Sai Krishna Narayananellore

Research Engineer at INL-Internatinal Iberian Nanotechnology Laboratory.
Av.Mestre Jose Veiga, s/n – 4715-330 Braga-Portugal
Contact no: +351920379655; + 91-7702492022,
E-mail: sai.krishna@inl.int; narayananelloresk@gmail.com

➢ Professional experiences

- **Research Engineer** (Sep 2019 to present)
  - **Supervisor:** Dr. Ricardo Ferreira
    Spintronics Group, Department of Nanoelectronics Engineering, International Iberian Nanotechnology Laboratory (INL), Braga, Portugal.
    Area of research: "Magnetic tunnel junctions and Nano-Oscillators.
  - **Key responsibilities:** Film growth and microfabrication of MTJs and Nano-Oscillators
- **Postdoctoral Researcher** (March 2018 to May 2019)
  - **Supervisor:** Dr. Tomoya Nakatani
    Magnetic Materials group, Research Centre for Magnetic and Spintronics Materials, National Institute for Materials Science (**NIMS**), Sengen, Tsukuba, Japan.
  - Area of research: "*Heusler alloy based CPP-GMR and epitaxial TMR thin films deposition and device microfabrication for high output sensors*"
  - **Key responsibilities:** Film growth and microfabrication of polycrystalline Heusler alloys (CMFG, CFAS) based current-perpendicular-to-plane giant magnetoresistance (CPP-GMR) sensor and epitaxial magnetic tunnel junctions (MTJ) with Heusler alloy (CMFS) and MgO tunnel barrier (by 10-target sputtering unit (ULVAC))

- **Postdoctoral Researcher** (November 2015 to February 2018)
  - **Supervisor:** Dr. Hidekazu Saito (Team leader)
    Semiconductor spintronics group at Spintronics Research Centre, National Institute of Advanced Industrial Science and Technology (**AIST**), Central-2, Tsukuba, Japan.
  - **Area of research:** "*Development of semiconductor tunnel barrier materials for fully epitaxial magnetic tunnel junctions*"
  - **Key responsibilities:** Film growth and microfabrication of fully epitaxial magnetic tunnel junctions (MTJs) using a non-cubic oxide semiconductors (Ga_2O_3, ZnO) as a tunnel barrier with ferromagnetic metal (Fe) electrodes (by MBE)

➢ Technical skills and hands-on experiences:

- Thin film deposition techniques:
  - MBE, Sputtering, Electron beam evaporation, Flash and thermal evaporation, Spin coating, Dip coating

- Molecular Beam Epitaxy (MBE): MBE is an ultra-high vacuum physical evaporation technique to grow epitaxial thin films with a precise thickness from sub monolayers to several nano-meters order

➢ Microfabrication:

- Electron beam lithography (JEOL JBX-6300 SM), Mask aligner (UV-photolithography), Ar ion milling machine (Dry etch), sputtering unit for insulation (SiO_2) and metal (Ta, Cr, Au) deposition, spin coating unit for photoresist coating.

➢ Key scientific measurement skills:

- **Structural Analysis:** Reflection High Energy Electron Diffraction (RHEED), X-Ray Diffraction (XRD) Rigaku Smart lab.
- **Surface characterizations:** Atomic Force Microscope (AFM), Scanning Electron Microscope (SEM).
- **Optical characterizations:** UV-Vis-NIR spectrophotometer, Photoluminescence.
- **Electrical measurements:** Magnetoresistance (MR) measurement (4-probe), I-V measurement, Hall measurement**.**
- **Magnetic measurements:** Superconducting Quantum Interference Device (SQUID), Vibrating Sample Magnetometer (VSM).

➢ Academic background:

- **Ph.D. Candidate** (September 2012 to July 2015)
- **Supervisor**: Dr. S. Kaleemulla
  Thin films laboratory, Dept. of Physics, School of Advanced Sciences (SAS), Vellore Institute of Technology (VIT) University, Tamilnadu, India
- Area of research: **Diluted magnetic semiconductors (Spintronics)**

Thesis title: "*Investigations on Cr, Fe, and Ni-doped* In_2O_3 *dilute magnetic semiconductors for room temperature ferromagnetism*."

A short summary of my thesis:

- The onset of ferromagnetism has been reported in many oxide-based DMSs even above RT. However, it has not yet been clear on this ferromagnetism, is it really come from the DMS? Since it was difficult to deny the existence of magnetic precipitates in DMS

- High-quality In_2O_3-based DMSs compounds and films were fabricated with several transition metals as dopants such as Cr, Fe, Ni, and Cu. With careful analysis, it was successfully confirmed that DMS samples are free from the magnetic precipitates. The ferromagnetism of DMS is not only observed with magnetic dopants (Fe and Ni) but also non-magnetic ones (Cr and Cu) at RT. As a result, it was clarified that oxygen vacancies in the In_2O_3 are playing a crucial role to induce the ferromagnetism in In_2O_3-based DMSs

- **Master of Science (M.Sc.) in Electronics**
  S.V. University
  M.Sc. Electronics, S.V.U. College of Sciences, Sri Venkateswara University, Tirupati, **First class, Secured 71%,** 2009-2011.

- **Bachelor of Science (B.Sc.)**
  S.V. Art's College
  B.Sc. M.E.Cs (Mathematics, Electronics, Computer Sciences), Sri Venkateswara Art's College, Sri Venkateswara, University, Tirupati, **First class, Secured 73.7%,** 2006-2009.

- **Intermediate**
  Sri Nalanda Jr College
  Intermediate (Mathematics, Physics, Chemistry), Sri Nalanda Jr College, Rajampet, Board of Intermediate Education, **First class, Secured 74.9%**, 2003-2005.

- **S.S.C**
  Board of Secondary Education Andhra Pradesh (S.S.C), Sri Saraswathi Vidya Nikethan High School, Vontimitta, Kadapa (dist.), India, **First class with Distinction, Secured 83%,** 2002-2003.

➢ List of publications:

1. Hidekazu Saito, Sai Krishna Narayananellore, Norihiro Matsuo, Naoki Doko, Shintaro Kon, Yukiko Yasukawa, Hiroshi Imamura, and Shinji Yuasa, "*Tunneling Magnetoresistance and Spin-Dependent Diode Performance in Fully Epitaxial Magnetic Tunnel Junctions With Rocksalt ZnO/MgO Bilayer Tunnel Barrier*". Phys. Rev. Applied **11**, 064032 – (2019)
2. Toshiki Kanaki, Shin Matsumoto, Sai Krishna Narayananellore, Hidekazu Saito, Yoshihiro Iwasa, Masaaki Tanaka and Shinobu Ohya, *"Room-temperature side-gate-induced current modulation in a magnetic tunnel junction with an oxide-semiconductor barrier for vertical spin MOSFET operation"*. Applied Physics Express, Vol.-12, 2 (2019)

3. Sai Krishna Narayananellore, Naoki Doko, Norihiro Matsuo, Hidekazu Saito, and Shinji Yuasa, "*Fabrication of magnetic tunnel junctions with a single-crystalline LiF tunnel barrier*". Japanese Journal of Applied Physics 57, 04FN04 (2018).

4. Sai Krishna Narayananellore, Naoki Doko, Norihiro Matsuo, Hidekazu Saito, and Shinji Yuasa, "*Effect of MgO Underlying Layer on the Growth of GaOx Tunnel Barrier in Epitaxial Fe/GaOx/(MgO)/Fe Magnetic Tunnel Junction Structure*". Sensors, Vol.17, pp.2424, 2017.

5. N. Sai Krishna, N. Doko, N. Matsuo, H. Saito, S. Yuasa, "*Investigation on the formation process of single-crystalline GaOx barrier in Fe/GaOx/MgO/Fe magnetic tunnel junctions*". Journal of Physics D: Applied Physics, Vol. 50, pp.435001, 2017.

6. N. Sai Krishna, S. Kaleemulla, G. Amarendra, N. Madhusudhana Rao, C. Krishnamoorthi, I. Omkaram, D. Sreekantha Reddy, "*Structural, optical and magnetic properties of Cr doped In_2O_3 powders and thin films*", Journal of Material Science Materials in Electronics, Vol. 26, pp. 8635–8643, 2015.

7. N. Sai Krishna, S. Kaleemulla, G. Amarendra, N. Madhusudhana Rao, C. Krishnamoorthi, M. Rigana Begam, I. Omkaram, D. Sreekantha Reddy, "*Room temperature ferromagnetism in $(In_{1-x}Ni_x)_2O_3$ thin films*", Physica B: Condensed Matter, Vol. 466-467, pp. 6–10, 2015

8. N. Sai Krishna, S. Kaleemulla, G. Amarendra, N. Madhusudhana Rao, C. Krishnamoorthi, M. Rigana Begam, I. Omkaram, D. Sreekantha Reddy, "*Room Temperature Ferromagnetism in Cu-Doped In_2O_3 Thin Films*", Journal of Super conductivity and Novel Magnetism, Vol. 28, pp.2089–2095, 2015.

9. N. Sai Krishna, S. Kaleemulla, G. Amarendra, N. Madhusudhana Rao, C. Krishnamoorthi, M. Rigana Begam, I. Omkaram, D. Sreekantha Reddy, "*Magnetic and superconductivity studies on $(In_{1-x}Fe_x)_2O_3$ thin films, Journal of Alloys and Compounds*", Vol. 637, pp. 436-442, 2015.

10. N. Sai Krishna, S. Kaleemulla, G. Amarendra, N. Madhusudhana Rao, C. Krishnamoorthi, M. Kuppan, M. Rigana Begam, D. Sreekantha Reddy, I. Omkarame, "*Structural, optical, and magnetic properties of Fe doped In_2O_3 powders*", Materials Research Bulletin, Vol. 61, pp. 486–491, 2014.

11. N. Sai Krishna, S. Kaleemulla, G. Amarendra, N. Madhusudhana Rao, M. Kuppan, M. Rigana Begam, D. Sreekantha Reddy, "*Structural, optical and magnetic properties of $(In_{1-x}Ni_x)_2O_3$ $(0 \leq x \leq 0.09)$ powders synthesized by solid state reaction*", Materials Science in Semiconductor Processing, Vol. 18, pp. 22–27, 2013.

12. M. Rigana Begam, N. Madhusudhana Rao, S. Kaleemulla, N. Sai Krishna, M. Kuppan, "*Structural and Magnetic properties of Cr diffused CdTe Nanocrystalline thin films*", Applied Physics A: Materials Science and Processing, Vol. 117, Issue 2, pp. 793-798, 2014.

13. M. Rigana Begam, N. Madhusudhana Rao, S. Kaleemulla, N. Sai Krishna, M. Kuppan, "*Room Temperature Ferromagnetism in Co diffused CdTe Nanocrystalline Thin Films*", Journal of superconductivity and Novel Magnetism, Vol. 27, Issue 9, pp. 2147–2152, 2014.

14. M. Kuppan, S. Kaleemulla, N. Madhusudhana Rao, N. Sai Krishna, M. Rigana Begam, D. Sreekantha Reddy, " *Physical Properties of $Sn_{1-x}Fe_xO_2$ Powders Using Solid State Reaction*", Journal of Superconductivity and Novel Magnetism", Vol. 27, Issue 5, pp 1315–1321, 2014.

15. M. Rigana Begam, N. Madhusudhana Rao, S. Kaleemulla, N. Sai Krishna, M. Kuppan, G. Krishnaiah, J. Subrahmanyam, "*Room temperature ferromagnetism in $Cd_{1-x}Cr_xTe$ diluted magnetic semiconductor crystals*", Materials Science in Semiconductor Processing, Vol.18, pp.146–151, 2014.

16. M. Kuppan, S. Kaleemulla, N. Madhusudhana Rao, N. Sai Krishna, M. Rigana Begam, M.Shobana, "*Structural and Magnetic Properties of Ni Doped SnO_2*", Advances in Condensed Matter Physics, Vol. 2014, Article ID 284237, pp. 5 pages, 2014. Imp.

17. S. Kaleemulla, N. Madhusudhana Rao, N. Sai Krishna, M. Kuppan, M. Rigana Begam, M. Shobana, "*Effect of Annealing on Structural and Optical Properties of Cu Doped In_2O_3 Thin Films*", Journal of Nano- and Electronic Phys. Vol. 5(4), pp.04048 (1-4), 2014.

18. M. Rigana Begam, N. Madhusudhana Rao, Girish M. Joshi, S. Kaleemulla, M. Shobana, N. Sai Krishna, and M. Kuppan, "*Structural, Optical, and Magnetic Properties of Co Doped CdTe Alloy Powders Prepared by Solid-State Reaction Method*", Advances in Condensed Matter Physics, Vol. 2013, Article ID 218659, pp. 5 pages, 2013.

19. M. Rigana Begam, N. Madhusudhana Rao, S. Kaleemulla, M. Shobana, N. Sai Krishna, M. Kuppan, " *Effect of Substrate Temperature on Structural and Optical Properties of Nanocrystalline CdTe Thin Films Deposited by Electron Beam Evaporation*" Journal of Nano- and Electronic Physics, Vol. 5(3), pp.03019 (1-4), 2013.

➢ Oral presentations:

1. 2019 Joint MMM-intermag Conference, Marriott Wardman Park, Washington, DC, USA.

2. 2017 International Conference on Solid State Devices and Materials held at Sendai international center, Sendai, Japan.

3. 2016 International Conference on Solid State Devices and Materials held at Tsukuba International congress center, Tsukuba, Ibaraki, Japan.

4. International Conference on Materials and Characterization Techniques (ICMCT-2014) held at VIT University, Vellore – 632 014, TN, INDIA.

5. Research Scholar's Workshop on Physics of Materials held at UGC – DAE Consortium for Scientific Research, Indore, India, 2013.

➢ Poster Presentation:

1. 2017 International Conference on Solid State Devices and Materials held at Sendai international center, Sendai, Japan.

2. The 2nd ImPACT International symposium on Spintronic memory, Circuit and Storage held at Tsukuba International Congress Center, Tsukuba, Ibaraki, Japan. 2016.

3. 59th DAE-Solid State Physics Symposium held at VIT University, Vellore-632 014, Tamil Nadu, INDIA, 2014.

4. One day national seminar on Nanomaterials and Nanotechnology held at Govt. Degree & P.G. College, Puttur, A.P., India, 2013.

5. 24th Annual General Meeting Materials Research Society of India, held at Indira Gandhi Centre for Atomic Research, Kalpakkam-603102, TN, India, 2013.

➢ Personal details:

First Name : Sai Krishna

Last Name : Narayananellore

Date of birth : 05-06-1987

Nationality : Indian

Marital status : Married

Address (Permanent): Door no: 4-475, B.S. Hall Nagar, Rajampet, Kadap (dist), Andhra Pradesh, India, Postal code: 516115.