“Lithionics” to Store Energy and Compute Data Neuromorphically

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Abstract: Next generation of energy storage and sensors may largely benefit from fast Li^+ ceramic electrolyte conductors to allow for safe and efficient batteries. Recently, Li-solid state conductors based on Li-garnet structures received attention due to their fast transfer properties and safe operation over a wide temperature range. Through this presentation basic theory and history of Li-garnets will first be introduced and critically reflected towards new device opportunities demonstrating that these electrolytes may be the start of an era to not only store energy or sense the environment but also to emulate environmental data and information based on simple electrochemistry device architecture twists.

In the first part we focus on the fundamental investigation of the electro-chemo-mechanic characteristics and design of disordered to crystallizing Li-garnet structure types and their description. Understanding the fundamental transport in solid state and asking the provokative question: how do Li-amorphous to crystalline structures conduct?

New insights on degree of amorphous to crystalline Li-garnet thin films are presented based on model experiments of the structure types. We first fundamentally examine and discuss the different amorphous phases and near order structures that Li-garnets can have being no Zachariasen glasses, and how those differ to other more established glass type Li-conductors such as LIPON, which can form Zachariasen glasses. The thermodynamic stability range of maximum Li-conduction, phase, nucleation and growth of nanostructure is discussed using high resolution TEM

studies, near order Raman investigations on the Li-bands and electrochemical transport measurements.

In a second part, we focus on new processing opportunities to Lithiate thin film structures in crystalline state and to assure cubic and fast conducting garnet structures for thin film form. For this we will review the field of thin film processing and structure-property for garnet type films and reflect our recent new processing routes based on vacuum and wet-chemical techniques.

The insights provide novel aspects of glass and ceramic thin film processing and material structure designs for both the Li-garnet structures (bulk to films) and their interfaces to electrodes, which we either functionalize to store energy for next generation solid state batteries or ... make new applications such as Li-operated neuromorphic computation via memristors, which we present in a final part.