Avinash Nayal

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SUMMARY

Ph.D. candidate in Mechanical Engineering specializing in thermal-mechanical system design and high-heat-flux cooling. Conducted testing of air, liquid, and PCM cooling systems that maintain < 2 °C temperature spread. Built heat-spreader composites with 4584% higher conductivity and optimized graphene/epoxy TIMs. Applied SolidWorks, ANSYS, and Python for thermal modeling, instrumentation, and test automation. ORNL internship experience linking phonon transport to device-level thermal resistance for electronics.

EDUCATION

University of Oklahoma | Norman, OK - Ph.D. in Mechanical Engineering **Aug 2020 – Present**

Arizona State University | Tempe, AZ - M.Sc. in Mechanical Engineering **Aug 2018 – Jul 2020**

RESEARCH & ENGINEERING EXPERIENCE

Graduate Research Assistant - Phase 2 | University of Oklahoma **Jan 2023 – Present**

Micro/Nano Heat Transfer Lab | *Ph.D. Advisor:* Dr. Jivtesh Garg

- Designed, prototyped, and tested air, liquid, PCM, and hybrid cooling systems for high-power cells, achieving < 2 °C temperature non-uniformity under varying loads.
- Built custom thermal test fixtures using SolidWorks and machined aluminum housings; integrated thermocouples, RTDs, heaters, and NI-DAQ for steady heat-flux evaluation.
- Formulated standardized workflows for DSC/TGA characterization, improving data repeatability across researchers and enabling materials-to-system thermal correlation.
- Mentored two junior researchers on sensor calibration, experimental setup, and Python-based data analysis.

Graduate Research at ORNL (GRO) Intern | Oak Ridge National Laboratory (ORNL) **Jan 2025 – May 2025**

Materials Science and Technology Division | *Mentor:* Dr. Lucas Lindsay

- Formulated a Python-based thermal resistance modeling framework using first-principles phonon data (Quantum ESPRESSO), enabling prediction of heat-path bottlenecks in semiconductor materials.
- Quantified the impact of mechanical strain on GaN thermal conductivity and mapped anisotropic heat flow behavior relevant to high-power electronic devices.
- Integrated empirical and phonon-transport models to estimate minimum achievable thermal conductivity, supporting material selection for heat spreaders and thermal interface structures.
- Automated data reduction and visualization pipelines, cutting analysis time by > 40% and improving reproducibility for design-focused thermal assessments.

Graduate Research Assistant - Phase 1 | University of Oklahoma **Aug 2020 – Dec 2022**

- Engineered and thermally characterized expanded-graphite (EG) enhanced PCM composites achieving up to 4584% higher thermal conductivity, enabling faster heat spreading in battery modules and power electronics.
- Designed and 3D-printed/machined molds for molding PCM/EG composite blocks and test coupons; optimized curing, compaction, and interface quality for reproducible thermal measurements.
- Improved graphene-epoxy thermal interface materials (TIMs) through solvent processing (DMF), achieving 44% higher thermal conductivity and improved particle dispersion for lower contact resistance.
- Performed first-principles thermal modeling (DFT/phonon transport) of hexagonal BC_2P, computing 162 Wm^{-1} K^{-1} conductivity, and benchmarking materials for heat-spreader and TIM applications.

Master's Thesis | Arizona State University **May 2019 – Jul 2020**

Nano-Engineered Thermal Radiation Group | *Ph.D. Advisor:* Dr. Liping Wang

- Developed a coupled radiation–conduction–electrical MATLAB model for solar thermophotovoltaic (STPV) systems, verified against experimental results with < 5 % deviation.
- Optimized multilayer absorber/emitter metafilms using Particle Swarm Optimization and fabricated coatings via PECVD-sputtering, achieving high spectral selectivity (0.4 – 1.6 μm).
- Engineered a vacuum-based STPV test setup with Xe-arc solar simulator and SiO microsphere spacers to maintain a 100 μm emitter–cell gap, minimizing conduction loss.
- Validated the experimental setup against analytical predictions using thermocouple networks, radiative flux measurements, and energy-balance calculations.

Research Intern | Indian Institute of Technology Gandinagar **Aug 2017 – Jul 2018**

Mechanical Engineering Department

- Led testing and mechanical overhaul of a 5 kWe diesel-powered fuel-cell reformer system as part of a DRDO-funded project.
- Developed the scale-up plan (5 kWe to 30 kWe) using ASPEN modeling, mass/energy balances, and PID-based control requirements to support higher thermal loads and stable reactor operation.
- Updated PIDs and mechanical layouts for heat-exchanger units, piping manifolds, and integrated DAQ/control subsystems, improving modularity and system maintainability.
- Collaborated with fabrication vendors to define component specifications, procurement lists, and manufacturability guidelines for thermal-fluid components and instrumentation hardware.

Research Intern | Institute for Plasma Research **Jan 2017 – Jul 2017**
Department of Atomic Energy | *Advisor:* Dr. Vinay Menon

- Simulated conjugate heat transfer and coolant flow in the ITER divertor under > 10 MW/m² heat flux using ANSYS APDL, evaluating swirl-tube vs. straight-flow geometries.
- Validated simulation results with calorimetry and RTD-based measurements, recommending design improvements that achieved 30% better thermal uniformity in the ITER divertor cooling system.
- Derived empirical peaking-factor correlations capturing heat-flux non-uniformity; provided predictive inputs for divertor cooling optimization with 10% error against experimental data.

SKILLS

Thermal Analysis & CFD: ANSYS (Fluent, APDL), COMSOL Multiphysics, thermal resistance modeling, high-heat-flux cooling, conjugate heat transfer, electronics cooling, transient thermal analysis.
CAD & Design: SolidWorks, Fusion 360, mechanical fixture design, machining, 3D printing, mold fabrication, assembly integration.
Instrumentation & Testing: Thermocouples, RTDs, heaters, NI-DAQ, vacuum systems, Raman Spectroscopy, DSC, TGA, thermal conductivity testing, contact-resistance measurements, transient cooling validation.
Programming & Data: Python (automation, data pipelines, visualization), MATLAB, C++.
Materials & Interfaces: PCM composites, expanded graphite, graphene/epoxy TIMs, heat-spreader materials, interfacial engineering.