

Materials Science & Engineering Dissertation Defense

Novel Gas Sensor Solutions for Air Quality Monitoring

School for Engineering of Matter, Transport and Energy

Kyle Mallires

Advisor: Dr. Erika Forzani

Abstract

Global industrialization and urbanization have led to increased levels of air pollution. The costs to society have come in the form of environmental damage, healthcare expenses, lost productivity, and premature mortality. Measuring pollutants is an important task for identifying its sources, warning individuals about dangerous exposure levels, and providing epidemiologists with data to link pollutants with diseases. Current methods for monitoring air pollution are inadequate though. They rely on expensive, complex instrumentation at limited fixed monitoring sites that do not capture the true spatial and temporal variation. Furthermore, the fixed outdoor monitoring sites cannot warn individuals about indoor air quality or exposure to chemicals at worksites. Recent advances in manufacturing and computing technology have allowed new classes of low-cost miniature gas sensor to emerge as possible alternatives. For these to be successful however, there must be innovations in the sensors themselves that improve reliability, operation, and their stability and selectivity in real environments. Three novel gas sensor solutions are presented. The first is the development of a wearable personal exposure monitor using all commercially available components, including two metal oxide semiconductor gas sensors. The device monitors known asthma triggers: ozone, total volatile organic compounds, temperature, humidity, and activity level. Primary focus is placed on the ozone sensor, which requires special circuits, heating algorithm, and calibration to remove temperature and humidity interferences. Eight devices are tested in multiple field tests. The second is the creation of a new compact optoelectronic gas sensing platform using colorimetric microdroplets printed on the surface of a complementary-metal-oxide-semiconductor (CMOS) imager. The nonvolatile liquid microdroplets provide a homogeneous, uniform environment that is ideal for colorimetric reactions and lensless optical measurements. To demonstrate one type of possible indicating system gaseous ammonia is detected by complexation with Cu(II). The third project continues work on the CMOS imager optoelectronic platform and develops a more robust sensing system utilizing hydrophobic aerogel particles. Ammonia is detected colorimetrically by its reaction with a molecular dye, with additives and surface treatments enhancing uniformity of the printed films. Future work presented at the end describes a new biological particle sensing system using the CMOS imager.



November 6, 2020; 3:30 PM;

Zoom Link: <https://asu.zoom.us/j/8343237362>