

## **NDnano Summer Undergraduate Research 2026 Project Summary**

**1. Student name & home university:** Aakarsh Misra, Texas Tech University

**2. ND faculty name & department:** Dr. Nosang Myung, Department of chemical and biomolecular engineering

**3. Summer project title:** Intelligent electronic nose system development using nanoengineered sensing materials

**4. Briefly describe new skills you acquired during your summer research:**

Gained hands-on experience across the complete nanomaterial sensor development pipeline, including electrospinning, spin coating, drop casting, and calcination of nanomaterials. Learned advanced characterization techniques such as UV-Vis spectroscopy, X-ray diffraction (XRD), and scanning electron microscopy (SEM), while developing chemiresistive gas sensors and applying machine learning to optimize electrospinning parameters for nanomaterial fabrication.

**5. Briefly share a practical application/end use of your research:**

This research contributes to an intelligent electronic nose capable of rapidly identifying complex chemical signatures. As a case study, the platform achieved approximately 96% accuracy in distinguishing volatile organic compound (VOC) signatures associated with avian influenza in infected birds. Beyond agriculture, the same sensing platform can be extended to applications including breath-based cancer and diabetes screening, respiratory disease detection, food quality monitoring, and environmental hazard detection.

**6. 50- to 75-word abstract of your project:**

My project focuses on developing an intelligent electronic nose that combines one-dimensional (1D) nanoengineered semiconductor metal oxide (MOS) gas sensors with machine learning to identify complex chemical signatures. This platform has broad applications, including avian influenza detection in poultry, disease diagnosis through breath analysis (such as cancer, diabetes, and respiratory diseases), food safety, and environmental monitoring. A major focus of my research was developing a machine learning-based electrospinning simulator that predicts and optimizes nanofiber fabrication parameters, enabling the design of high-performance sensing materials to enhance the sensitivity and reliability of these chemical sensing applications.

## *Summary;*

The ability to rapidly identify volatile organic compounds (VOCs) has the potential to transform applications ranging from disease diagnosis and food safety to environmental monitoring and biosecurity. Many diseases, contaminants, and hazardous substances produce unique VOC signatures that can be detected long before they become visible through conventional testing. However, existing analytical techniques often require expensive instrumentation, specialized laboratories, and lengthy processing times, limiting their use for rapid, point-of-care detection.

The goal of this research was to develop an intelligent electronic nose (E-nose) capable of identifying complex chemical signatures through arrays of chemiresistive semiconductor metal oxide (MOS) gas sensors coupled with machine learning. Rather than relying on a single highly selective sensor, the E-nose recognizes characteristic response patterns across multiple nanoengineered sensors to distinguish different VOC mixtures. Such systems have the potential to enable rapid disease diagnosis through breath analysis (including cancer, diabetes, and respiratory diseases), avian influenza detection in poultry, food quality monitoring, environmental surveillance, and chemical threat detection.

My research focused on developing the nanoengineered sensing materials and the 16-sensor array that serve as the foundation of this system. I fabricated one-dimensional semiconductor metal oxide nanofibers using electrospinning, optimized calcination conditions to obtain the desired material morphology, and characterized the resulting nanomaterials using UV-Vis spectroscopy, X-ray diffraction, and scanning electron microscopy (SEM) to understand their morphology and various chemical properties such as bandgap. Beyond material synthesis, I also designed and fabricated the Chemresistive sensor array by integrating the synthesized nanofibers onto interdigitated electrode (IDE) chips, enabling a multi-sensor E-nose architecture capable of pattern-based chemical recognition. The assembled sensor array then underwent electrical characterization, including temperature-dependent resistance change studies, to verify device performance and inter-sensor consistency. The sensor array is currently undergoing controlled analyte exposure studies, where its sensitivity, selectivity, response, and recovery characteristics are being evaluated against a range of volatile organic compounds and other target chemical species.

Working through every stage of the sensor fabrication process revealed that device performance is fundamentally determined long before gas testing begins. The diameter and morphology of electrospun nanofibers directly influence surface area, porosity, charge transport pathways, and the density of active reaction sites, making them critical factors governing sensor sensitivity and selectivity. However, achieving a desired nanofiber morphology remains largely a trial-and-error process because electrospinning outcomes depend on a complex interaction between solution properties, precursor chemistry, and processing parameters.

To address this challenge, I further developed a machine learning framework capable of predicting electrospun nanofiber diameter and morphology directly from fabrication conditions. Using a curated dataset of in-house experimental electrospinning formulations, the model learns relationships between solution composition, polymer chemistry, precursor concentration, and processing parameters, including applied voltage, flow rate, and collector distance, to predict the resulting fiber structure. The current model achieves a mean absolute percentage error (MAPE) of 27.4% and an  $R^2$  of 0.88 on held-out data, demonstrating competitive performance to state of the art models. By enabling researchers to optimize nanomaterial fabrication before sensor manufacturing, this framework reduces experimental iteration, improves reproducibility, and accelerates the development of high-performance gas sensors. Together, this work integrates nanomaterials engineering, semiconductor gas sensing, and machine learning to advance the next generation of intelligent electronic nose technologies.