**Objectives**

- Create sphene (CaTiO(SiO$_4$)) by Friction Stir Reaction Processing (FSRP)
- Use Scanning Electron Microscopy (SEM) and X-ray diffraction to determine if compounds formed

**Materials**

- Calcium Oxide (CaO), Calcium Carbonate (CaCO$_3$), Silica (SiO$_2$), Titania (TiO$_2$) powders
- Aluminum 1100 plates, Aluminum 3011 1/8 inch square tube, Aluminum foil tape

**Procedure**

- Use ThermoCalc to determine thermodynamically favorable powder combinations
- Thoroughly mix powders by ball milling in methanol overnight
- Pack powder into tube and set up as shown in figure 1
- Friction stir weld at 1400 revolutions per minute at a speed of 1 inch per minute
- Cut welds in the longitude and transverse directions, prepare metallographic samples
- Analyze samples by SEM and XRD

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**Results & Discussion**

**Optical Microscopy**

Figure 2 shows the cut, polished and etched welds in the transverse and longitude direction. Left: CaO welds, Right: CaCO$_3$ welds. The lighter color gray area is the nugget zone, which is where the powders are stirred into.

**Scanning Electron Microscopy**

Figure 3 Left: SEM image of large particle at 1000X. Right: Optical microscope image of particle at 800X.

**X-Ray Diffraction**

Figure 5 X-ray diffraction angles 25-40, scanned at a speed of 0.5 degrees per minute. Shows no evidence of sphene peaks.

**Conclusions**

- Powder was well distributed throughout the weld nugget
- Particles were too fine to resolve using SEM
- Particles were either too fine, or not in enough concentration to detect through XRD

**Future Work**

- Use TEM to resolve fine particles and determine compounds
- Reproduce experiment with different weld parameters to increase temperature.

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**References**
