Website Information

Department of Physics

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Faculty details:

Item	Details
Faculty Name	Dr. Murali Krishnan M
Room No	A311, 3rd Floor, School of Engineering
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Research Area	• Spintronic and magnetic sensor devices based on tunnel magnetoresistance (TMR). • Thin-film deposition and optimization of ferromagnetic and Heusler alloys. • Low-frequency noise reduction and sensitivity enhancement using magnetic flux concentrators. • Topological Materials and Transport Phenomena: Anomalous Hall effect (AHE) studies in Weyl semimetals and Co–Mn–Al thin films. • Micro/nanofabrication and magnetotransport characterization of spintronic devices. • Magnetic sensors and gas sensors
Publications (Past 5 years)	**PATENTS** 1. **Japanese Patent:** Heusler alloy, magnetic sensor and read head, **Murali Krishnan Manikketh**, Ryo Toyama, Tomoya Nakatani, Hirofumi Suto and Yuya Sakuraba, (Filed), Ref No: 20240171 2. **Indian Patent:** An improved magnetic multilayer structure for sensor applications and a process for the preparation thereof., P. Chowdhury, Harish C. Barshilia, Jakeer Khan, **Murali Krishnan** and Prabhanjan Kulkarni, (**Granted-04/01/2024)** File No: 0052NF2015/IN **BOOK CHAPTER** 1. *Kumar A., **Murali Krishnan M.**, Singh V., Samanta S., Ramgir N.S. (2020) Room Temperature Chemiresistive Gas Sensing Characteristics of Pristine Polyaniline and Polyaniline/TiO_2 Nanocomposites. In: Thomas S., Joshi N., Tomer V. (eds) Functional Nanomaterials. Materials Horizons: From Nature to Nanomaterials. Springer, Singapore, Print ISBN:* 978-981-15-4809-3, *doi:* https://doi.org/10.1007/978-981-15-4810-9_15, **PUBLICATIONS** 1. Benugopal Bairagya, Gaurav K Shukla, Akhilesh Kumar Patel, **Murali Krishnan**, Sunil Nair, Yuya Sakuraba, and Sanjay Singh, ***Anomalous Nernst effect in Ni_2MnGa/MgO (001) shape memory Heusler alloy thin-film***, *P. Rev. B,* Ref. No: BAR1478BR (Under review) 2. **Murali Krishnan Manikketh**, Prabhanjan D. Kulkarni, Tomoya Nakatani,

	Hirofumi Suto, and Yuya Sakuraba, ***Effects of layer thickness and annealing process on low-frequency noise and detectivity in tunnel magnetoresistive sensors with CoFeSiB soft magnetic layers***, Journal of applied physics, J. Appl. Phys. 136, 203901, (2024), doi: 10.1063/5.0231800 3. Syed Abdul Lateef, A. T. Sriram, **Murali Krishnan M**, A. Sivathanu Pillai, **Design of Magnetic Circuit for Stationary Plasma Thruster**, Journal of Physics: Conference Series, 2070 (2021) 012032, doi:10.1088/1742-6596/2070/1/012032 4. Piu Rajak, P.D. Kulkarni, **M. Krishnan**, P. Chowdhury, Somnath Battacharyya, ***Spatially resolvedstructure and domain wall propagation in defect induced SmCo/Co exchange spring magnet***, Journal of Magnetism and Magnetic Materials, 491, 165612
Profile Links Scopus and Orcid	**LinkedIn:** www.linkedin.com/in/dr-murali-krishnan-manikketh-b8789133 **Scopus Author ID:** 7102069663 **Orcid:** https://orcid.org/ 0000-0002-6445-1121
Research Activities (Write about your best research results max of 2-3 pages including diagrams)	My research focuses on the design and development of spintronic and magnetic sensor devices for next-generation data storage and field-sensing technologies. The central theme of my work involves engineering thin-film heterostructures and magnetotransport devices that exploit spin-dependent phenomena such as Giant magnetoresistance (GMR), tunneling magnetoresistance (TMR) and the anomalous Hall effect (AHE). Through systematic material optimization, device fabrication, and characterization, my studies aim to realize high-sensitivity, low-noise magnetic sensors and novel magnetic readers for advanced spintronic applications. Presently, my focus is on expanding my expertise in the synthesis of nanomaterials using various methods and broadening my knowledge of other sensing technologies, such as gas sensing, for applications in environmentally relevant issues. **1. Weyl Semimetal Devices for Anomalous Hall Effect (AHE)** During my post-doc period at NIMS, in collaboration with Western Digital corpotation, we explored the use of Weyl semimetals exhibiting large intrinsic AHE for magnetic reader devices. This work combined materials physics with device engineering, targeting a new generation of magnetic sensors based on topological transport phenomena. **Co–Mn–Al Thin Films with Giant Anomalous Hall Effect** My recent work focused on Co–Mn–Al-based Heusler-type thin films, where careful control of composition and crystalline order yields a giant anomalous Hall effect (AHE). • AHE property for wide range of compositions was studied by preparing composition gradient films using combinatorial sputtering technique • Observation of a giant AHE of 30 μΩ·cm was achieved for off-stoichiometric composition of Co-Mn-Al in uniform films post-annealed at 500°C

- Strong correlation between film microstructure, magnetic anisotropy, and AHE magnitude.
- Demonstrated potential for high-sensitivity read-head elements and topological spintronic devices.
- One Japanese patent was filed for this innovation

Key Results and achievements:

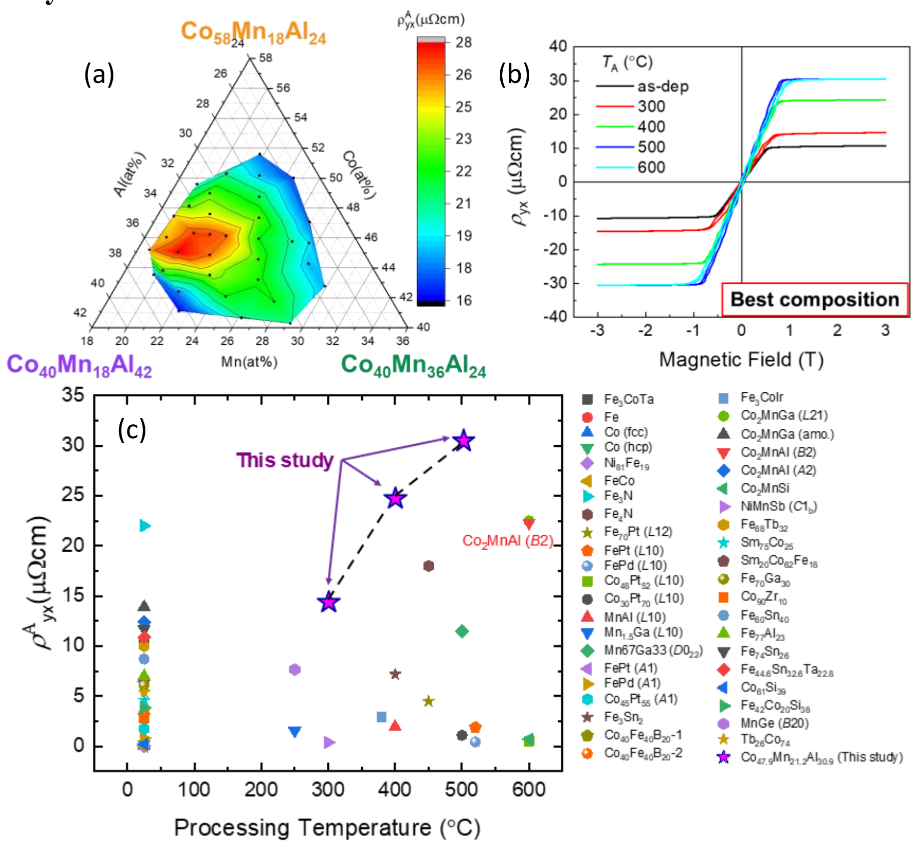

Fig.1: (a) Ternary contour plot of the variation of ρ^A_{yx} for Co-Mn-Al composition, (b) annealing temperature dependence for uniform film prepared with the optimal composition (c) comparison of our result with previous studies

2. Development of High-Performance TMR Sensors

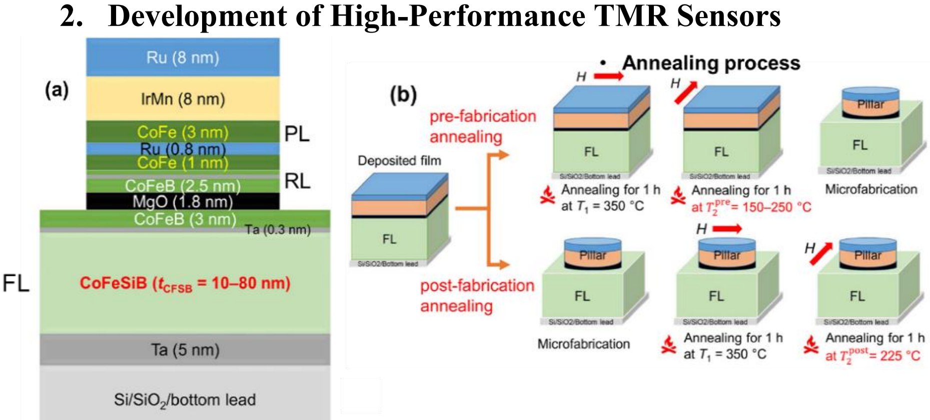

Fig.1: Schematics of (a) the layer structure of TMR sensor, (b) two different annealing process followed for the TMR sensors

I have developed and optimized CoFeSiB/MgO/CoFeB-based magnetic tunnel junctions (MTJ) by depositing films using magnetron sputtering followed Tunnel magnetoresistance (TMR) sensor fabrication by multi-step lithography process.

My work revealed the crucial influence of the CoFeSiB soft magnetic layer thickness and order in which post-annealing is performed on the electric and magnetic noise components of the sensor.

Achievements:

- Enhanced TMR ratio and low-frequency noise suppression were achieved by tuning the soft layer thickness and thermal treatment.
- The optimized sensor exhibited superior magnetic field sensitivity and detectivity of 0.8 nT/√Hz, suitable for low-field detection such as biomagnetic field sensing.

Key Results:

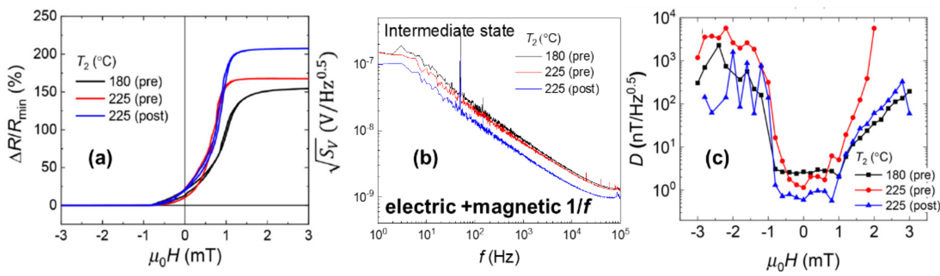

Fig.2: (a) $\Delta R/R_{min}$–H curves (b) noise voltage spectra for the intermediate state (at 1 mT applied field) (c) detectivity (*D*) at *f* = 10 Hz

3. Giant Magnetoresistance (GMR) Multilayers and Sensor Applications

During my tenure at NAL we developed CoFe/Cu-based multilayer structures exhibiting GMR using ultra-high-vacuum magnetron sputtering. The work focused on controlling oxygen partial pressure during deposition, which led to a significant enhancement in GMR ratio, linearity, and thermal stability.

Key Results:

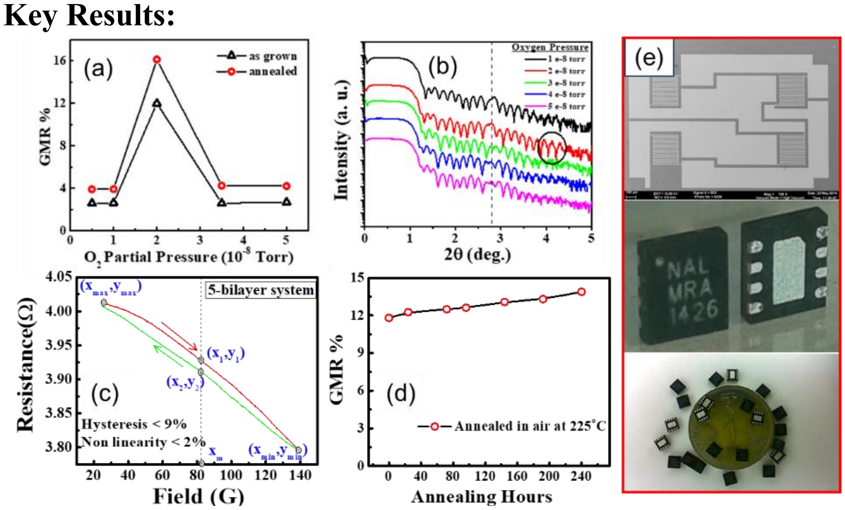

Fig.1: (a) O_2 partial pressure dependence of GMR ration (b) XRR spectra showing formation of sharper interface at optimal O_2 pressure (c) Reduced hysteresis and linearity and (d) improved long term thermal stability for the fabricated GMR sensors (e) patterned sensing element and actual GMR sensors as a market-ready product.

	Achievements: • Discovered that introducing a critical oxygen partial pressure (1–2 × 10^{-8} Torr) during deposition improved multilayer interfaces, resulting in enhanced GMR response. • Achieved low hysteresis, thermally stable GMR multilayers suitable for harsh environments. • Fabricated a GMR-based magnetic gradiometer sensor using photolithography and wafer-scale processing, later packaged into an 8T-DFN device used for two-wheeler RPM measurement. • One Indian patent was granted for this innovation.
Collaborations	• Dr. Tomoya Nakatani, Principle Researcher, Center for Magnetic and Spintronic Materials, National Institute for Materials Science, Japan • Dr. Prasanta Chowdhury, Senior Scientist, Surface Engineering Division, National Aerospace Laboratories, Bangalore • Dr. Arvind Kumar, Assistant Professor – Physics, Chaman Lal Mahavidyalaya, Haridwar • Dr. Madhav Haridas, Scientist, Flight Dynamics, URSC, ISRO, Bangalore • Dr. Prabhanjan Kulkarni, Scientist, Sensor Technology Development Centre, CMTI, Bangalore
Awards and Recognition	• **Best poster award at the Interaction corridor event** held on 20-06-2025, NIMS, Sengen, Japan • **SERB-NPDF Fellowship (Reference No.PDF/2017/001770)** approval for the submitted proposal in August 2017. • **Best Innovation award from CSIR-National Aerospace Laboratories** in July 2014 for "*Development of Speed Sensors with Magnetoresistive Element Technology for Application in Automobiles*". • **Senior Research Fellowship** awarded by CSIR-National Aerospace Laboratories (NAL), Bangalore, June 2012