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Emergent Quantum Materials and Technologies

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Nanostructured Materials to Negate Nanosecond Voltage Spikes

ABSTRACT

Sandia National Laboratories leverages cutting edge science to address national security challenges, including supporting integration of renewable energy resources and increasing the resilience of the nation's electrical grid. This talk will highlight one such instance where materials are being optimized to protect the electrical grid against nanosecond voltage spikes. These voltage spikes originate from a variety of sources including switching events and insulation faults, and cause damage to power electronics critical for integration of wind and solar power. We are optimizing quantum tunneling and capacitive electron transport in granular metals, which consist of a 3-dimensional network of metal nanoparticles separated by insulating barriers. These granular metals will be used as the active material in nanosecond responsive shunt devices that will divert voltage spikes away from critical infrastructure. These devices must be highly insulating at typical electrical grid voltages and frequencies (to prevent energy from leaking away from the electrical grid), but must become conductive at high-voltages and GHz frequencies to redirect nanosecond voltage spikes to ground. By careful consideration of metal/insulator interface chemistry and insulator defects within granular metals, we have achieved several orders-of-magnitude improvements to both leakage currents and on/off ratios [1-3], and we are currently working to scale devices to demonstrate feasible grid-level protection. This talk will focus on the physics of granular metal conduction mechanisms; sputtering synthesis and characterization considerations (XPS, TEM, XRD, etc); and will conclude with a brief discussion on other granular metal applications and potential future collaborations.

BIO

Simeon received his bachelor's degree in physics from South Dakota State University and his Ph.D. from the University of Nebraska-Lincoln under the supervision of Prof. Peter Dowben. In 2020, Simeon began as a postdoc at Sandia National Labs, and he converted to staff in 2023. Simeon's current work focuses on the synthesis and characterization of nanostructured materials including granular metals, carbon nanotube arrays, and two-dimensional films. Simeon has received several research and presentation awards including winning Sandia's Postdoctoral Technical Showcase and recognition as an "Emerging Leader" by the Journal of Physics: Condensed Matter. Simeon and his wife have two daughters that are 5 and 3. When not doing physics or chasing kids, Simeon can often be found at the rock climbing gym.

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2. S.J. Gilbert, M.L. Meyerson, P.G. Kotula, S.G. Rosenberg, T.G. Kmieciak, M.P. McGarry, M.P. Siegal, and L.B. Biedermann, "Granular Metals with SiNx Dielectrics," Nanotechnology 34, 415706 (2023)
3. M.P. McGarry, S.J. Gilbert, L. Yates, M.L. Meyerson, P.G. Kotula, W.B. Bachman, P.A. Sharma, M.P. Siegal, and L.B. Biedermann, "Interfacial defect reduction enhances universal power law response in Mo-SiNx granular metals," submitted

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