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Morphology control in solid polymer electrolytes

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Solid polymer electrolytes (SPEs) with high ionic conductivity are important for energy-related applications, such as solid state batteries and fuel cells. In this talk, I will discuss how nanoscale morphology affects the properties of SPEs. In the first part of the talk, I will show quantitatively that the effect of polymer crystallization on ion transport is twofold: structural (tortuosity) and dynamic (tethered chain confinement). We decouple these two effects by designing and fabricating a model polymer single crystal electrolyte system with controlled crystal structure, size, crystallinity, and orientation. Ion conduction is confined within the chain fold region and guided by the crystalline lamellae. We show that, at low ion content, due to the tortuosity effect, the in-plane conductivity is 2000 times greater than through-plane one. Contradictory to the general view, the dynamic effect is negligible at moderate ion contents. Our results suggest that semicrystalline polymer is a valid system for practical polymer electrolytes design. In the second part of the talk, I will discuss how to use holographic photopolymerization (HP) to fabricate long-range, defect-free, ordered SPEs with tunable ion conducting pathways. By incorporating polymer electrolytes into the carefully selected HP system, electrolyte layers/ion channels with length scales of a few tens of nanometers to micrometers can be formed. Confinement effects on ion transport will be reported.