

Zirconia-Modified Garnet Electrolytes: Toward Safer, Longer-Life Li Batteries

Scientific Achievement

A new garnet-based solid electrolyte incorporating amorphous zirconia at grain boundaries suppresses lithium dendrite propagation and improves the mechanical and electrochemical robustness of lithium metal batteries.

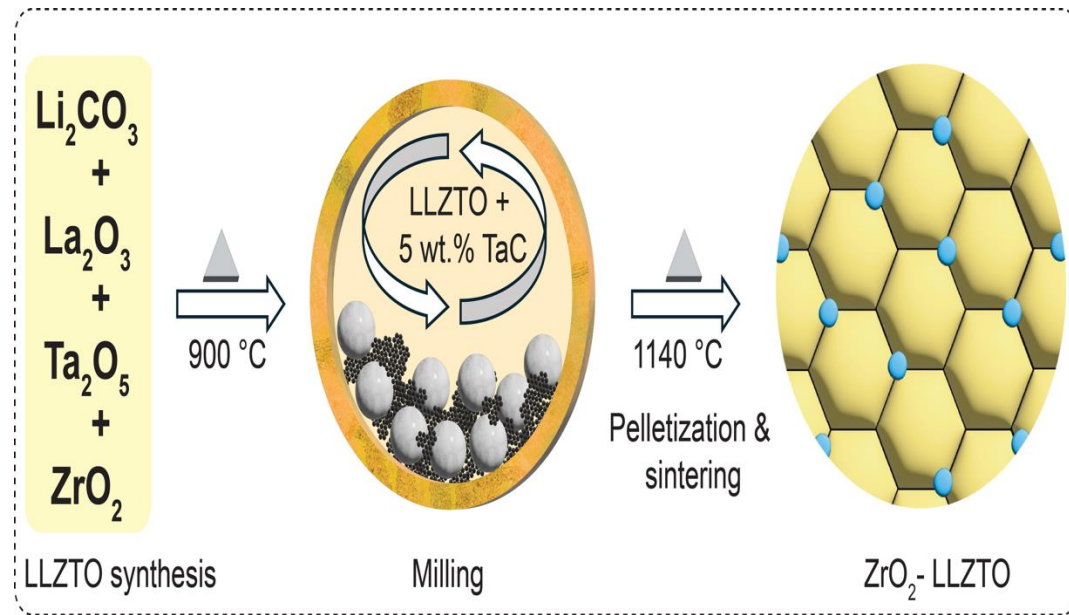


Figure: Schematic illustration of zirconia modification in garnet solid electrolytes. During sintering, tantalum carbide (TaC) reacts with the LLZTO matrix and ambient oxygen to form amorphous zirconia (ZrO_2) along grain boundaries.

Significance and Impact

Grain boundary engineering with zirconia improves the mechanical toughness, electrochemical stability, and dendrite resistance of garnet electrolytes, providing a scalable pathway toward safer, high-performance solid-state lithium batteries.

Research Details

- During sintering, TaC reacts with LLZTO and ambient oxygen to generate amorphous ZrO_2 at grain boundaries.
- Improved structure: The zirconia phase reduces porosity from $\sim 14\%$ to $\sim 3\%$ and increases fracture toughness by $\sim 15\%$.
- The composite electrolyte doubles the critical current density and effectively suppresses lithium dendrite growth.

Raj, V.; Wang, Y.; Feng, M.; Naik, K. G.; Jain, M.; Vishnugopi, B. S.; Deng, S.; Schorr, N. B.; Salazar, M.; Heusser, A. M.; Huang, X.; Manning, A. S.; Kalnaus, S.; Liu, Y.; Watt, J.; McBrayer, J. D.; Boyce, B. L.; Fang, H.; Jena, P.; Mukherjee, P. P.; Qi, Y.; Mitlin, D., Grain boundary zirconia-modified garnet solid-state electrolyte. *Nature Materials*. 2025.

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