NDnano Undergraduate Summer Research Exchange (McMaster University, Hamilton, Ontario)

1. Student name: Liam McDermott

2. Faculty mentor name: Dr. Paul McGinn

3. Project title: Fabrication methods of solid state battery electrolytes.

4. Briefly describe any new skills you acquired during your summer research:

During my time here at Notre Dame I was able to apply what I learned in the class room to real research by gaining experience with instruments that Materials Engineers often use for characterization and analysis of materials. I learned how to do solid state synthesis of ceramic materials. This involved selecting precursor materials; the operation of PID controlled furnaces; and particle size reduction with high energy ball milling. I then learned how to operate an X-Ray diffractometer to identify what crystalline phases were present in my materials.

I then used a dilatometer to analyze the sintering behavior of the powder I synthesized. A dilatometer measures the change in length of a pelletized sample during a controlled temperature program. This enabled me to determine sintering temperatures and rates and compare these values between samples.

5. Briefly share a practical application/end use of your research:

Lithium ion batteries are everywhere. They are in smartphones, laptops, car and many other devices that need to store their own power. Lithium ion battery development seeks to increase the battery's energy density and enhance their safety. For example most lithium ion batteries use flammable organic liquid electrolytes that present a fire risk if the battery fails.

A solution to fix this safety concern is to use an alternative electrolyte. One such material is the solid electrolyte $Li_7La_3Zr_{1.75}Nb_{0.25}O_{12}$ (LLZO). It has a high ionic conductivity (approximately $3x10^{-4}$s/cm) and, as a solid oxide material, it is both fire resistant and likely to inhibit common battery failure mechanisms such as lithium dendrite growth.

One challenge in using LLZO as an electrolyte is that it can decompose at temperatures (1200^{o}C) that are normally needed for sintering. My research focused on enhancing the density and ionic conductivity of LLZO sintered at lower temperatures (800^{o}C). I investigated the composition and concentration of Li_3BO_3 as an additive to lower LLZO's sintering temperature; the use of other sintering atmospheres including Argon and a 5% Hydrogen 95% Argon mix; and pellet pressing conditions such as pressure and the use of organic binder. These experiments can be used to determine the sintering conditions for production of high quality LLZO electrolytes for use in next-generation solid-state lithium ion batteries.