Thermal modelling of smart power devices

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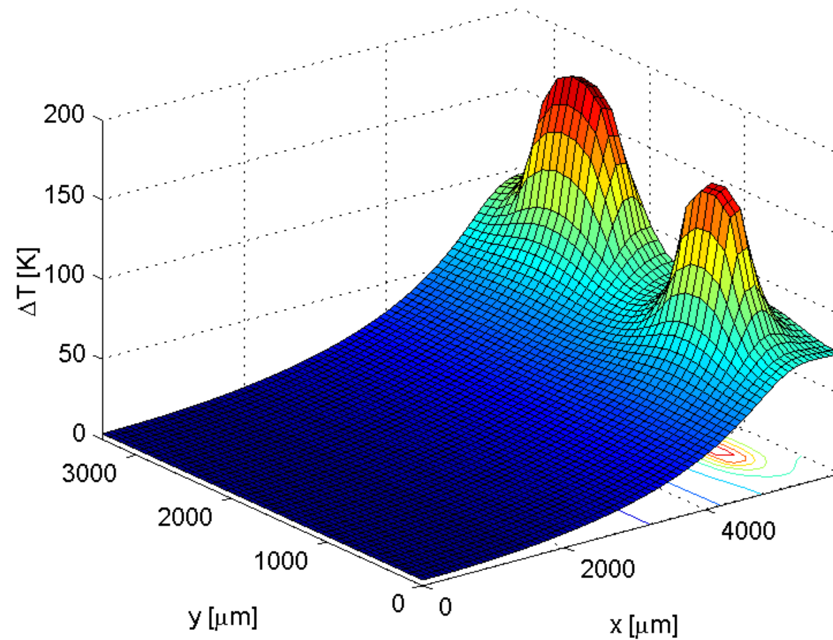
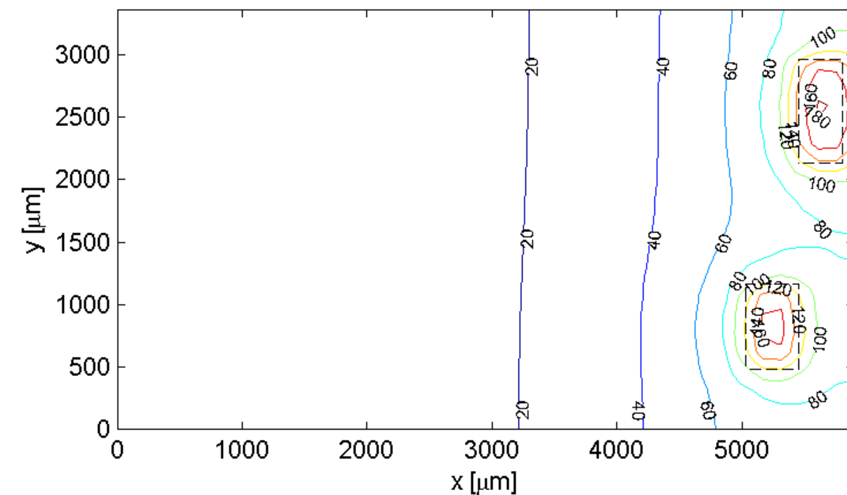
Thermal simulation tool

- ***Thermal simulation tool developed in Matlab***
- ***Analytical solution based on Green's functions***
- ***Assumptions:***
  - Adiabatic top boundary, while other boundaries at infinity
  - Rectangular power sources
- ***Adiabatic die edges: using method of images***
- ***Calculation of T(x,y,z,t):***
  - For any number of power sources
  - For any power function P(t)
- ***Advantages:***
  - Faster than dedicated commercial software
  - Good accuracy
  - Flexible for designers

Simulations on smart-power IC

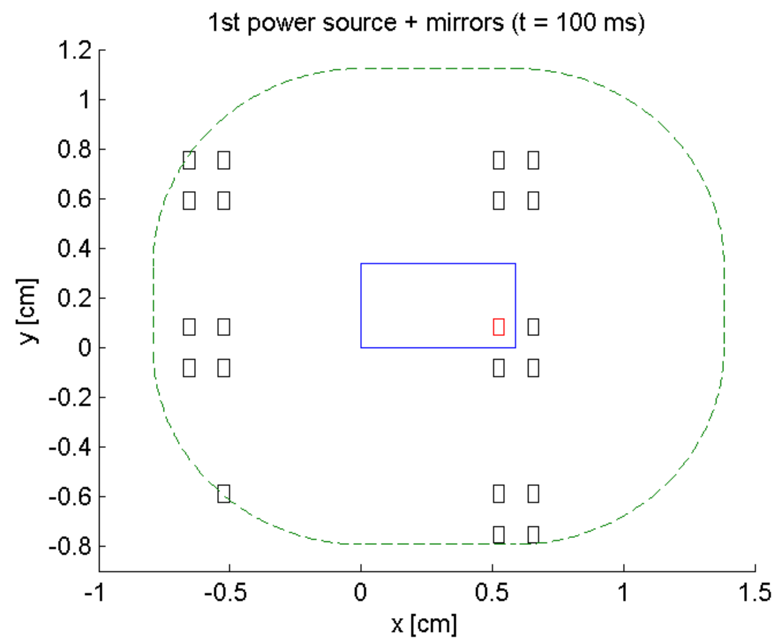
- *Example: 2 DMOS drivers inside H-bridge*
- *Power step function: 12.5 W per driver*

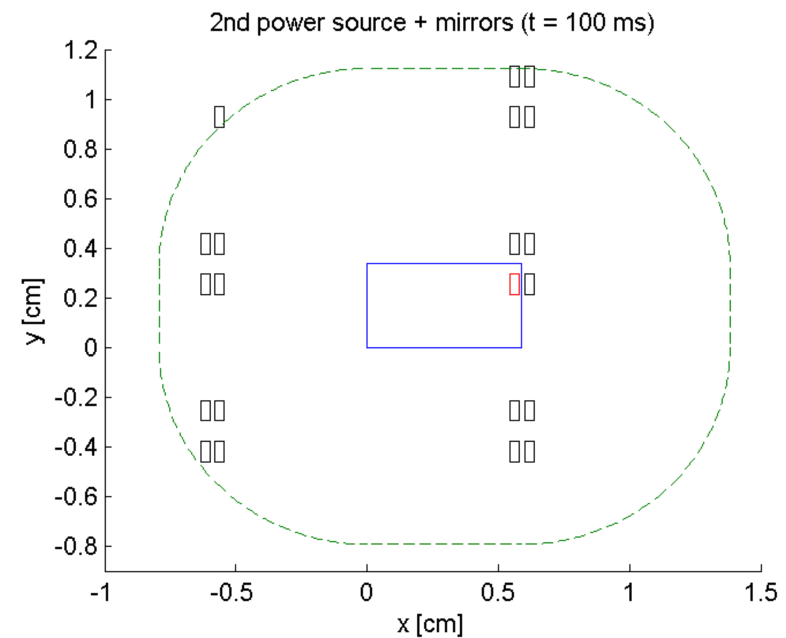




Method of images

- Adiabatic die edges: introduce image sources
- Number of images limited by thermal diffusion boundary (grows with time)

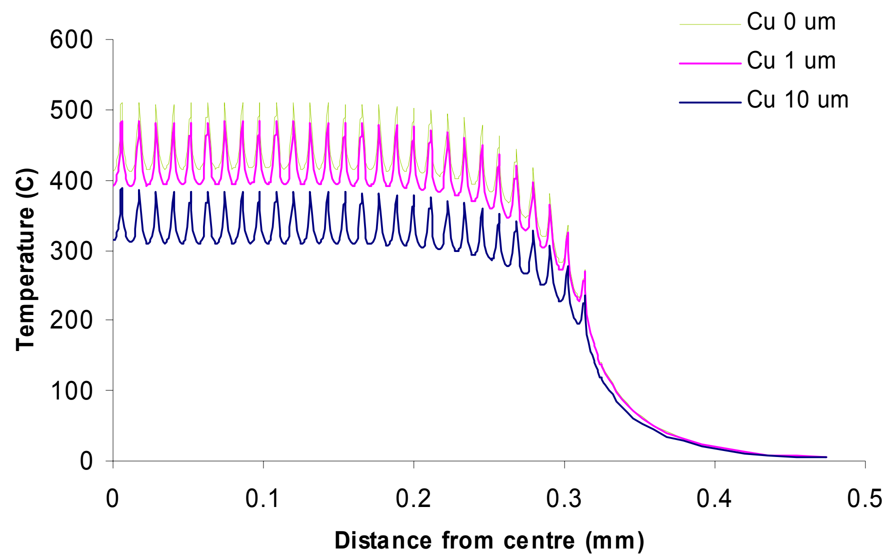




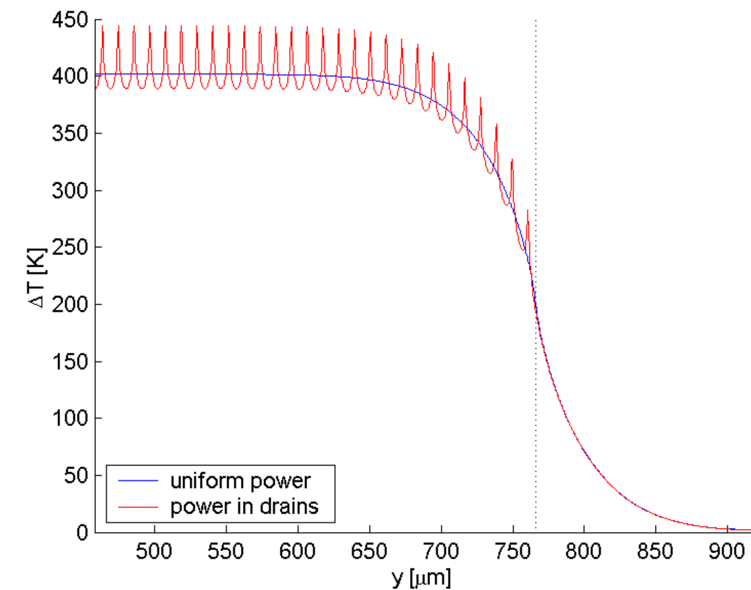
Comparison commercial software

- *Numerical simulations: **MSC.Marc** software*
- *Good **agreement** for small Cu thickness*

commercial software

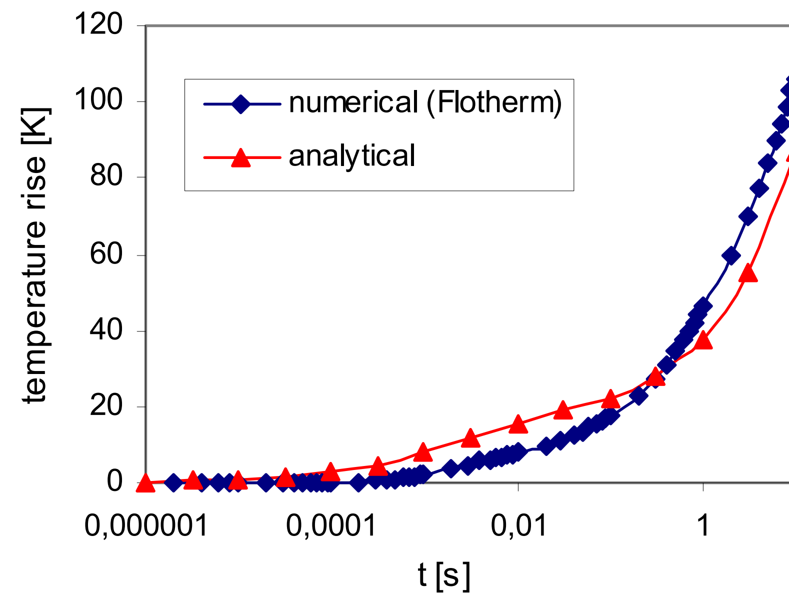


developed tool



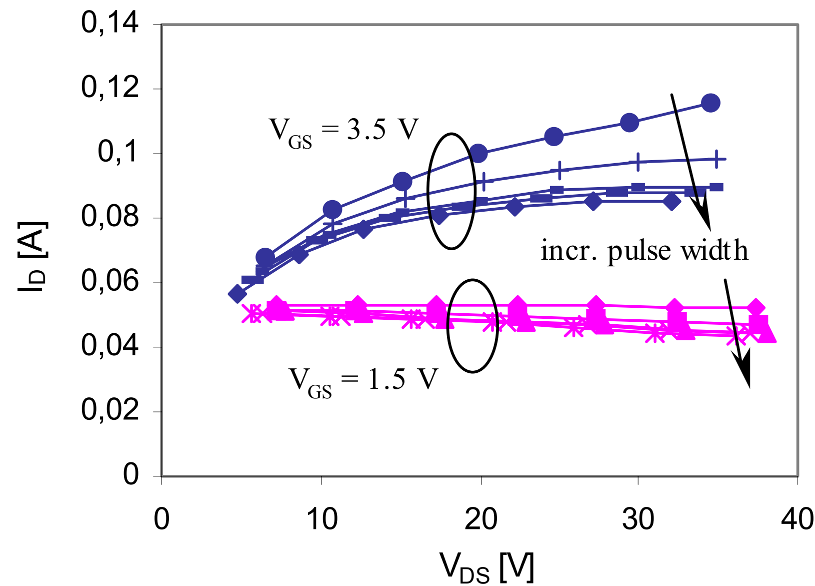
Comparison commercial software

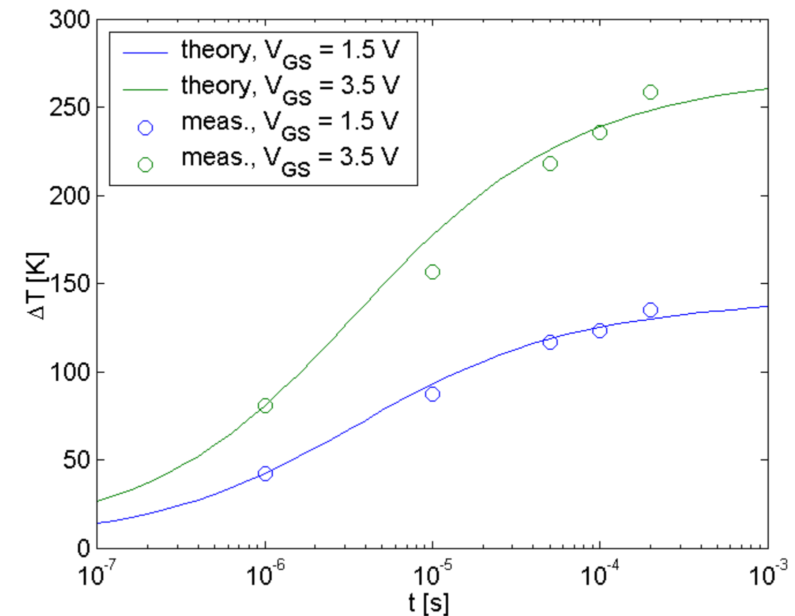
- *Numerical simulations: Flotherm software*
- *Good agreement up to 10 s: much longer than typical diffusion time (~ 100 ms)*



Pulsed measurements validation

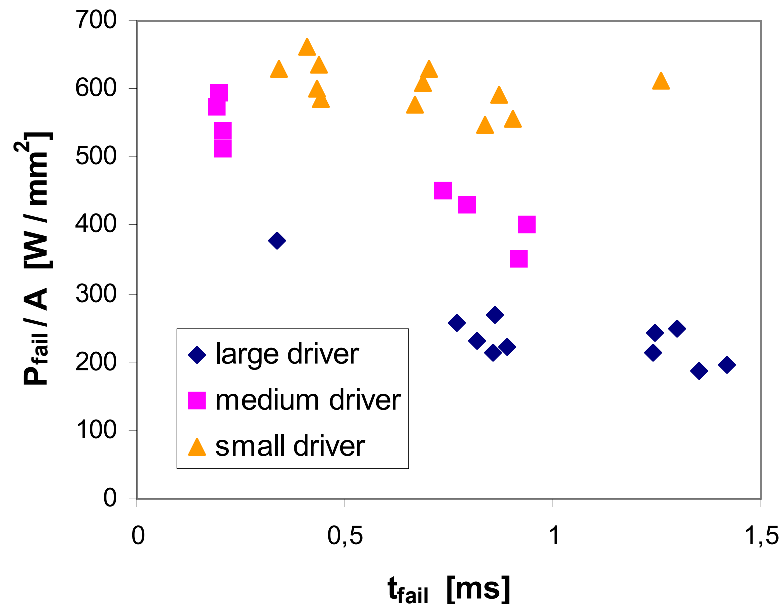
- *Mobility decrease model:* $I/I_0 = (T/T_0)^{-k}$
- *Current decrease used to predict temperature increase (using high-field k-value)*
- *Good agreement if T_0 same as predicted by analytical model*

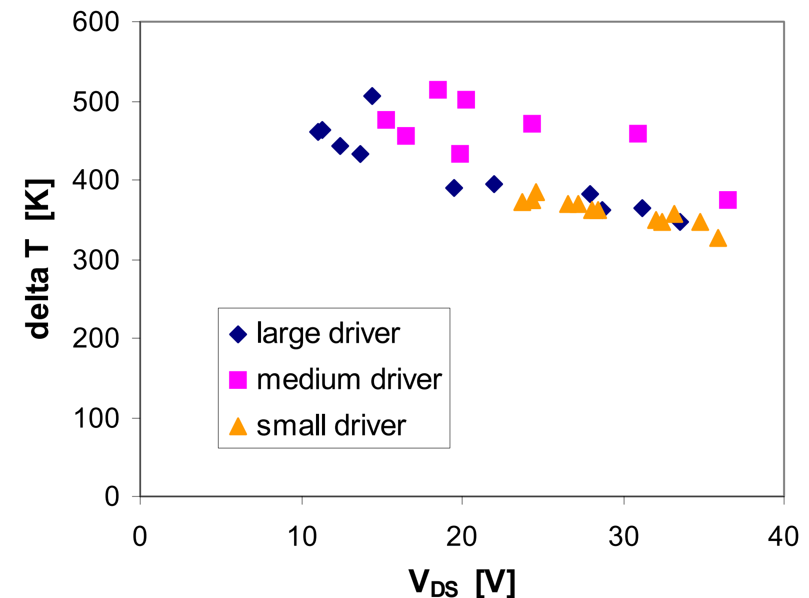




Thermal failure prediction

- ***Energy capability measurements:***
  range of (V_{DS},V_{GS})-values → range of (P_{fail},t_{fail})-values
- ***Prediction of T_{fail} using tool:***
  - Low V_{DS}: agreement with TCAD simulations
  - High V_{DS}: earlier failure explained by impact-ionisation





Acknowledgements

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