherr, P. K. Muduli, and K. H. Ploog, Magnetic anisotropy of ultrathin epitaxial Fe films grown on As terminated GaAs(001)-2×1 substrates, in *International Symposium on Compound Semiconductors: Post-Conference Proceedings, edited by M. R. Melloch and C. Tu,*, pages 96, 101, IEEE, Piscataway, 2004.
- P. K. Muduli, J. Herfort, H.-P. Schönherr, and K. H. Ploog, *Evolution of magnetic anisotropy and spin-reorientation transition in Fe films grown on GaAs(113)A substrates by molecular beam epitaxy,* J. Appl. Phys. **97** 123904 (2005) (7 pages)
- P. K. Muduli, J. Herfort, H.-P. Schönherr, L. Däweritz, and K. H. Ploog, *Magnetic anisotropy of Fe films on GaAs(113)A substrates*, Appl. Phys. A, **81** 901 (2005) (Rapid Communications) (6 pages)
- P. K. Muduli, K.-J. Friedland, J. Herfort, H.-P. Schönherr, and K. H. Ploog, *Anti-symmetric contribution to the planar Hall effect of Fe_3Si films grown on GaAs(113)A substrates*, Phys. Rev. B **72,** 104430 (2005)

- K.-J. Friedland, J. Herfort, P. K. Muduli, H.-P. Schönherr, and K. H. Ploog, Planar Hall effect in epitaxial Fe layers on GaAs(001) and GaAs(113)A substrates, Journal of Superconductivity, In Press on line at http://dx.doi.org/10.1007/s10948-005-0002-5

- P. K. Muduli, J. Herfort, H.-P. Schönherr, and K. H. Ploog, *Epitaxial Fe_3Si films stabilized on GaAs(113)A substrates*, J. Cryst. Growth, (2005) (In Press)

- P. K. Muduli, J. Herfort, H.-P. Schönherr, and K. H. Ploog, *Strong dependence of growth conditions on magnetic anisotropy of epitaxial Fe_3Si films on GaAs(113)A substrates*, (In preparation)

Conference contributions

- J. Herfort, H.-P. Schönherr, P.K. Muduli, and K.H.Ploog, *Magnetic anisotropy of ultrathin epitaxial Fe films grown on As terminated GaAs(001)-2×1 substrates*, 30th International Symposium on compound semiconductors (ISCS-2003), San Diego, (USA), 25-27 August 2003

- K. J. Friedland, P. K. Muduli, J. Herfort, H.-P. Schönherr, and K. H. Ploog, *Planar Hall effect in epitaxial Fe layers on GaAs(001) and GaAs(113)A substrates,* 3rd International Conference on Physics and Applications of Spin-Related Phenomena in Semiconductors (PASPS III), Santa Barbara (USA), July 21-23 (2004)

- K. J. Friedland, M.Bowen, J. Herfort, P. K. Muduli, H. -P. Schönherr, and K. H. Ploog, *Intrinsic contributions to the planar Hall effect in epitaxial Fe and Fe_3Si films on GaAs substrates*, 11th Advanced Heterostructure Workshop, Kohala Coast (USA), December 5-10(2004)

- P. K. Muduli, J. Herfort, H.-P. Schönherr, and K.H.Ploog, *Magnetic properties of Fe and Fe_3Si films on GaAs(113)A substrates* 338. WE-Heraeus-Seminar: Nanomagnetism: New Insights with Synchrotron Radiation, Bad Honnef, January 05 – 07 (2005).

PREVIOUS RESEARCH EXPERIENCES

1) Master of Technology (M.Tech):Project work on "Study of Silicon carbide based Schottky junctions for hydrogen Gas sensor applications"
Duration: 8 months
Supervisors: Prof S Basu and Dr C Jacob

During this project work, polycrystalline and bulk 3C-SiC samples were used to fabricate Ru/3C-SiC Schottky junctions for hydrogen gas sensor applications. The deposition of Ru was performed in e-beam evaporator and preliminary structural properties were characterized with XRD, resistivity, and Hall effect measurements. A homemade senor set-up was used to perform preliminary studies on the sensor properties of the Schottky junctions. An increase in diode

current was observed with H_2 concentration. Sensitivity was found to increase with biasing voltage. More details can be found in the above thesis.

Part of this work was also presented at the 9th International meeting on chemical sensors, Boston, USA, S Basu, S Roy, P K Muduli, C Jacob, A K Tyagi, *High Temperature Hydrogen Sensors based on 3C-SiC Bulk and epilayer*

2) M.Sc Summer project on "Plasma Paste Boronizing of stainless steel: A novel technique to improve hardness of metal surface" See the annual publication in Blossom here, Duration: 1.5 months

This was my first experience of research in a real experimental environment. I got flavor of different plasma processing techniques. Also some preliminary studies on the measurement of surface hardness were performed,

SEMINARS DELIVERED

During Ph.D:

- An overview of MOKE and SQUID magnetic measurement Techniques. Zip Archive (264K)
- Taking spin into account [PDF]
- An introduction to programming in Origin. [html]
- Growth and Magnetic properties of Fe on GaAs (311)*A* substrates. PDF,
- Growth, structure and magnetism of Fe and Fe_3Si films on GaAs(113)*A* substrates. [PDF]

During M.Tech:

- "Growth and Characterization of $\mathbf{Si_{1-x-y}Ge_x\ C_y}$ epilayers on Si substrates"
- "A Ferroelectric memory field effect transistor (FEMFET) using Metal/PZT/MgO/SiO_2 structure"
- "Blue GaN-InGaN MQW LED on Silicon Substrate"
- "An Overview of Silicon Carbide Technology"

EXPERIMENTAL SKILLS

Samples preparation

- Growth of magnetic thin films and preparation of III-V semiconductor surfaces by molecular-beam epitaxy***
- Growth of metals on SiC by e-beam evaporation**

Structural characterization

- Reflection high-energy electron diffraction***

- High resolution X - Ray Diffraction (HXRD) and X-Ray Reflectivity (XRR) with PANalytical high-resolution diffractometer, High-resolution Bede Diffractometer and a Home made XRD system***
- Atomic force microscopy (Park scientific and ***
- Scanning Electron Microscopy*

Magnetic Characterization

- SQUID magnetometry with MPMS XL***
- Magneto-optical Kerr effect**
- Magnetotrantranport and Hall effect (anamolous) ***
- Magnetic force Microscopy*

(* indicates level of experience, three * for highest)

OTHER SKILLS:
Computer Knowledge:

- Programming Languages: C, FORTRAN, VHDL
- Operating Systems: Windows, Linux, Unix
- Software expertise: Latex, MS Office, Origin (with knowledge of programming), Igor Pro (with knowledge of programming), Mathmatica, MATLAB, Crystal drawing programs such a Diamond, Several X-ray simulation Softwares, little knowledge of VLSI Design TOOLS such as circuit simulation by Win- SPICE, T-SPICE and Digital Logic synthesis using SYNOPSYS

REFERENCES:

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