UPISC UNIVERSITY OF PITTSBURGH INFRASTRUCTURE SENSING COLLABORATION WORKSHOP

NATIONAL ENERGY TECHNOLOGY LABORATORY

Grid Research, Integration, and Deployment for Quantum (GRID-Q): Quantum Sensing Thrust

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GRID MODERNIZATION INITIATIVE U.S. Department of Energy

Problem Statement

- ❑ Changes in power grid – introduction of faster acting devices (power electronics), presence of extreme events. There are new requirements and needs for grid modernization.
- ❑ New quantum-based computing, communication, and sensing solutions need to be evaluated.
  - Limited understanding of impact of quantum technologies on power grid
  - Early potential observed to make an impact
- ❑ Quantum Sensing can enhance security and resilience

GRID-Q Objectives

Thrust 1: User Facility: Design an applied user facility of Quantum Information Science (QIS) for power grids with grid simulation capabilities.

Thrust 2: Engage stakeholders from utilities, system operators, and quantum industry (workshops, working group meetings, RFI, panel sessions in relevant conferences, quantum industry groups [QED-C]), including lab data call and **perform gap analysis** to identify critical power grid related quantum technology development needs and define roadmap

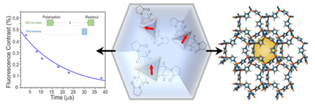
Thrust 3: Use Cases: (1) Quantum computing approaches for contingency analysis and optimization (unit commitment, planning) [ORNL, LLNL]; (2) Integrated quantum security/communication: hybrid quantum-classical channels; heterogeneous quantum communication links; resilient timing [LANL, ORNL]; **(3) Secure quantum sensing for event detection (magnetic fields), gas leak detection (CO_2, hydrogen, gas pipelines) [NETL]**

GRID-Q project team – ORNL, NETL, LANL, LLNL, ANL**.**

NETL and UPitt Quantum Sensing Capabilities

NETL and UPitt will develop novel quantum sensors for power grid monitoring and gas leak detection, using optically detected magnetic resonance (ODMR) and functionalized nanodiamond (ND) with nitrogen vacancy (NV) centers.

Nanodiamond (ND) coated with MOF materials



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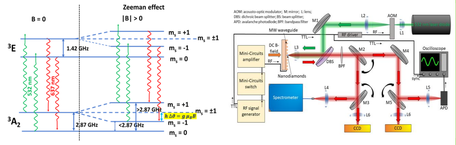
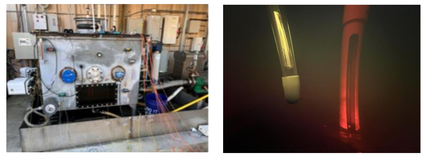
Optically detected magnetic resonance (ODMR)

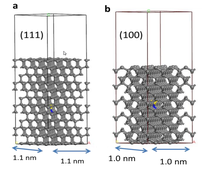


GMLC Transformer Sensing Field Test

2023 R&D 100 Award: Transformer Watchman



First-Principal Quantum Material Simulation



DFT calculations of NV centers in ND surfaces

QUEST NETL: QUANTUM FOR ENERGY SYSTEMS AND TECHNOLOGIES

NGI NATURAL GAS INFRASTRUCTURE

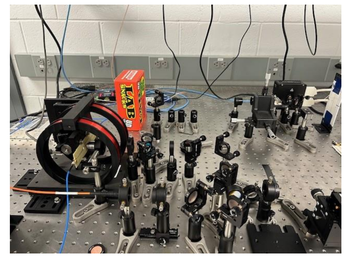
NETL Natural Gas Infrastructure – NGI (doe.gov)

UPitt Energy Innovation Center

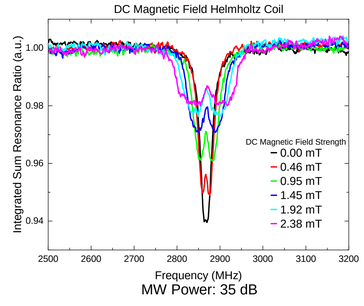
Progress

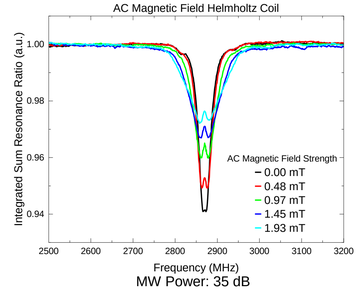
- ❑ NETL has improved the bench-scale ODMR system with automated RF frequency sweeping and data collection, and successfully demonstrated magnetic sensing function at mT level.
- ❑ NETL demonstrated AC magnetic field sensing relevant to power grid system.
- ❑ NETL and UPitt have identified magnetic field sensing applications relevant to power grid monitoring and anomaly detection including sensitivity and sensing ranges.
- ❑ NETL will kick off the Quantum Sensing Working Group meetings in early December 2024.

Upgraded benchtop scale ODMR system with DC and AC field control and automated operation



AC and DC Magnetic Field Sensing





Acknowledgment: This work is funded by the U.S. Department of Energy Grid Modernization Laboratory Consortium (GMLC) 2023 lab call under Topic 3. The authors would like to thank GMLC Topic 3 Program Managers Rima Oueid and Alireza Ghassemian for their guidance and support.