

# JOINT SEMINAR

Materials Engineering Program  
Texas Center for Superconductivity at the Univ. of Houston  
Center for Integrated Bio and Nano Systems

## Dr. Sergiy Kalnaus

Oak Ridge National Laboratory

**Friday, November 10, 2023**

10:00 a.m. – 11:00 a.m.

Face to Face: Houston Science Center (HSC), 102

Zoom: <https://uh-edu-cougarnet.zoom.us/j/97136580701>

Meeting ID: 971 3658 0701

Host: Electrochemical Society UH Student Chapter

### The story of solid state batteries from mechanics perspective



**ABSTRACT:** Coupling of charge and mass transport with the stress-strain state has been an important subject of research for many decades, especially in the area of stress-corrosion cracking. The importance of material degradation due to the stresses coupled to electrochemical cycling has been realized for secondary Li-ion batteries with the experimental evidence of crack formation in the particles of active electrode materials.

Any dimensional changes (strains) caused by compositional changes are of even higher importance when it comes to solid state batteries. These strains and correspondingly stresses come from both cathode and metallic anode. Inorganic electrolytes for solid state batteries with Li metallic anodes must combine properties such as high ionic conductivity, chemical stability, and resistance to failure due to propagation of Li filaments. Abundance of experimental evidence suggests that cracking of the solid electrolytes due to pressure exerted by lithium plating into the material defects is the primary source of failure. This presentation will discuss the origins of stress build up in different battery materials and different mechanisms of such stress relief. Using the example of lithium phosphorous oxynitride, Lipon, we demonstrate how these mechanisms are capable of accommodating applied stress while avoiding creation of new surfaces by cracking.

We investigate the resistance to fracture in Lipon and the underlying connection to its composition via instrumented nano-indentation and numerical simulations. We observe enhancement of isochoric shear in Lipon with increase of Li content, similarly to the reports of increased plasticity in sodium aluminoborate glasses with high alkali content. Nano-indentation demonstrates that Lipon is extremely resistant to fracture, compared to other inorganic solid electrolytes.

**BIO:** Sergiy Kalnaus is a Senior Staff Scientist at Oak Ridge National Laboratory. He joined ORNL's Materials Science and Technology Division in 2009. His interests are in mechanics of materials and numerical simulations of mass and charge transport to improve battery performance and safety. He received his BS and MS degrees from Kharkiv Polytechnic University in Ukraine and PhD from the University of Nevada. He has published over 100 papers, has 7 patents, and is a recipient of the R&D100 award for the development of impact resistant electrolyte.

Persons who require special accommodations to attend this lecture should call 713-498-9703 as soon as possible.