



# Department of Materials Science and Engineering Seminar Series 2026

## NaCaPO<sub>4</sub>-Based Architected Ceramic Composites: Structural Evolution from Dense Walls to Closed- and Open-Cell Architectures for Thermal Insulation and Oil-Water Separation

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**Date and time:** 5 May 2026, 4.15 pm to 6.45 pm

**Venue:** EA-02-15

### **Abstract**

At the intersection of high-temperature insulation and liquid separation, architected ceramic materials must reconcile chemistry, pore morphology, and structural robustness within a single design framework. This thesis advances beta-NaCaPO<sub>4</sub> as such a platform by showing how one phosphate-based wall material can be translated from dense ceramics into closed-cell and open-cell architectures with distinct functions. Through this platform-centered approach, the work establishes a structure-processing-property pathway for designing ceramic composites that combine intrinsic thermal resistance, controlled pore connectivity, and application-specific surface behavior.

The study follows this platform through three progressive stages. It begins with dense-phase screening in the Na-Ca phosphate system, where phase-pure beta-NaCaPO<sub>4</sub> is identified as a high-resistivity wall material. Building on this foundation, a direct-foamed NaCaPO<sub>4</sub>@glass composite is developed into a closed-cell architecture that delivers ultra-high thermal insulation together with substantial compressive strength at very high porosity. The architectural concept is then extended to open-cell systems for oil-water separation: first through a superhydrophilic NaCaPO<sub>4</sub>-based foam for gravity-driven water purification, and then through a thermally regenerable 3D-printed C/SiOC lattice that overcomes robustness limitations at extreme open porosity. Taken together, these results present architected ceramic composites not as isolated application-specific materials, but as a transferable platform whose dense-wall chemistry, pore topology, and surface functionality can be co-designed for demanding thermal and interfacial environments.

## Biography

Xian Tongfeng is currently a Ph.D. candidate in the Department of Materials Science and Engineering at the National University of Singapore under the supervision of Prof. Ding Jun. His doctoral research focuses on  $\text{NaCaPO}_4$ -based architected ceramic composites, spanning dense, closed-cell, and open-cell structures for thermal insulation and oil–water separation. Prior to and alongside this work, he has also worked on hydrogel-based systems, including hydrogel-based biosensors, reflecting a broader interest in functional materials design across both structural and soft-matter platforms.