POROUS UHTCS FOR TRANSPIRATION COOLING OF HYPERSONIC FLIGHT

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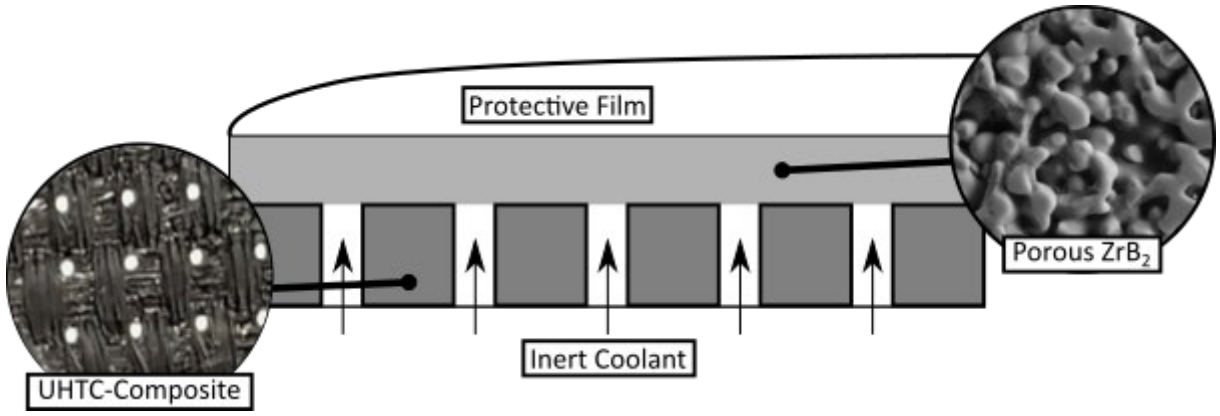
The leading edges of hypersonic vehicles require materials with high melting temperature and thermal conductivity. Ultra-high temperature ceramics (UHTC) would be a good candidate, but their use is limited in such environments by oxidation. Transpiration cooling is then proposed as a solution, flowing an inert coolant through porous UHTC, providing a protective film of inert gas at the boundary layer at the surface of the material.

Coarsening is promoted in the sintering of ZrB_2 to produce a highly porous UHTC which is both permeable to the coolant gas and does not densify at application temperatures of 2000 °C. Coarsening is encouraged during sintering by oxidising ZrB_2 powders prior to hot pressing. While the promotion of coarsening is shown to improve both permeability and strength, a more robust substructure is required to lend mechanical integrity to the system. This would sit below the porous layer, with channels allowing the flow of coolant to the surface, as shown below.

One proposed substructure material is a ZrC/Cf composite, made by liquid infiltration of C/Cf preforms which are in turn made by pyrolyzing phenolic resin/Cf composites. The success of the final composite relies heavily on the quality of C/Cf preforms, which suffer from cracks formed during pyrolysis. This work will then explore methods to improve the preform matrix quality through repeated resin impregnation and pyrolysis, as well as creating channeled preforms to allow for coolant gas flow.



Schematic of a transpiration cooled UHTC system. Porous partially sintered ZrB_2 sits above a channeled substructure of ceramic matrix UHTC composite. Coolant gas flows through the system, creating a boundary layer that protects from oxidation.