United States Department of Agriculture
Project Initiation

Project Data for Accession Number 1033078

Project Title

Durable High-Temperature Humidity Sensors for Precision Food Processing

Project Details

Sponsoring Institution National Institute of Food and Agriculture	**Project Status** COMPLETE
Funding Source NIFA Non Formula	**Grant Year** 2024
Grant No. 2024-51406-43578	**Cumulative Award Amt.** $175,000.00
Proposal No. 2024-00121	**Multistate No.** (N/A)
Project Start Date Sep 15, 2024	**Project End Date** May 14, 2026
Program Code [8.5] Food Science & Nutrition	

Project Director

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Recipient Organization

ZDC TECH LTD. CO.

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Performing Department

(N/A)

Non Technical Summary

Most commercial humidity sensors on the market are polymer-based sensors. However, the polymer-based humidity sensors are not stable at temperatures of >80°C. We found that the commercial polymer-based humidity sensors significantly drifted (8%) after only one month of exposure to a harsh environment (temperature at 90°C and relative humidity at 80%). This level of drift leads to an under-performed pathogen control process and thus increases the risk of food contamination. There are not any high-temperaure humidity sensors on the market that can operate at temperatures of >80°C with high stability. We will create a solid-state (non-polymer) humidity sensor for food industrial applications in a harsh environment at high temperatures with high stability. We will carry out preliminary studies of stability of sensors at high temperatures similar to food processing conditions. The overall goal of this project is to

create a durable solid-state humidity sensor and calibration methods for the food industry for high-temperature food processing control and monitoring. The successful accomplishment of the project will improve the food safety and thus the health of people.

Animal Health Component

Animal Health Component: 0%

Research Effort Categories

Basic	0%
Applied	100%
Developmental	0%

Classification

Knowledge Area (KA)	Subject of Investigation (SOI)	Field of Science (FOS)	Percent
404	7299	2020	100%

Knowledge Area

[404] Instrumentation and Control Systems

Subject Of Investigation

[7299] Research equipment and methods, general/other

Field Of Science

[2020] Engineering

Keywords

humidity sensor instability food safety harsh environment

Goals / Objectives

Overall goal: Create a solid-state humidity sensors for high-temperature food processing applications.Phase I Technical Objectives:Study deposition of hafnium oxide (HfO2) using atomic layer depositionFabricate humidity sensors using a porous ?-Al2O3 structures with a HfO2/SiO2 stack layerCalibrate the sensors at moderate temperatures (25-95°C) and test the durability of the humidity sensors by exposing them to high temperature of 300°C for a long time.

Project Methods

Novel humidity sensor structure includes a layer of HfO2 added between SiO2 and the porous structure. The major task is to find optimum HfO2 thickness so that sensor remains stable at 300°C for long time. On the aluminum substrate, porous ?-Al2O3 (sapphire) film was formed by anodic spark deposition. Then conformal HfO2film and SiO2 film were deposited on the surface, pore walls, and pore bases of porous ?-Al2O3 film by atomic layer deposition (ALD). Effect of varying HfO2 thickness on the sensor's stability and sensitivity will be studied (Technical Objective 1).

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A gold film with Ti as an adhesion layer is deposited on the top of the porous structure, which serves as the top electrode. The aluminum substrate serves as the bottom electrode. Thus the sensors are successfully fabricated. Sensors fabricated by ZDC Tech will be calibrated at WSU at moderate temperatures (25-95°C). After calibration, the preliminary durability test will be carried out at WSU. After initial test cycles at T: 25-95°C and RH: 55-86%. The sensors will be loaded in to the oven and exposed to a high temperature of 300°C in air for one month. The stability of the sensor in the oven at 300°C in air will be continuously monitored during the high temperature exposure,