Shivam Nitin Kajale

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Ph.D. candidate specializing in nanoelectronics and superconducting devices for energy-efficient computing. Skilled in cleanroom nanofabrication, material characterization, and automation. Proven track record in van der Waals spintronic devices, AI hardware accelerators, and custom instrumentation.

Education

Present: **Doctor of Philosophy (Ph.D.) in Media Arts and Sciences** (Electronics and Materials Science)
Massachusetts Institute of Technology, Cambridge, MA
- Awarded the MIT-HPI Design for Sustainability Grant for AI hardware innovation.
- Research on field-free switching of vdW magnets led to two high-impact publications.

2023: **Master of Science (S.M.) in Media Arts and Sciences** *CGPA: 4.95/5.00*
Massachusetts Institute of Technology, Cambridge, MA
- Thesis: Study of vdW magnetic materials for spintronic applications

2020: **Dual Degree (B.Tech+M.Tech) in Electrical Engineering** *CGPA: 9.33/10.00*
Indian Institute of Technology Bombay, Mumbai, India
- Ranked 1st in Electrical Engineering (Microelectronics) cohort.
- Thesis: Interaction of Surface Acoustic Waves and Magnetization

Experiences

2021-Present: **Research Assistant** — MIT, Cambridge, MA *Guide: Prof. Deblina Sarkar*
- Developed the **first all-van der Waals** spin-orbit torque device for **field-free**, electrical switching of van der Waals magnets above room temperature for application in advanced MRAM and eNVM technologies.
- Designed **brain-inspired hardware accelerator** using stochastic magnetic tunnel junctions (s-MTJs), achieving random number generation 5000× more energy-efficiently than state-of-the-art algorithms for AI applications.
- Performed light penetration Monte-Carlo and heat transfer simulations to study thermal effects of photovoltaic neural implants, and their application in wireless biphasic stimulation of the brain through compact modelling and SPICE simulations
- Fabricated vdW spintronic devices using **cleanroom techniques**, including e-beam lithography, photolithography, sputtering, dry transfer, and etching, to achieve atomically smooth interfaces and precise device geometries.
- Executed extensive **electrical transport measurements**, including Hall, higher harmonic, magneto-transport, and I-V characterizations, to probe switching and magnetic properties of vdW devices, using **magnetic cryostats** and **self-developed LabVIEW** instrumentation and automation platforms.
- Built and utilized custom **micrometer resolution** magneto-optical Kerr effect (**MOKE**) setups (polar and longitudinal modes) and **FMR** system for accurately probing magnetic thin-films.
- Designed and built a cost-effective 2D material transfer system (4X cheaper than commercial options), enabling micrometer-precision placement of air-sensitive vdW flakes inside a glovebox for novel devices fabrication.

2020: **Digital Hardware Design Engineer** — Intel Corporation, Bangalore, India
- Design and verification of DFX logic of AI oriented graphics core in the Alder Lake SoC

2019-20: **Research Assistant** — IIT Bombay, India *Guide: Prof. Ashwin Tulapurkar*
- Developed a finite-element method (FEM)-based simulation framework in **COMSOL Multiphysics** to model interactions between surface acoustic waves (SAWs) and magnetization in **piezoelectric and magnetic materials**.
- Implemented the Landau-Lifshitz-Gilbert (LLG) equation within COMSOL's mathematical module to enable simulations of magnetization dynamics, **extending the platform's capabilities** for coupled magneto-dynamic, elasto-dynamic, and electrostatic analyses.
- Designed and **optimized interdigitated transducers** (IDTs) for efficient SAW generation, using parametric

studies to improve energy conversion and validated results against analytical models

- Demonstrated coupled magnetoelastic phenomena, including acoustically-driven ferromagnetic resonance (ADFMR) and magnon-driven elastic wave propagation, providing insights into applications in spintronics.

2018: **Research Intern** — Purdue University, IN *Guide: Prof. Pramey Upadhyaya*

- Built a simulation suite to study ferromagentic nanoscale microwave source using LLG equation, driven by oscillating voltage, and induced Rabi oscillation in a qubit subjected to the nanomagnet's microwave field

- Developed a theoretical model for a room temperature voltage based driver for NV-centre qubits for quantum computing applications

2017: **Computer Vision Intern** — Superbolter^{TM}, Bangalore, India

- Designed and built a Python-based computer vision toolkit for a virtual reality interior designing platform

- Image processing utilizing OpenCV for segmenting RGB floorplans to create input for 3D virtual reality (VR) renditions of the spaces.

Technical Skills

Nanofabrication: Photolithography, e-beam lithography, 2D dry-transfer, atomic layer deposition, E-Beam deposition, sputter deposition, pulsed laser deposition, reactive ion etching, FIB lithography & sectioning

Characterisation: SEM, TEM, EDS, AFM, XRD, Raman, Magneto-transport, MOKE, Transistor I-V

Programming: LabVIEW, Python, MATLAB, VHDL, Verilog, C++, LaTeX, HTML

Software: COMSOL Multiphysics, Quantum Espresso, Cadence Virtuoso, Altera Quartus, OOMMF

Awards & Achievements

2023: Awarded the MIT-HPI **Design for Sustainability Grant** for the design of brain-inspired low-energy computing devices for AI applications

2022: Delivered a talk at **TEDxBoston's** Planetary Stewardship forum, titled "A new race: making computation sustainable", creating awareness on the environmental impact of large scale AI and computation.

2020: Akshay Dhoke Memorial Award for securing **Rank 1** in Electrical Engineering - Microelectronics batch of 2020, IIT Bombay

2018: Nominated as the **Indian delegate to the Metropolitan Environmental Resource Management** (MERM) camp at Chulalongkorn University (CU), Bangkok. Awarded **first prize** for focus report on **Indoor Air Pollution mitigation**

2015: All India Rank (AIR) 296 in IIT JEE-Advanced out of 150 thousand candidates

2014: Awarded fellowship for pursuing research under Kishore Vaigyanik Protsahan Yojana (KVPY), with AIR 191, by Department of Science & Technology of the Government of India

2011: Granted scholarship under National Talent Search Exam, by the Government of India

Publications

[11] Kajale S.N., Nguyen T., Hung N.T., Li M., Sarkar D.,"Field-free deterministic switching of all-van der Waals spin-orbit torque system above room temperature", **Science Advances**, 10, eadk8669 (2024)

[10] Kajale S.N., Nguyen T., Chao C.A., Bono D.C., Boonkird A., Li M., Sarkar D., "Current-induced deterministic switching of van der Waals ferromagnet at room temperature", **Nature Communications** 15, 1485 (2024)

[9] Kajale S.N., Hanna J., Jang K., Sarkar D., "Two-dimensional magnetic materials for spintronic applications", **Nano Research** 17, 743–762 (2024)

[8] Ryu J., Kajale S.N., Sarkar D.,"Van der Waals magnetic materials for current-induced control toward spintronic applications", **MRS Communications** 14, 1113–1126 (2024)

[7] Yadav S., Lee R., Kajale S., Joy B., Saha M., Bull Loey., Cao Sarah., Mitragotri S., Bono D., Sarkar D., "Non-surgical Bioelectronic Implant for Targeted Focal Brain Stimulation", 2024 (*under review at* **Nature**

Biotechnology)

[6] Jang K., Kajale S.N., Joy B., Bono D.C., Neltner B., Sarkar D., "CircTrek: A wearable device for continuous monitoring of circulating cells at single-cell resolution", 2024 (*under review at* **npj Biosensing**)

[5] Rustagi A., Kajale S.N., Upadhyaya P. "Manipulating quantum impurity spins via dynamical modes of nanomagnets", 2022 (*under review at* **Applied Physical Letters**)

[4] Verma S., Kajale S., Gomez-Bombarelli, R "Machine learning for accurate and fast bandgap prediction of solid-state materials", 2022 IEEE High Performance Extreme Computing Conference (**IEEE HPEC**), pp. 1-2, 2022

[3] Kajale S.N., Yadav S., Cai Y., Joy B., Sarkar D. "2D material based field effect transistors and nanoelectromechanical systems for sensing applications", **iScience** , Volume 24, Issue 12, 103513, 2021

[2] Rustagi A., Solanki A. B., Kajale S., Bogdanov S., Dilley N. R., Shen T., Debashis P., Chen Z., Appenzeller J., Chen Y., Shalaev V. M., Upadhyaya P. "Quantum-classical spin hybrids: leveraging spintronic tools for information processing applications", Proc. SPIE 11470, **Spintronics** XIII, 114702B, 2020

[1] Kajale, S.N., "Interaction of Surface Acoustic Waves and Magnetisation". 2020. IIT Bombay, M.Tech. Thesis

Seminars and Conferences

Dec, 2024: Poster presentation at the **38th NeurIPS Conference** workshop on Machine Learning with New Computing Paradigms (**MLNCP**), titled "Energy-efficient random number generation using stochastic MTJs"

Jun, 2024: Oral presentation at the 24th International Conference on the Science and Applications of Nanotubes and Low-Dimensional Materials (**NT24**), titled "Field-free deterministic switching of a van der Waals ferromagnet above room temperature"

Jun, 2024: Delivered a talk at the Spintronics Seminar series hosted by Trinity College Dublin

Apr, 2024: Seminar talk titled "Propelling van der Waals magnets towards energy-efficient spintronics" at the NanoBio Seminar Series at MIT

Jan, 2024: Poster presentation at the Microsystems Annual Research Conference (MARC) 2024