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Topology Optimized Fin Designs for Base Plate Direct-Cooled Multi-Chip Power Modules

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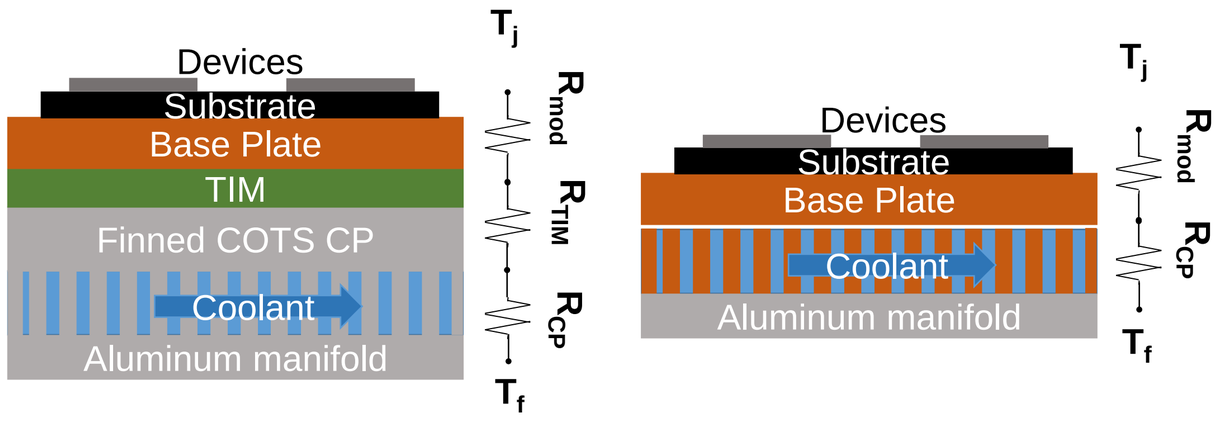
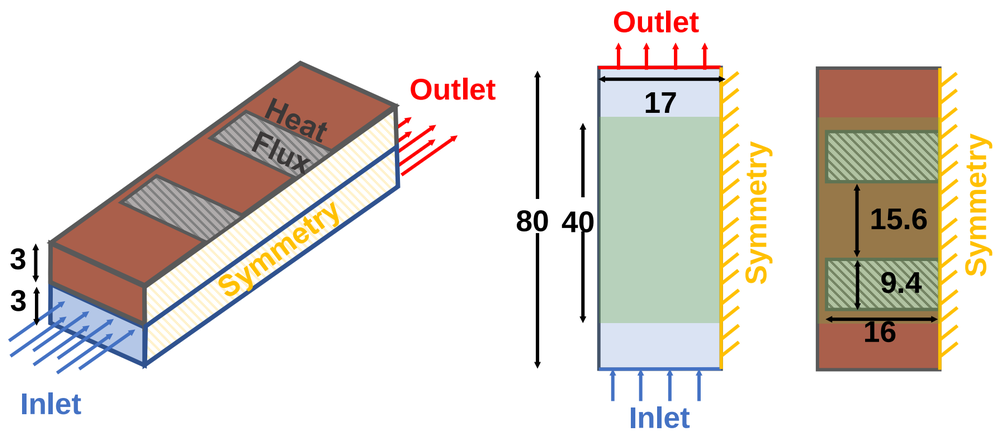
- Advances in electrified transportation are enabled by Wide Bandgap devices packaged into **Multi-Chip Power Modules (MCPM)**.
- Base plate direct cooling lowers the junction-to-coolant thermal resistance.
- We demonstrate the use of **Topology Optimization** to design the base plate integrated fins used for direct cooling of the MCPMs.
- **Multi-objective optimization** of thermal and hydraulic performance is solved with a special emphasis on inter-device isothermalization.

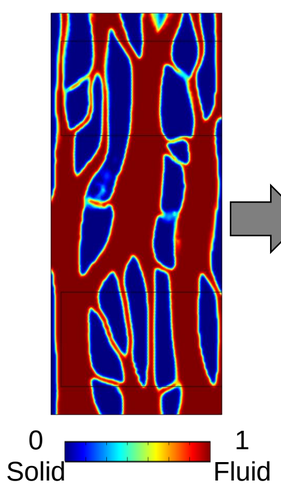


Typical thermal resistance stackup for conventional cold plates with TIM and direct-cooled approach with finned base plate.

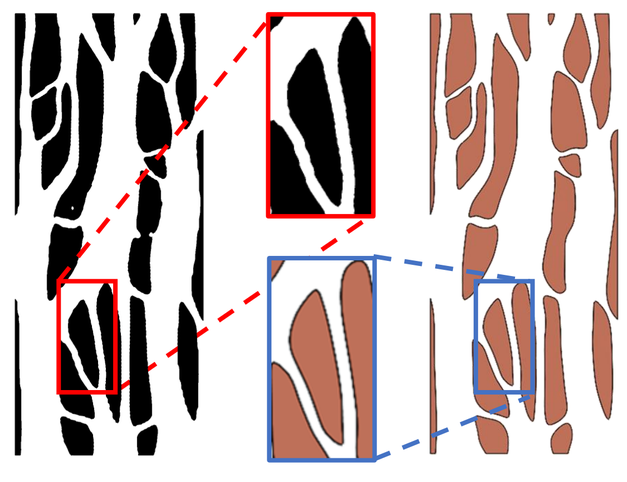
Methodology and Approaches



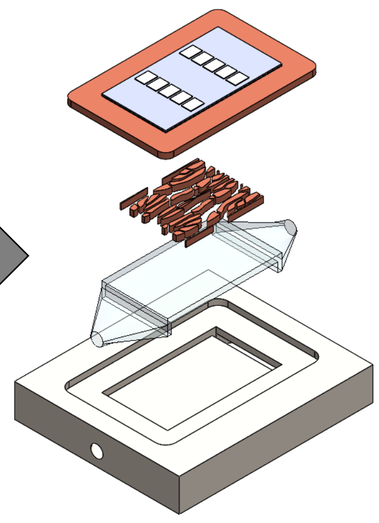
Simplified 3D Domain ***Fluidic layer*** ***Solid layer***



Density field obtained using TO



Postprocessing in SolidWorks

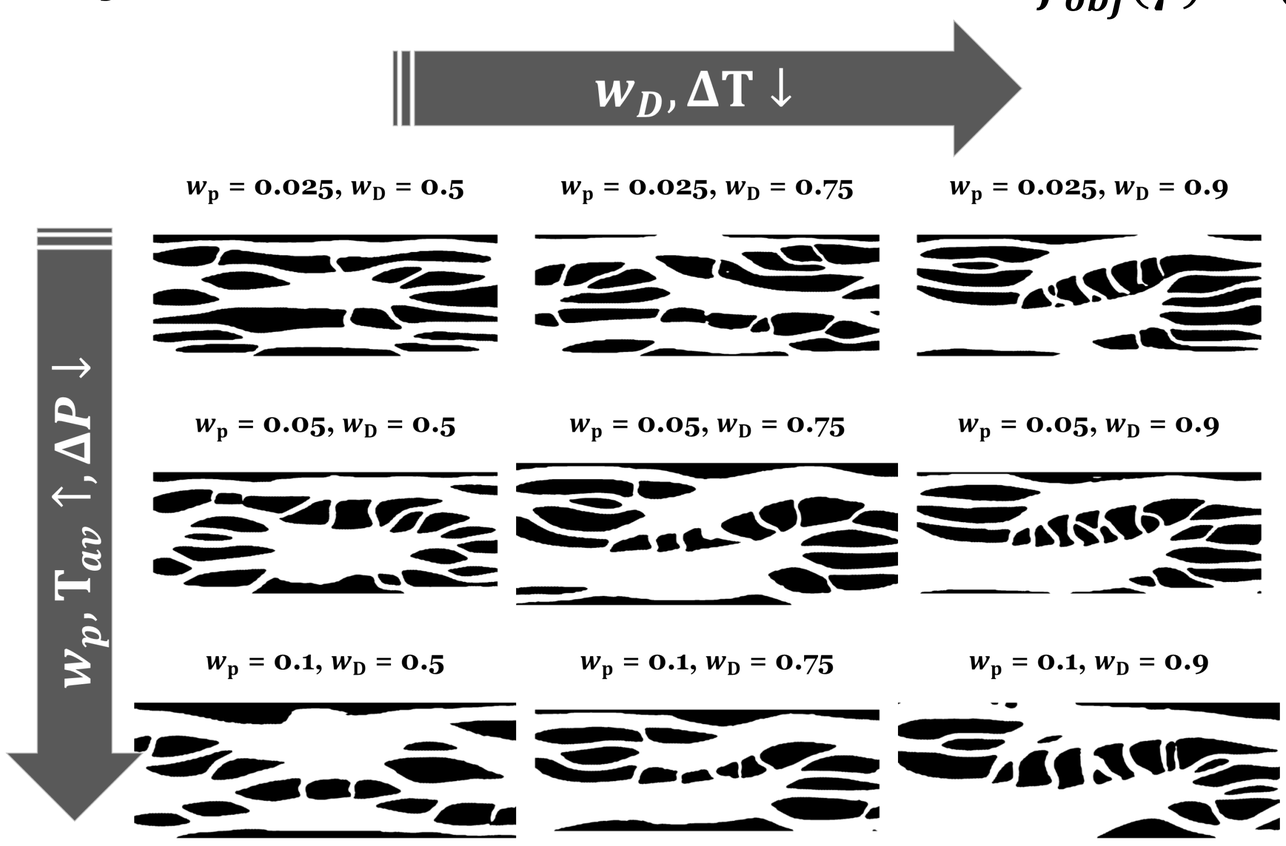


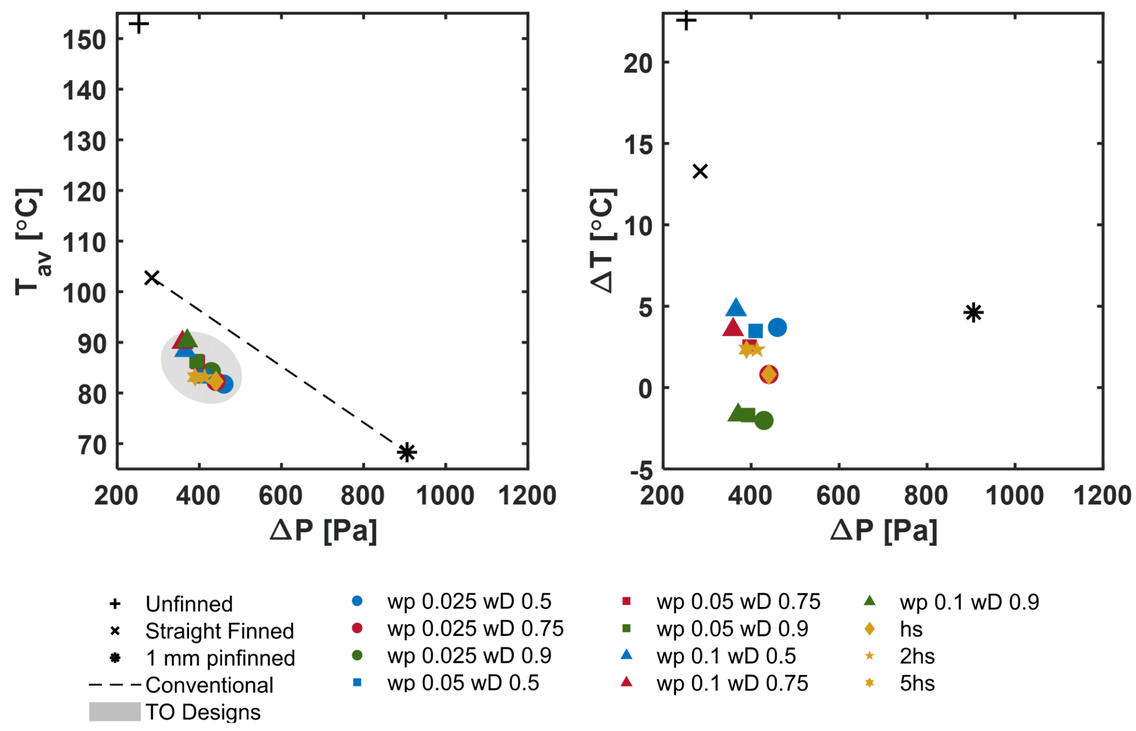
3D FEA Simulation Geometry

- 3D design domain is simplified. **Two-layer 2D method** is used to solve for performance metrics.
- **Weighted sum** approach is used to solve multi-objective topology optimization in COMSOL Multiphysics.
- Fin designs used to perform 3D FEA simulations for performance estimations and comparisons with conventional designs.

Key Results

$$f_{obj}(\gamma) = (1 - w_D)T_{s,1} + w_D T_{s,2} + w_p \Delta P$$





- Topologically optimized (TO) designs deliver **better thermal performance** compared to the conventional fin designs **without requiring additional pumping power**.
- TO designs are inherently **better at maintaining inter-device isothermalization**.

P/O/E/T/S

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