Enhancing Li-Ion Batteries by Protecting Them Against Enormous Volume Changes

Sean Wood & Dr. Buddie Mullins
## Group IV: Silicon, Germanium, and Tin

<table>
<thead>
<tr>
<th></th>
<th>Graphite</th>
<th>Silicon</th>
<th>Germanium</th>
<th>Tin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity</td>
<td>372 mAh/g</td>
<td>3579 mAh/g</td>
<td>1324 mAh/g</td>
<td>782 mAh/g</td>
</tr>
<tr>
<td>Volume Change</td>
<td>10%</td>
<td>280%</td>
<td>230%</td>
<td>300%</td>
</tr>
</tbody>
</table>

The table above shows the capacity and volume change for different materials.

In the images below, the progression of Li-ion intercalation into Si is shown over time. The images illustrate the changes in structure and volume expansion as Li ions are inserted into the silicon material.
My Research: Engineer a Protective Space (Approach 1)

Objective: Protect the surface of particles from SEI formation by coating it with a carbon shell and allowing the volumetric expansion within that protective shell.
**My Research: Buffer Particles from the Inside (Approach 2)**

*Objective:* Synthesize silicon, germanium, or tin nanoparticles that have built-in structural supports like titania (TiO$_2$) or alumina (Al$_2$O$_3$).

- Blue circle: $\text{SiO}_2$, GeO$_2$, or SnO$_2$
- Red line: TiO$_2$ or Al$_2$O$_3$

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**Specific Capacity (mAh/gSnO$_2$)**

**Coulombic Efficiency (%)**

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