3D POL using Stacked Power process

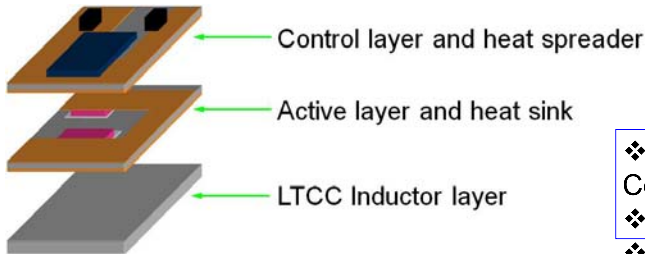
CPES Center for Power Electronics Systems

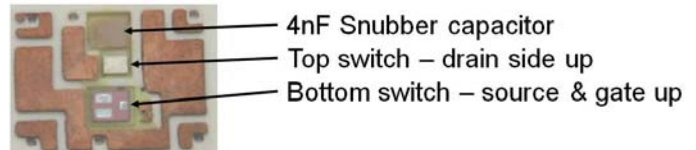
Arthur Ball, Michele Lim, David Gilham, Fred C. Lee

Virginia Tech Invent the Future

Objective: 3D-integrated buck with LTCC inductor, running at 1.3 MHz, with integrated thermal management, very low profile & small footprint

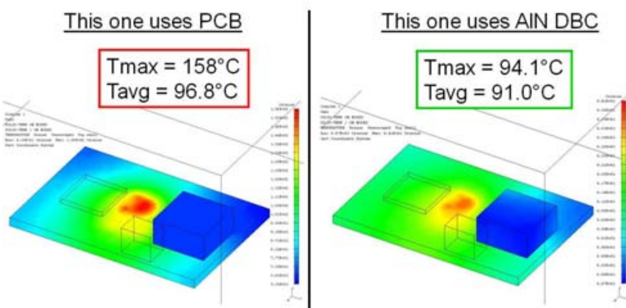
Conceptual diagram of 3D POL Structure

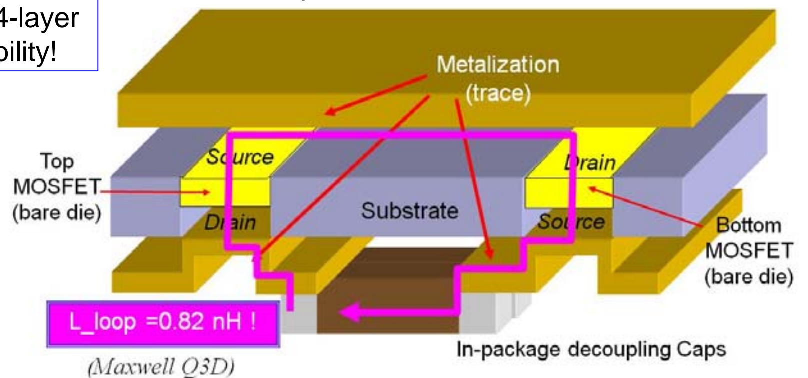




- ❖ Active and Control layers made using Direct Bonded Copper
- ❖ Device dies are ***inside*** ceramic to allow z-axis integration
- ❖ Benefits: Reduced parasitics and low thermal resistances:

- ❖ DBC has ~6x greater thermal conductivity than 4-layer PCB. This allows for much higher integration capability!

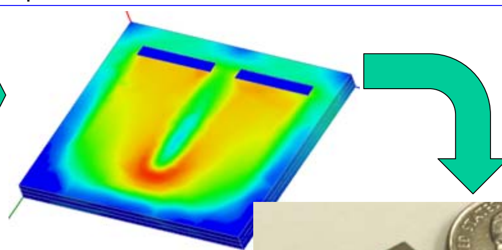


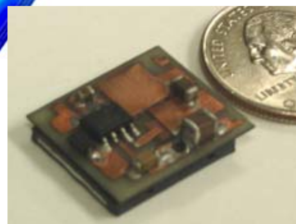


LTCC Inductor Substrate: Single-phase Design or Two-phase Coupled-Inductor

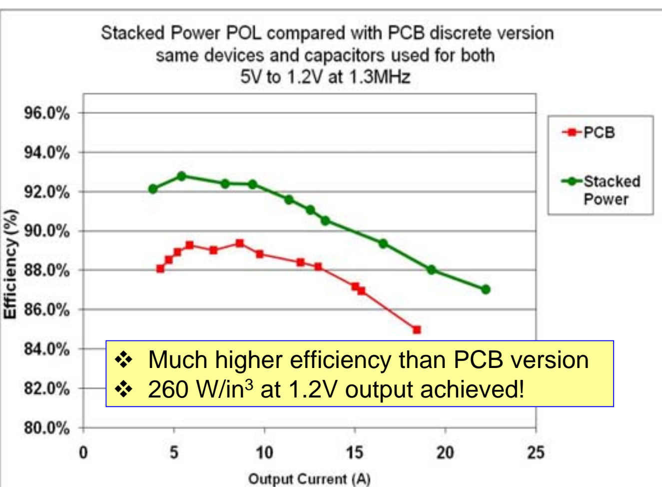
- ❖ 1-phase, 3 LTCC layers:

- ❖ Maxwell simulations for design and to minimize footprint. Final size: 18 x 18 x 1.4 mm at 70nH/18A

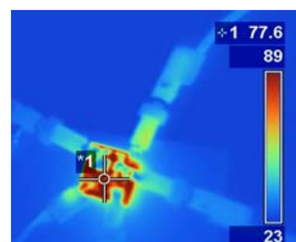




- ❖ Completed single-phase 3D ceramic POL using inductor as a substrate. Final size is 18 x 20 x 5 mm.

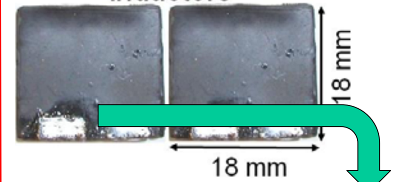


- ❖ Much higher efficiency than PCB version
- ❖ 260 W/in³ at 1.2V output achieved!

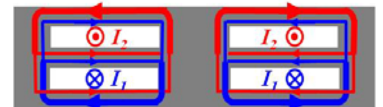


- ❖ At full 20A output, no fan & no heat sink needed, up to 55° C ambient temperature!

- ❖ 2-phase Coupled Inductor:



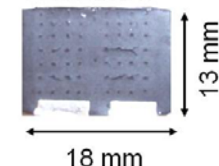
LTCC coupled inductor



- ❖ 37% less volume !
- ❖ 28% smaller footprint !

than 2 non-coupled inductors

2 phase coupled inductors



- ❖ Stay tuned for future 2-phase POL featuring superlative power density!