

# Smart Frost Sensor for Frost Diagnostics and Defrosting Control Zhiming Gao, Senior R&D Staff (gaoz@ornl.gov)

## **Frost/Defrosting Issues**

- Frost accumulation significantly reduces HVAC efficiency through restricting airflow and heat transfer
  - Frosting and defrosting involve water, ice, and frost









20 minutes 40 minutes 60 minutes

- A wet surface catalyzes frost rapid formation and growth
- Drying the outdoor coil is vital after each defrosting
- Typical defrosting technology: Time-based defrosting initiation and termination with or without preset temperature values using resistance temperature detector
  - Inaccurate control, leading to poor efficiency for HVAC defrosting

80 minutes

# Condition: 1.67°C (35°F)/90% rel. humidity

To improve HVAC reliability and energy efficiency, defrosting needs accurate control sensors for defrosting initiation and termination.

# **Novel Solution: Smart Frost Sensor**







(a–c) Electrical properties of frost, water,

# **Current Research**

#### **Future Research**



- Successful demonstration of low-cost smart frost sensor for frost detection and defrosting diagnostics
- Successful characterization of the capacitive frost sensor  $\bullet$ over successive frost-defrost testing cycles
- Successful repeatable capacitance measurements between  $\bullet$ 2.5 months
- Successful sensor performance over a long-duration  $\bullet$ (i.e., multiple days) frost and defrost cycle
- Advanced frost sensor configuration design and fabrication  $\bullet$
- Preliminary sensor demonstration in a 2023 refrigerator

Advanced technology readiness level (TRL)-4/5 probe sensor configuration design and fabrication



- Higher TRL design and fabrication for compact electronic hardware for frost sensor
- Sensor wire improvement minimizing measurement error
- Lab comprehensive validation and characterization of new frost sensors
- Demonstration in refrigerators/heat pumps available at ORNL or HVAC device provided by Trane



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