

Power Device Analysis in Design Flow for Smart Power Technologies

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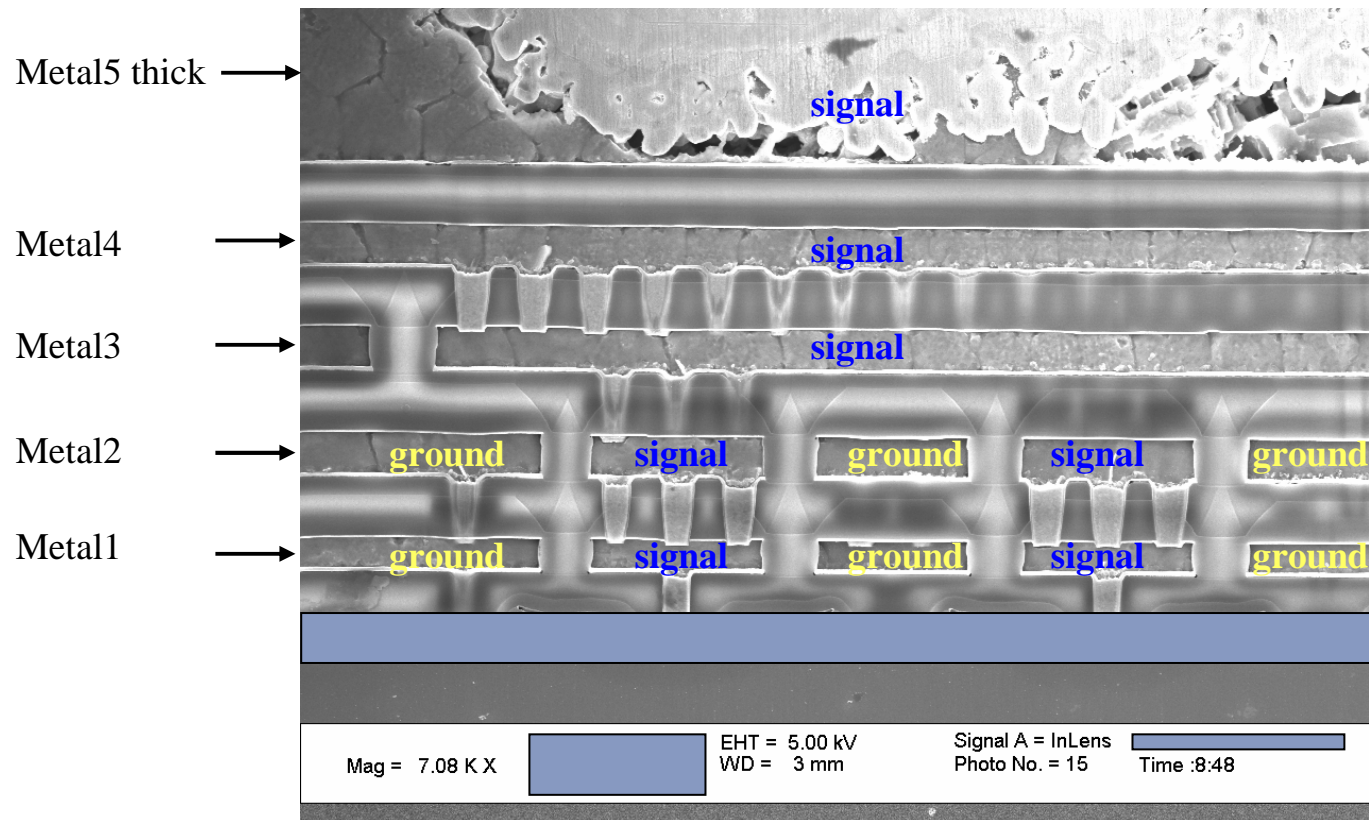
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The goal of this work

- This work presents a new design methodology for power device design using R3D – software for metal interconnects simulation for power devices
- The novelty of the proposed methodology is in a deep integration of R3D with existing design environment
- This integration enables an automation and ease of use that make power device design, analysis, and optimization accessible for every designer
- As a results, higher quality designs can be accomplished in a much shorter period of time avoiding expensive re-spins

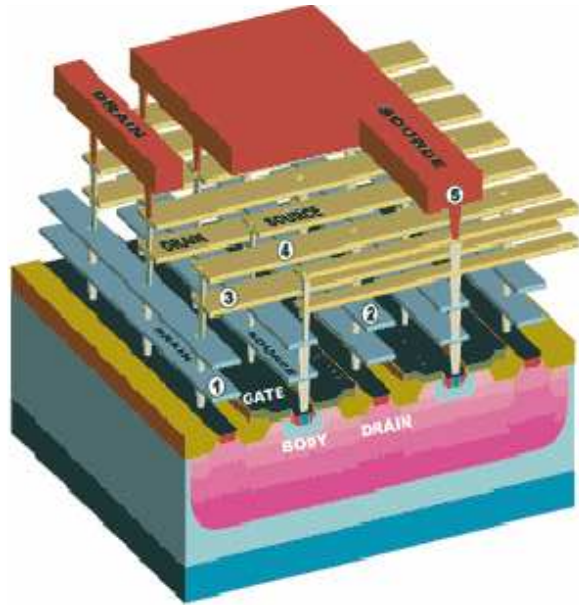
Overview – Smart Power Technologies

Power Device configuration of MOS transistors designed with large channel width and multiple metal layer stacks are commonly used to reduce device ON-resistance (R_{dson}).



SEM picture of metal stacks in a power component

Design Methodology request



The complete simulation of the voltage and current distribution in such a complex layout is a complicated and time-consuming task



Design Methodology to replace expensive silicon runs and reduce the time to obtain a complete electrical analysis of the power structure from months to hours

ST Micro choice for Power Analysis: R3D

- R3D is a software tool, developed by Silicon Frontline, for extraction, simulation, and analysis of metal interconnects of power semiconductor devices
- Rigorous efficient 3D field solver for current flow
- R3D reads in standard files (layout, technology, etc.), and simulates current flow and voltage distributions in metals, vias, and devices
 - Device model: distributed resistors or SPICE elements
- Capable to simulate various device types
 - MOS, DMOS, LDMOS, vertical DMOS, waffle-style, HEMTs
- R3D accuracy validated on over 150 various designs
- Adoption of R3D tool in power technology design flow allows to generate high-quality and error-free designs

R3D features and capabilities

- Automated Rdson value calculation (device + metal)
- Visualization of current density and voltage distributions
- Designing sense point or matched sense device
- Current density / Electromigration analysis
- Metal slotting optimization
- Optimization of metal, via, and wire bonds layouts
- “What if” and sensitivity analysis
- Tradeoff analysis: cost versus efficiency (Rdson)
- Layout design debug and verification
- Optimization of metal layouts at early design stages

The need for R3D integration into design flow

- While R3D can operate in a stand-alone mode, its integration into design flow offers significant advantages:
 - Automation of data input, for multiple device types and technologies
 - Minimization of human error (especially for novice or infrequent users)
 - Shortening of learning curve for designers
 - Possibility for R3D to be used by all designers within an organization
- Instead of being a tool for an expert user, R3D integrated into design flow becomes a standard design tool that any designer can use for debug, analysis, and optimization
- Example of automation:
 - Instead of specifying “low level” information (meshing, metal and device resistivities, layout info, etc.) the user selects the technology name and metal option, and runs R3D in a “push button” approach

Evaluation results – strong benefits

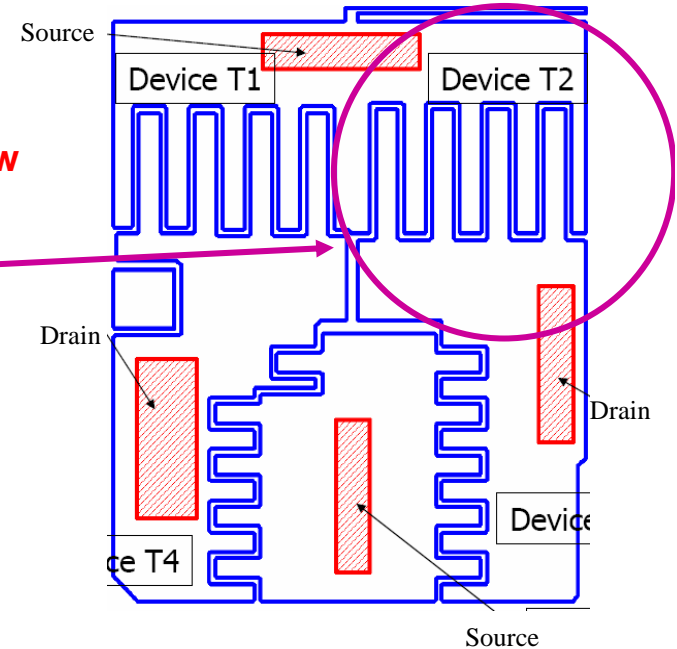
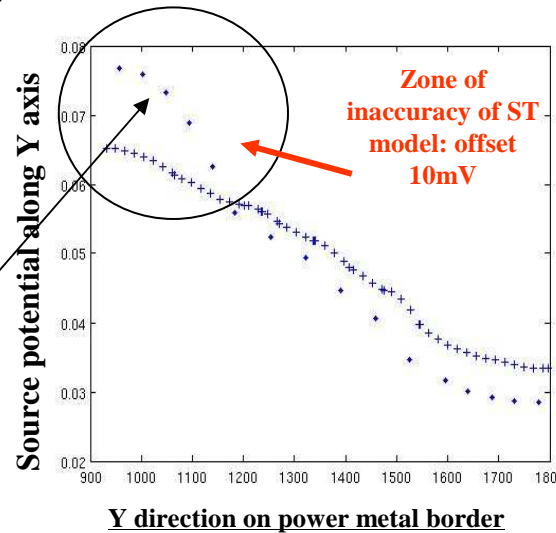
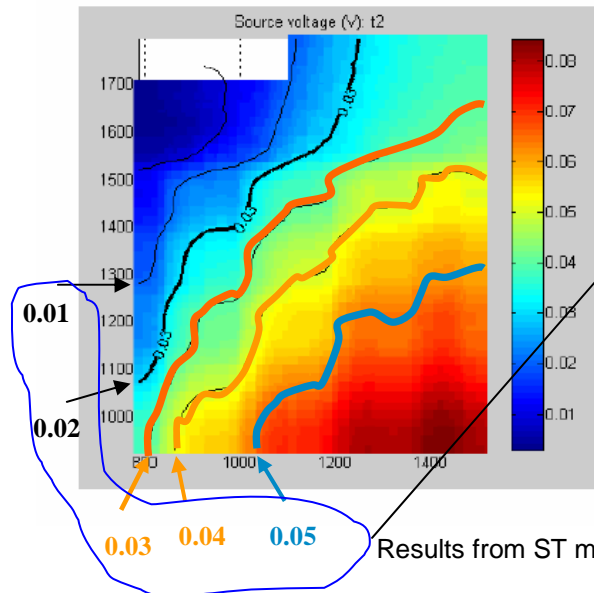
Car radio design: Full half-Bridge power stage

Request from design: potential value on power border for a precise sensing

4-hours R3D automatic mesh creation & power simulation

6-months, manual schematic, thousand of elementary blocks to draw

Example: analysis of T2 device



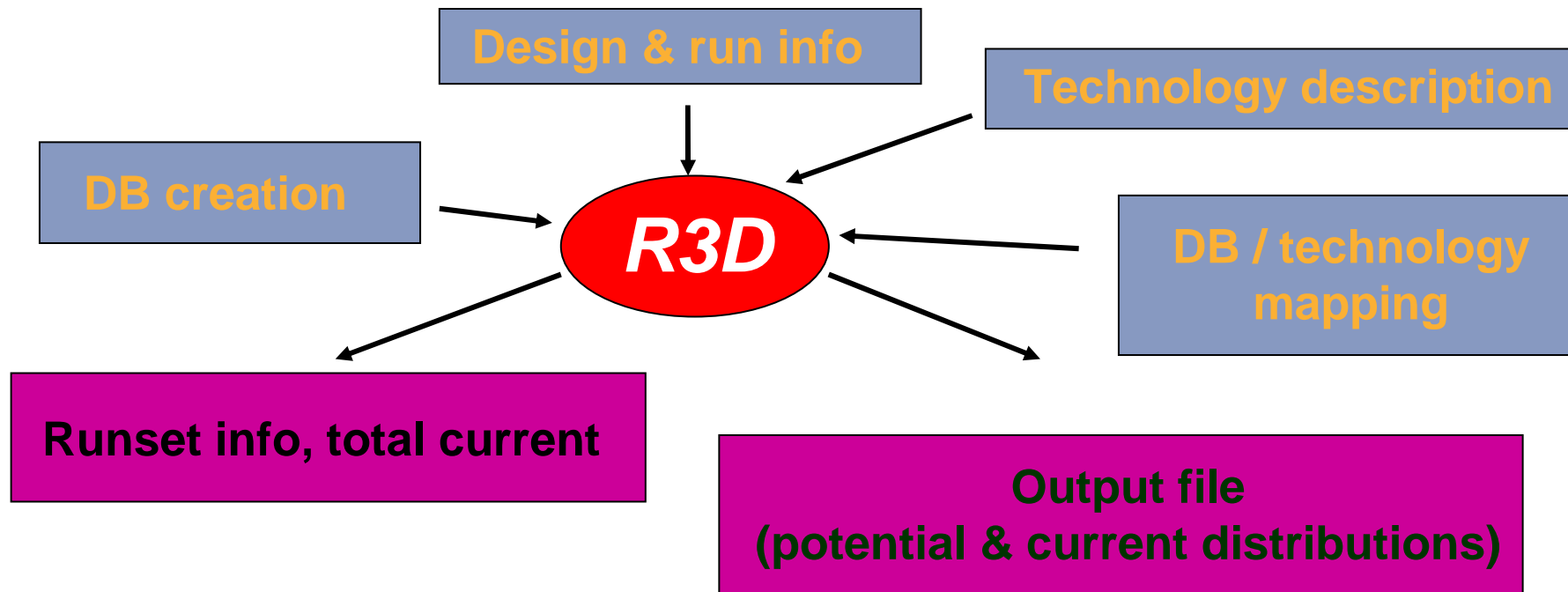
Very good results accuracy (the tool underlines an inaccuracy of ST' Model) in a not comparable time -> great benefit in analysis efforts and in recycle time

Design Flow – complexity managing

- Design & run info supply
- Connected DB creation
- Back-end Technology usage
- Layout/Techno Mapping
- Results collection and visualization



Necessary a GUI to drive the flow



Design Flow GUI

Automation of the whole flow

Fully integrated in Design Framework environment

Developed internally by STMicroelectronics

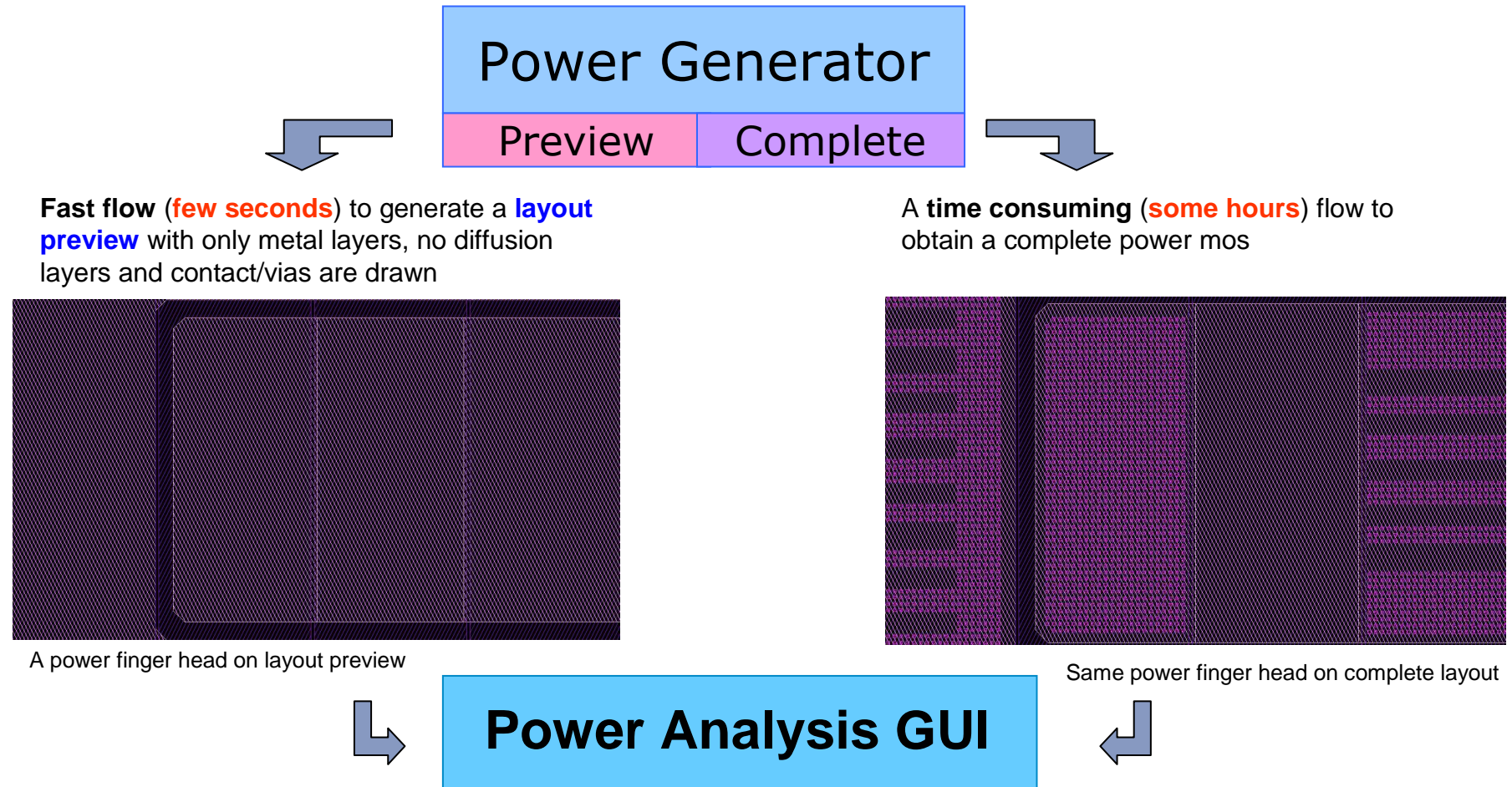
The screenshot shows the PowerKit GUI with the following sections:

- Mesh:** Includes a 'Default' button and input fields for 'Points of Mesh for Devices' (50), 'Points of Mesh for Top Contacts' (50), 'Points of Mesh for Vias: X' (100), and 'Points of Mesh for Vias: Y' (100).
- Interconnections:** Includes a 'Typical' dropdown, 'Bottom Metal Layer' (metal1), 'Top Metal Layer' (metal4), and a 'Sensitivity' checkbox.
- Top Contacts Configuration Editor:** Includes buttons for 'Add New Top Contact', 'Remove Top Contact', 'Write Top Configuration on Layout', and 'Discard Top Configuration Edits'.
- Table:** A table with columns: X, Y, Width, Height, Type, Current Name, Net, Voltage, Res, and a 'Move' button. It contains two rows of data.
- Bottom Buttons:** 'LOAD COMMAND FILE', 'SAVE COMMAND FILE', 'RUN', and 'CLOSE'.

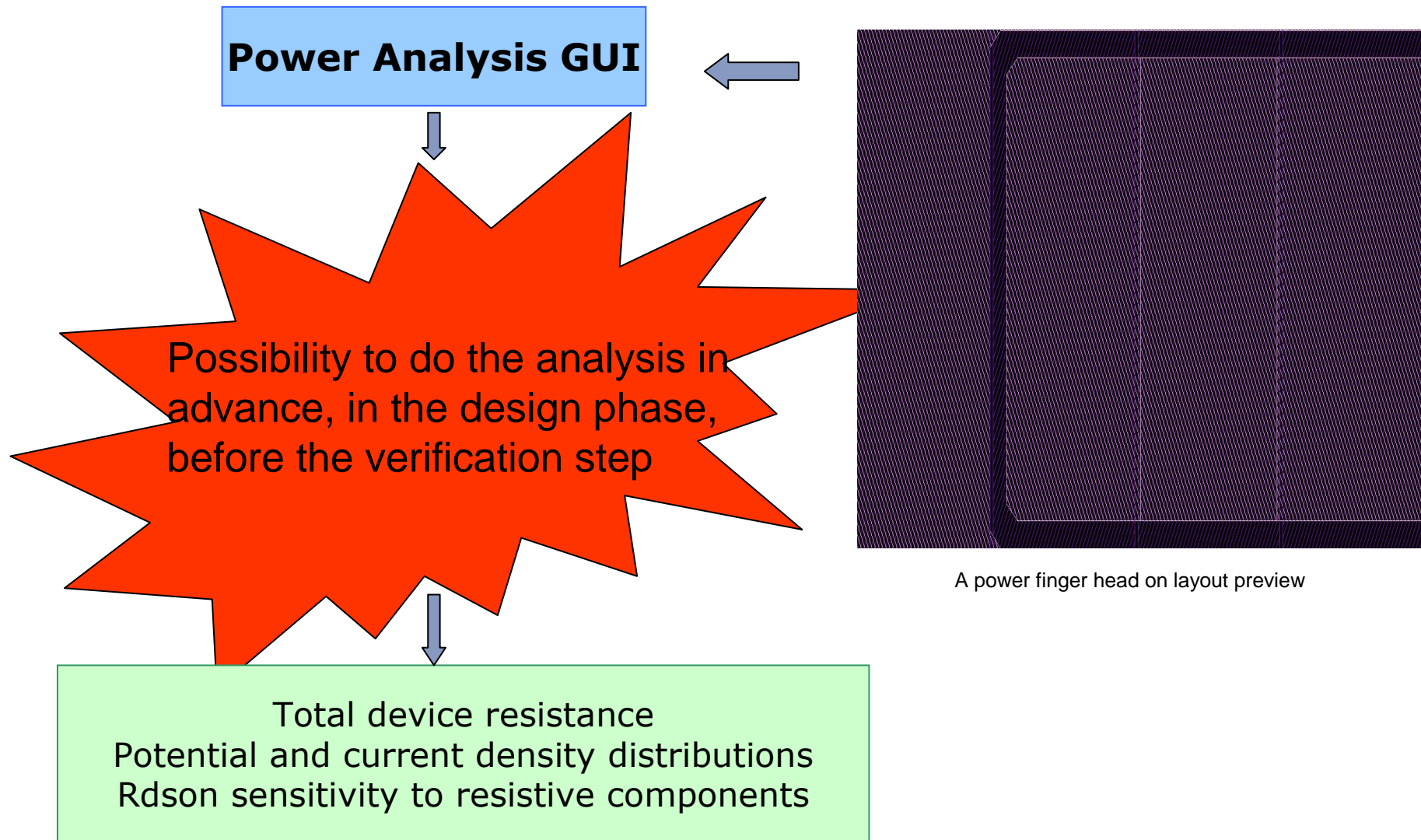
	X	Y	Width	Height	Type	Current Name	Net	Voltage	Res	Move
<input checked="" type="checkbox"/> Edit	142.06	25.89	9.20	9.20	drain	name228	net_d	1	0.00	Move
<input checked="" type="checkbox"/> Edit	166.52	175.64	9.20	9.20	source	name230	net_s	0	0.00	Move

Flow linked to Power Generator Tool

Power Generator is a STMicroelectronics Tool to generate in automatic way optimized power mos layouts. Two main flows:

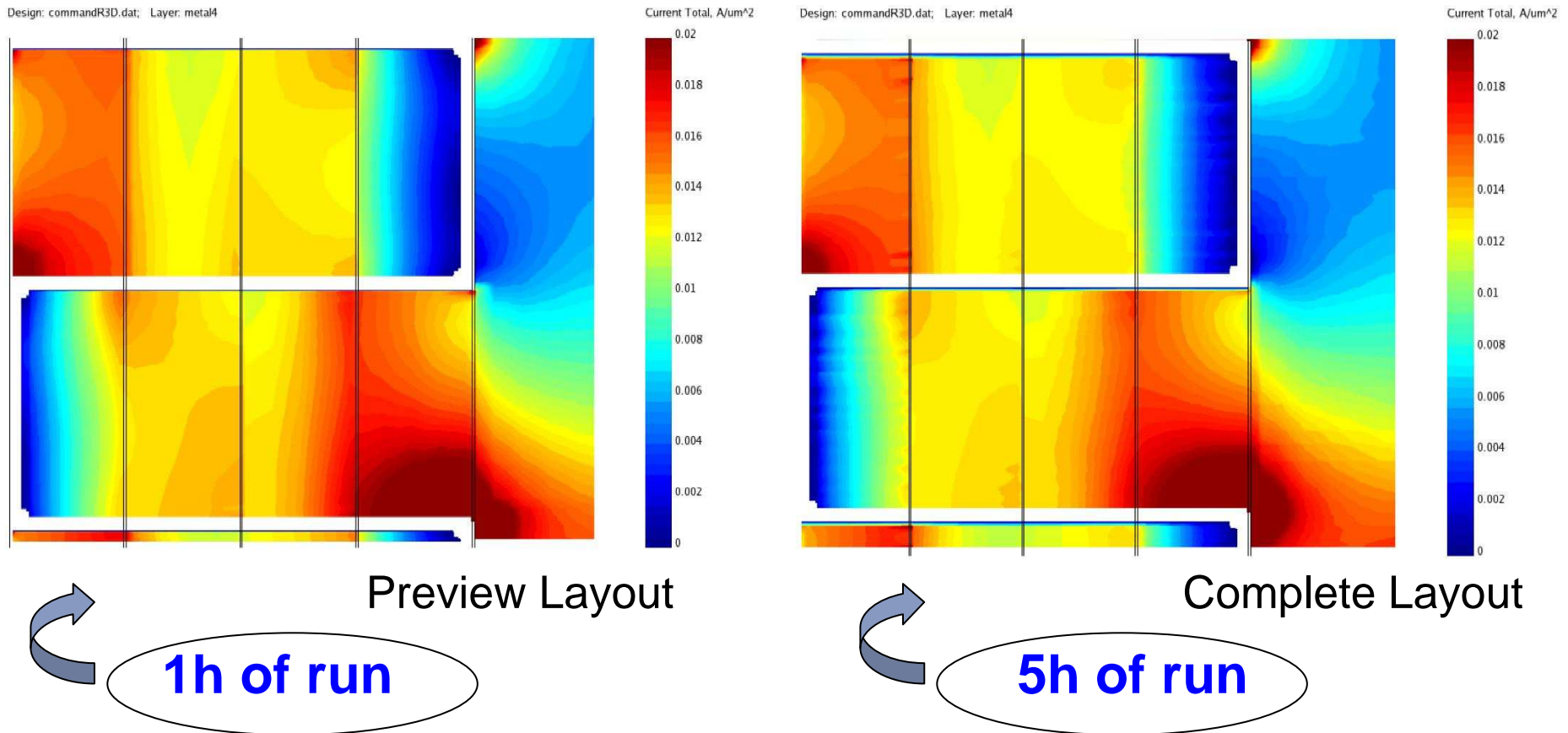


Power Analysis in advance during design flow



Methodology Results -1

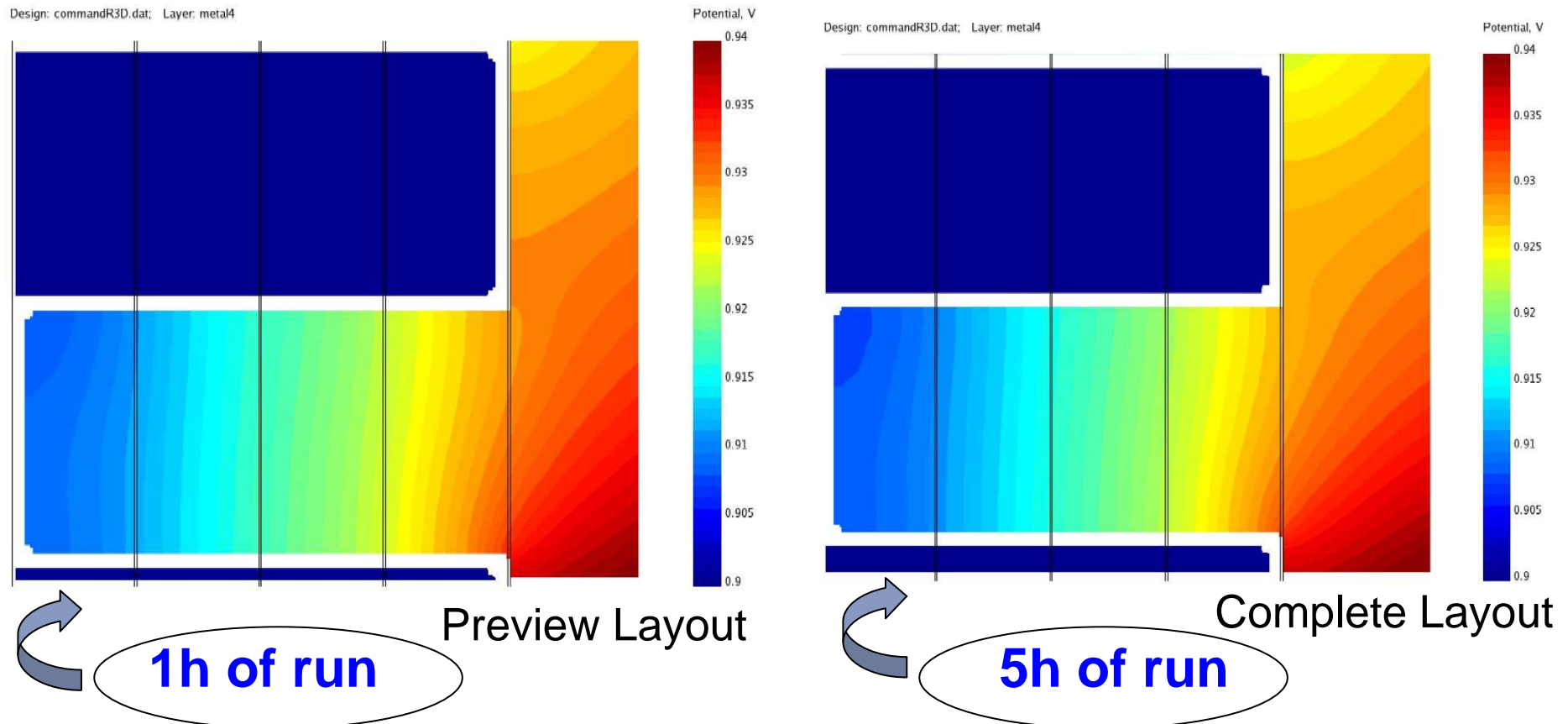
Total current density on metal4 layer



Very good accuracy on current density result in 1/5 of run time!!

Methodology Results -2

Potential value on metal4 layer



The accuracy on potential computation is really acceptable, as the difference in total R_{on} = 1.05% and in total W =0.01%

Conclusions

- In STMicroelectronics a design methodology, using an external Tool, to save time for the **development of the Power structures** (from **20% till 80%**) respect to manual actions was validated
- A simple and user-friendly Graphical User Interface to let the **wide usage** of this flow was given to design community
- The possibility to do the Power analysis **on a simplified layout structure**, for having valuable results in the early stage of design instead during the final verification step, is the other great facility for STMicroelectronics designers

Special acknowledgement to Dario Passoni – STMicroelectronics – for ST Power Layout Generator development and the support to us during the activity