Volatile-Templated Ceramic Microstructures

NSF / DOE SBIR Phase I Concept Brief - Excerpt

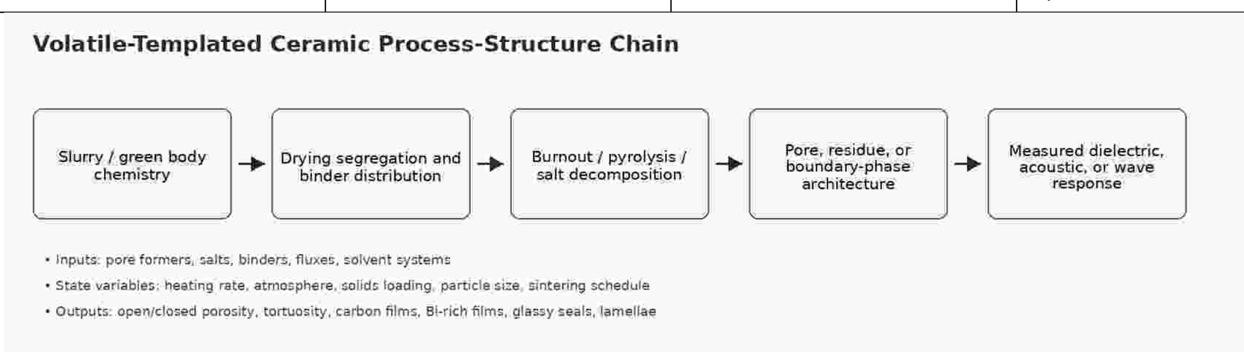
Executive Decision Summary

The proposed Phase I project converts a materials-process synthesis into a fundable ceramic R&D concept: volatile removal, sacrificial templating, salt/flux segregation, and controlled burnout are treated as microstructure-design variables rather than as defect-control problems. The core technical risk is whether selected volatile-templating pathways can generate reproducible pore, residue, or boundary-phase architectures that produce measurable dielectric, RF/microwave, acoustic, or nonlinear electrical response.

The proposal should be framed as a process-structure-property validation program. NSF fit comes from unproven, high-impact R&D that must retire technical risk before productization; DOE fit comes from feasibility/proof-of-concept work in energy-relevant materials, advanced manufacturing, sensing, RF/microwave structures, and harsh-environment components [1-4].

Phase I Aim Structure

Objective	Risk retired	Output	Go/no-go
1. Thermal/process map	Unknown decomposition and burnout pathways.	TGA/DSC/EGA and staged-firing map.	Clear thermal event and firing window for each formulation.
2. Microstructure fabrication	Uncertain repeatability of pore/residue architecture.	SEM/micro-CT/porosity atlas.	>=3 reproducible microstructure families.
3. Functional measurement	Unproven link between structure and response.	Dielectric/RF/acoustic response matrix.	Statistically separable response vs controls.
4. Downselect	Platform too broad for Phase II.	Prototype target and design rules.	One application-specific Phase II path.



Causal chain used to structure the proposed Phase I validation program.

Concept-to-Test Matrix

Claim	Evidence basis	Phase I test	Success signature	Reviewer risk
Sacrificial additives can form designed pore architectures.	Starch consolidation and pore-forming literature [5-9].	Coupon matrix with starch/saccharide/polymer pore formers.	Repeatable pore size/connectivity and density shift.	Seen as mature porous ceramics unless tied to function.
Aligned or structured porosity can alter wave response.	Freeze-cast pore networks and acoustic porous ceramic studies	Measure dielectric/RF/acoustic response of aligned and	Directional or frequency-specific response shift vs control.	Wave-guiding claims require measured data.

	[10-12].	random pore coupons.		
Segregated boundary phases can create nonlinear response.	ZnO-Bi2O3 varistor grain-boundary literature [13,14].	Comparator formulation with grain-boundary mapping and I-V test.	Nonlinear I-V curve and boundary-phase evidence.	Must avoid overgeneralizing varistor behavior to all systems.

Reviewer Objection Map

1. "This is only porous ceramics." Response: define novelty as predictive process-to-function mapping rather than pore generation alone.

2. "Resonant function is speculative." Response: use measured dielectric loss, VNA response, acoustic absorption, and I-V behavior as Phase I endpoints; reserve THz/wave-guiding claims for Phase II unless measured.

3. "The scope is too broad." Response: make dielectric/RF response the primary endpoint, with acoustic response as secondary or downselect-dependent.

References Used in Excerpt

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