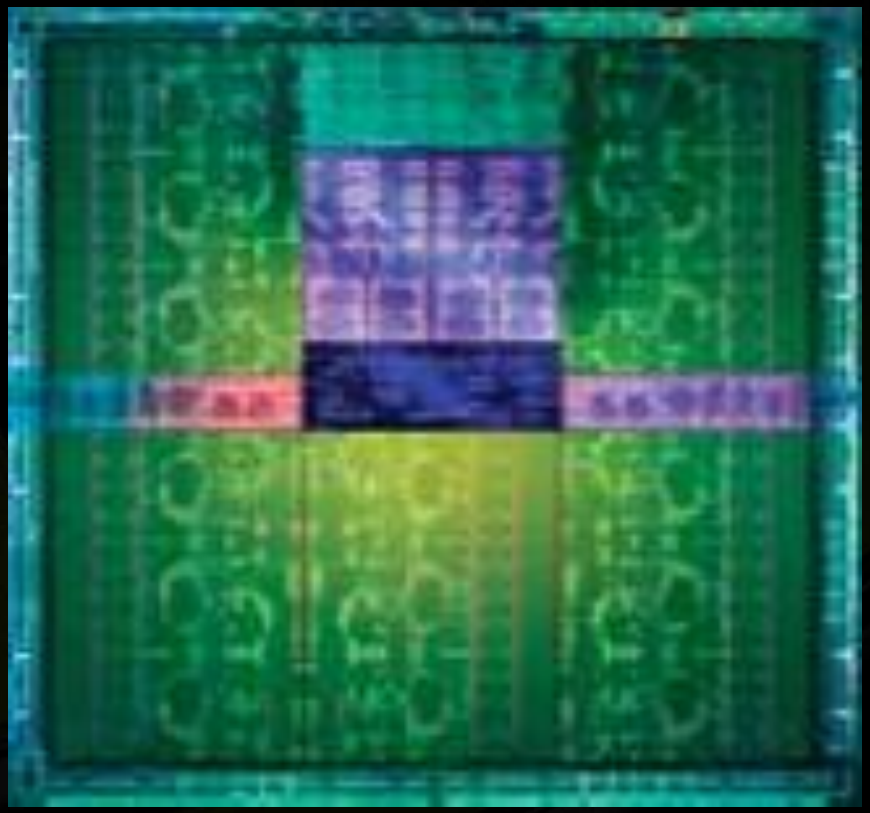
From lines and spaces to patterns and shapes

John Y. Chen

Kepler GK110, a high performance chip for graphics and computing



- **2048 SM cores made by 28nm Hk/MG tech**
- **7.1B X’tors**
- **19.7B contacts + 20.5B via’s + 20Km 1x metal lines**
- **553 mm^2**

Graphics is common in Hollywood today. With10 million hairs, and all the vertices & pixels to animate, the tiger is hardly filmed, but looks so real with GPU rendering.

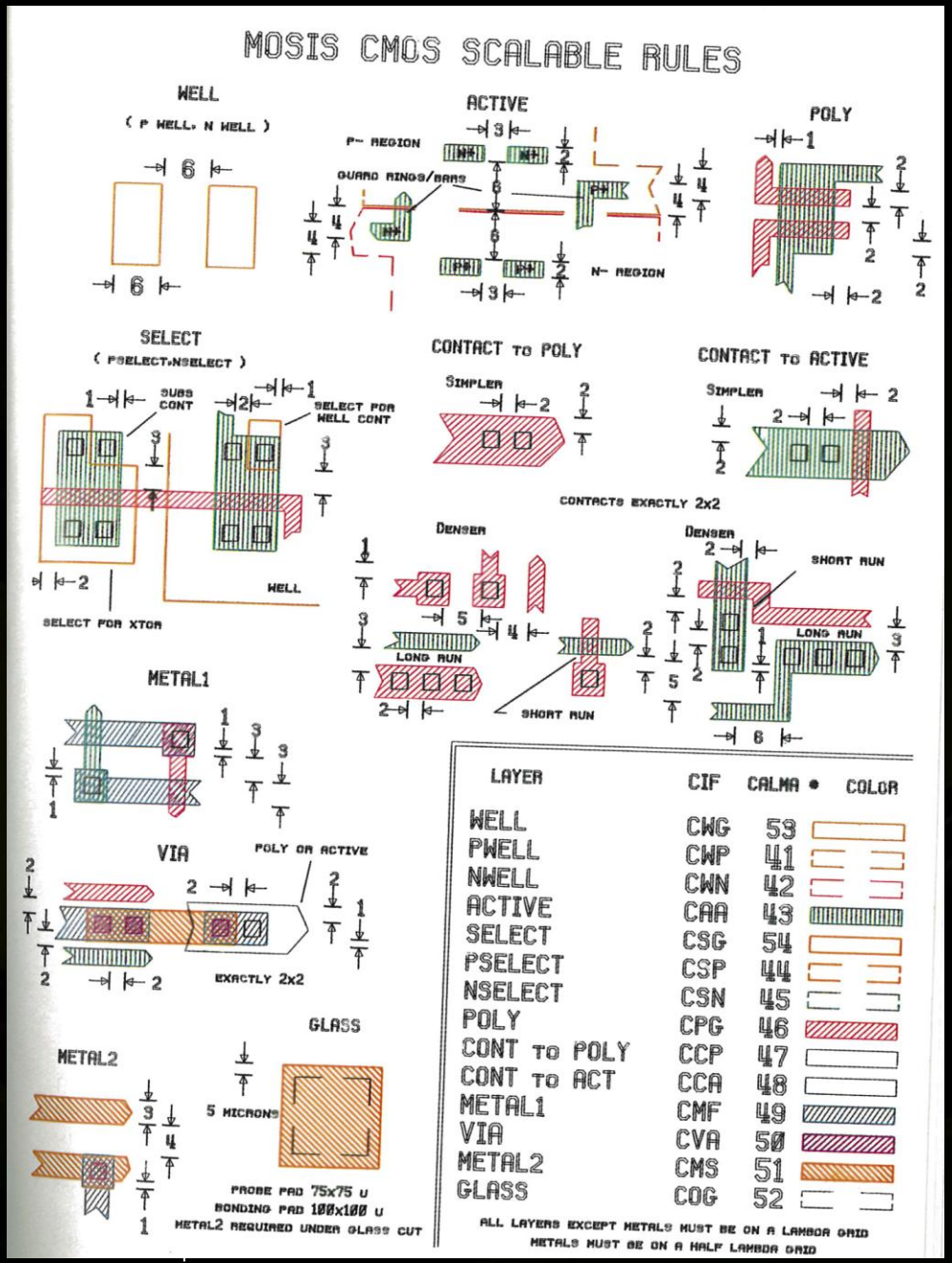
Jen-Hsun Huang's keynote at 2013 GPC

Showing off a digital tiger generated for 'Life of Pi' by Rhythm and Hues.

Graphics vs. Mask making

Graphics	Mask making
Vertices, Lines, & Triangles	Lines, spaces & rectangles
Geometries	Shapes
Pixel shading	Dose and Contrast
Photo realism	Pattern replication

Both deal with images with huge data base



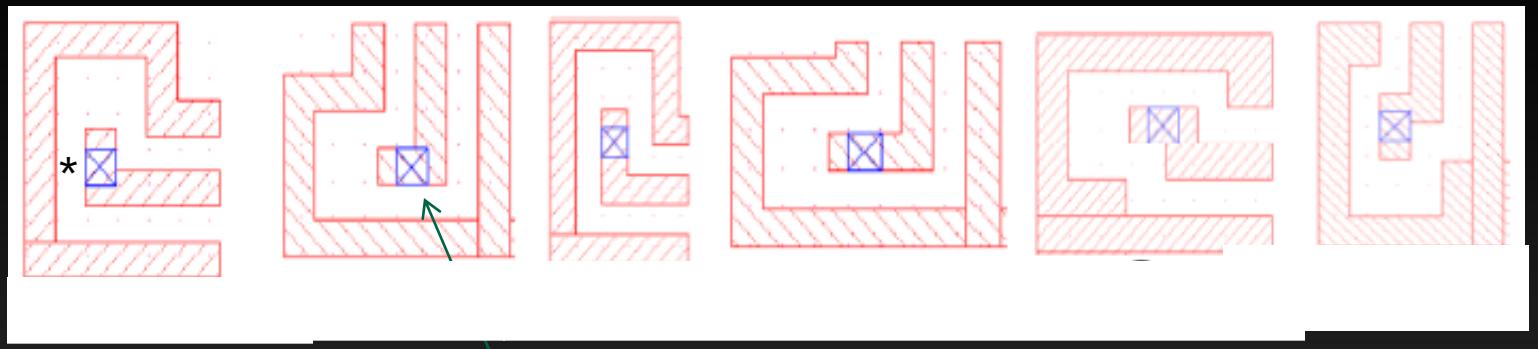
MOSIS offering in the 80's

Scalable Design Rules drawn by unit of λ, *(λ scales w/ technology node)*

All lines/spaces on one page

John Y. Chen, "CMOS Devices and Technology for VLSI," Prentice Hall, 1990.

L-shape metal pattern with via above



Via Layout:

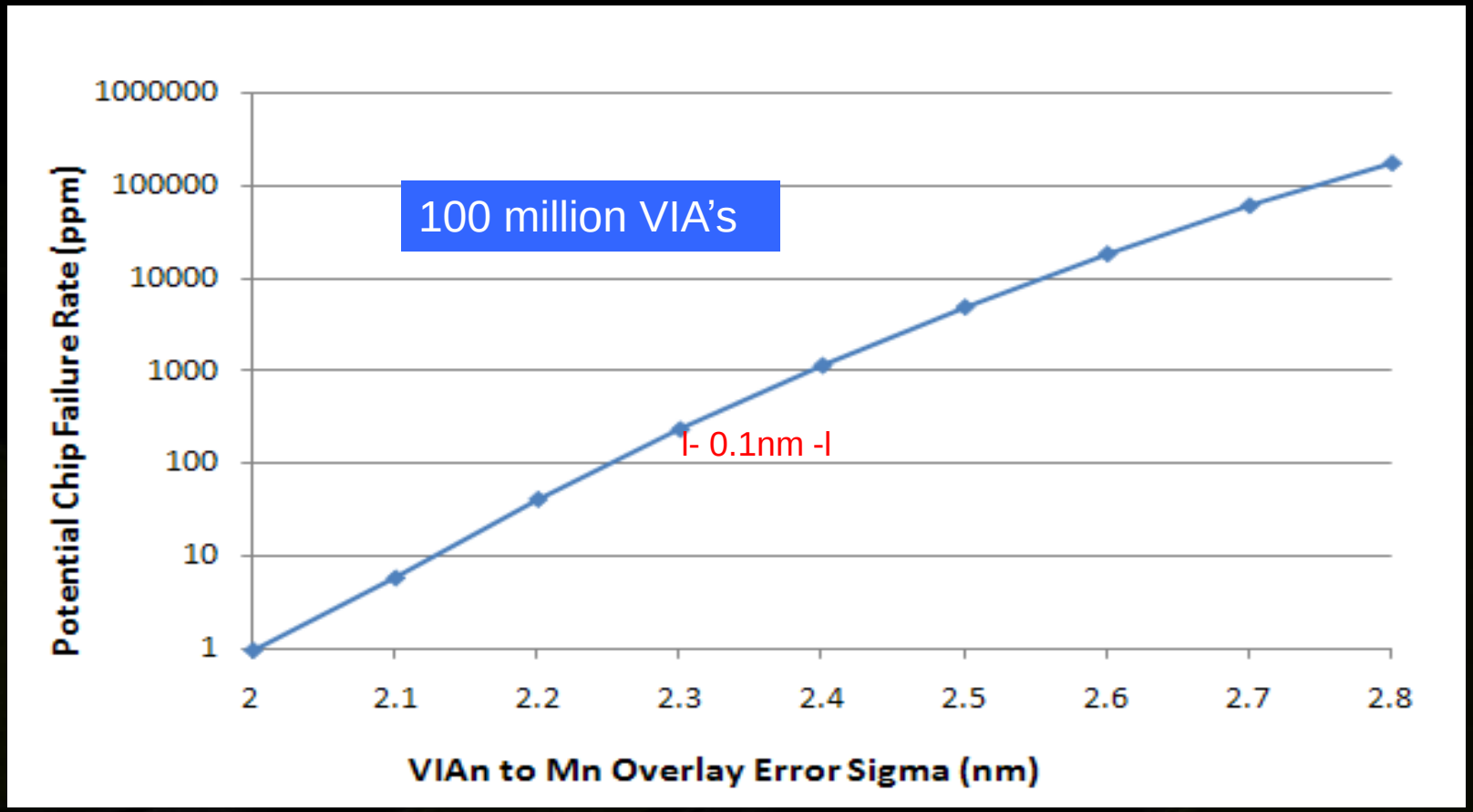
- L shaped underlying metal line
- 0/min enclosure on x/y
- 4 corners with another surrounding metal -> OPC unfriendly
- DFM down to 1% for this type

Process control:

- Precise Litho
- Etch with min μ-loading
- Perfect Cu fill

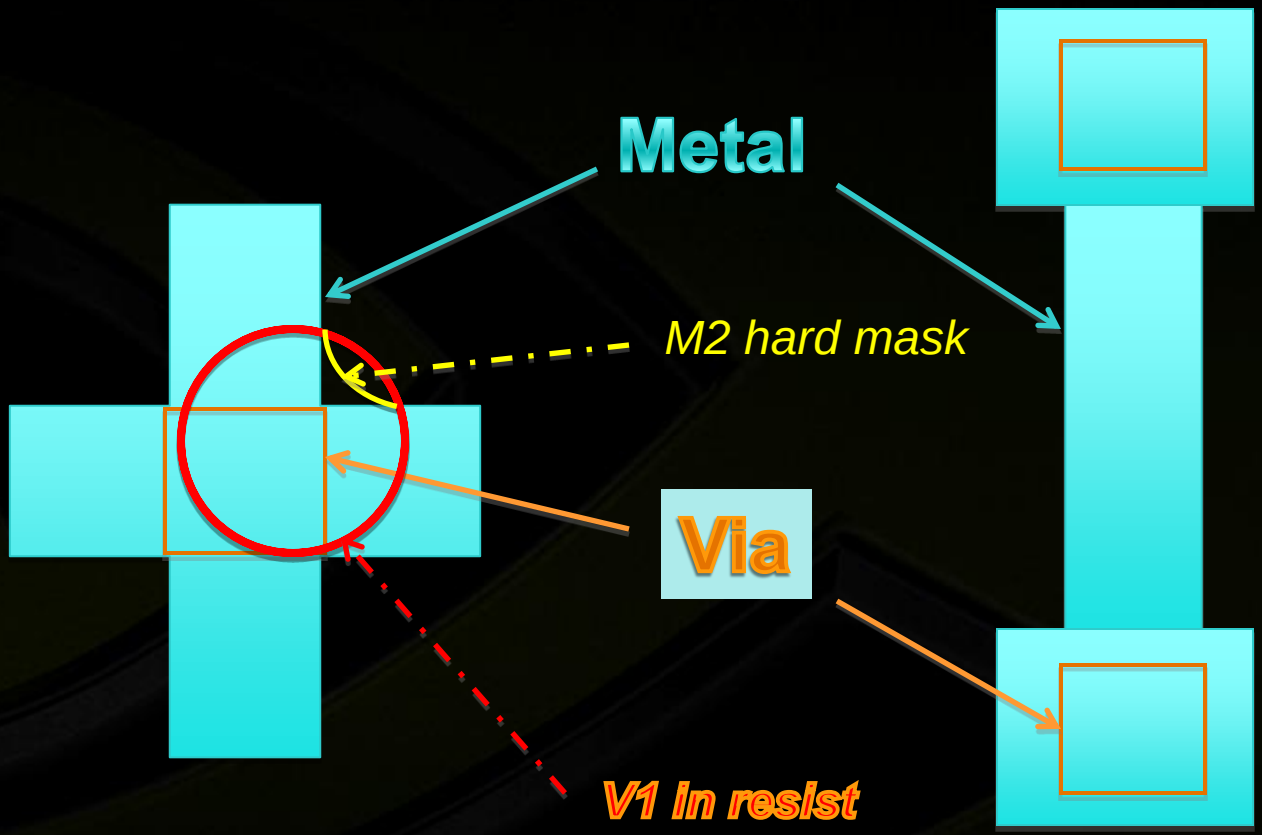
- ***To guarantee the min space needed for TDDB Reliability, how tight the control needs to be ?***

Control down to 0.1nm, every tenth nm counts!

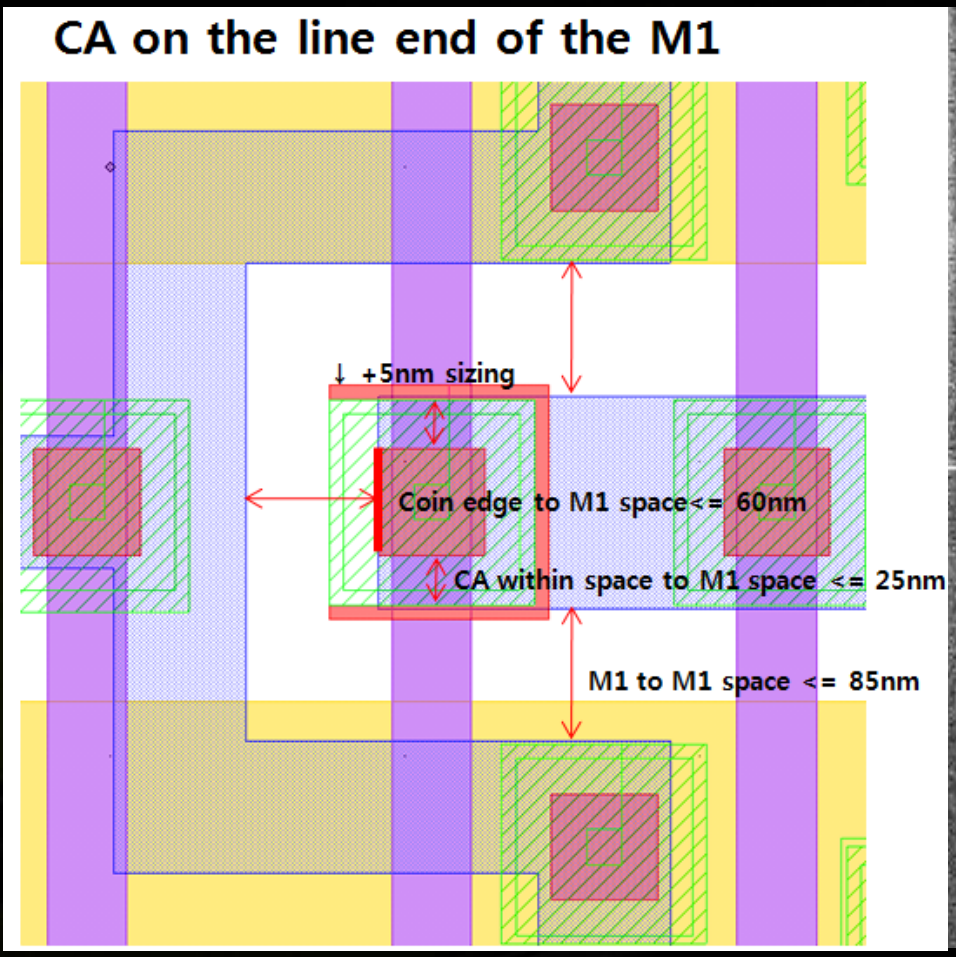


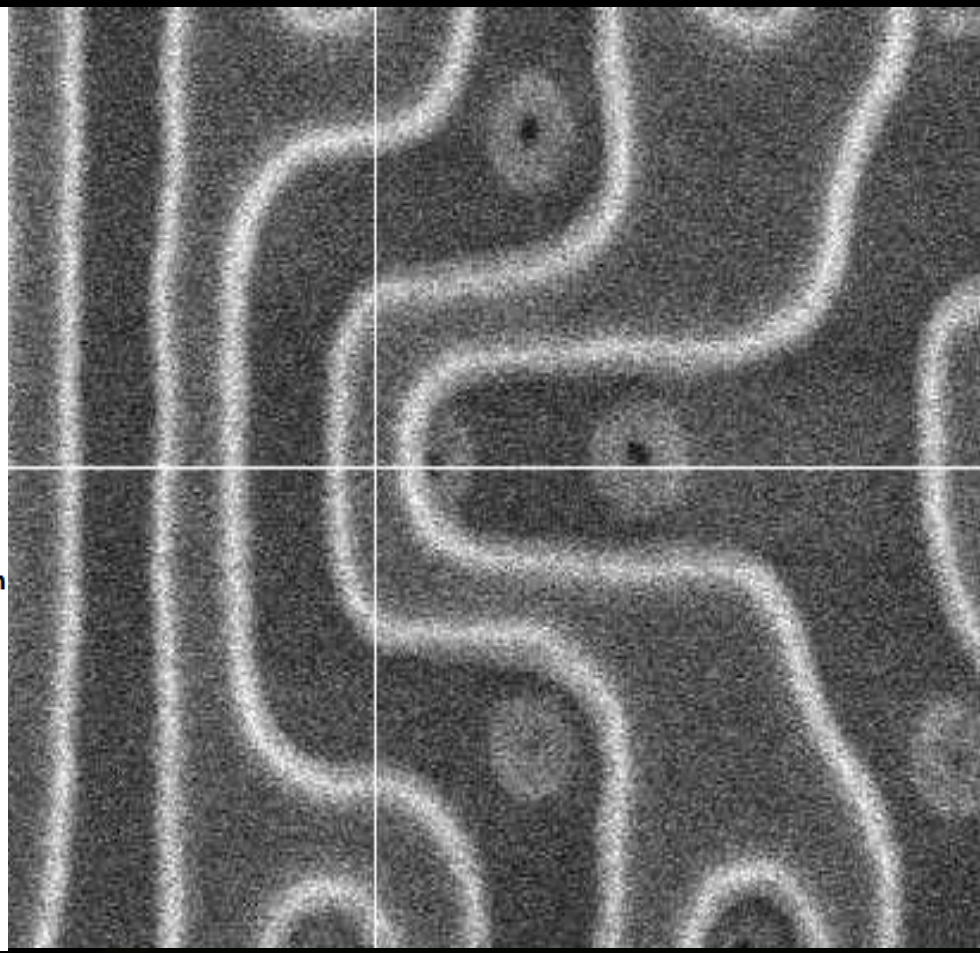
32nm drawn rule for min Mn and VIAn in a 20nm design

Crosses and Dogbones



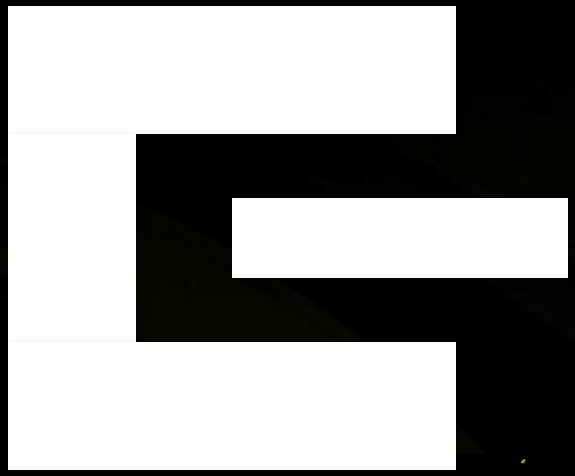
E-shape metal over contact



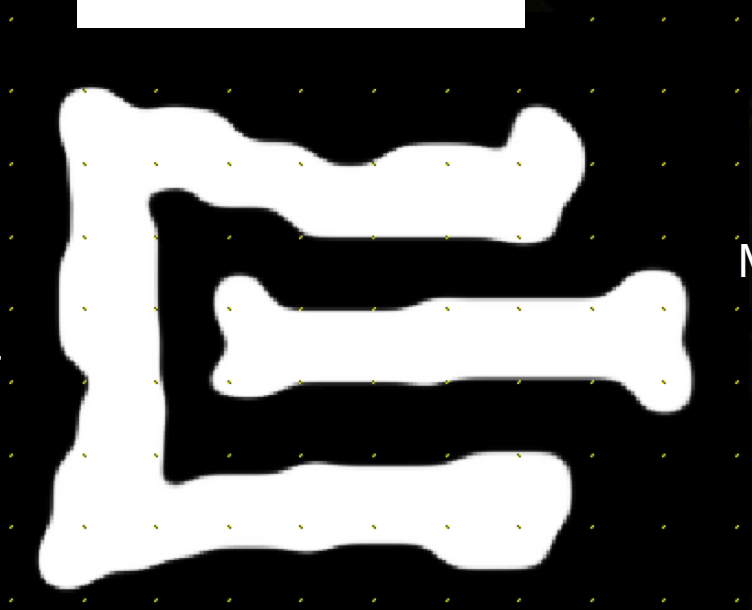


The E-shape metal

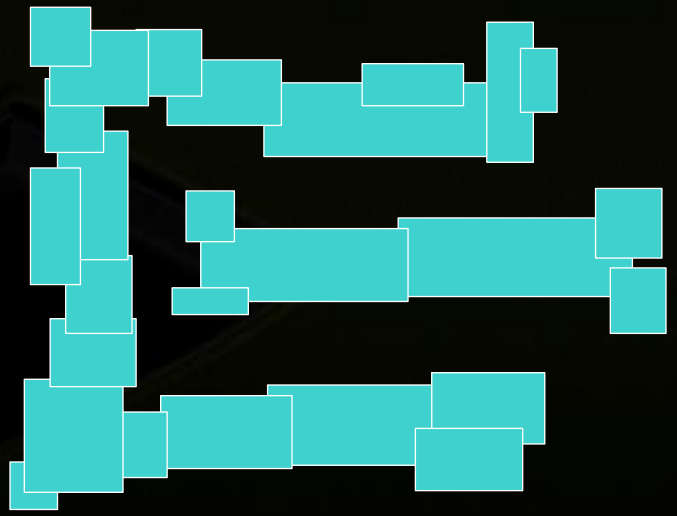
DESIGN



ILT

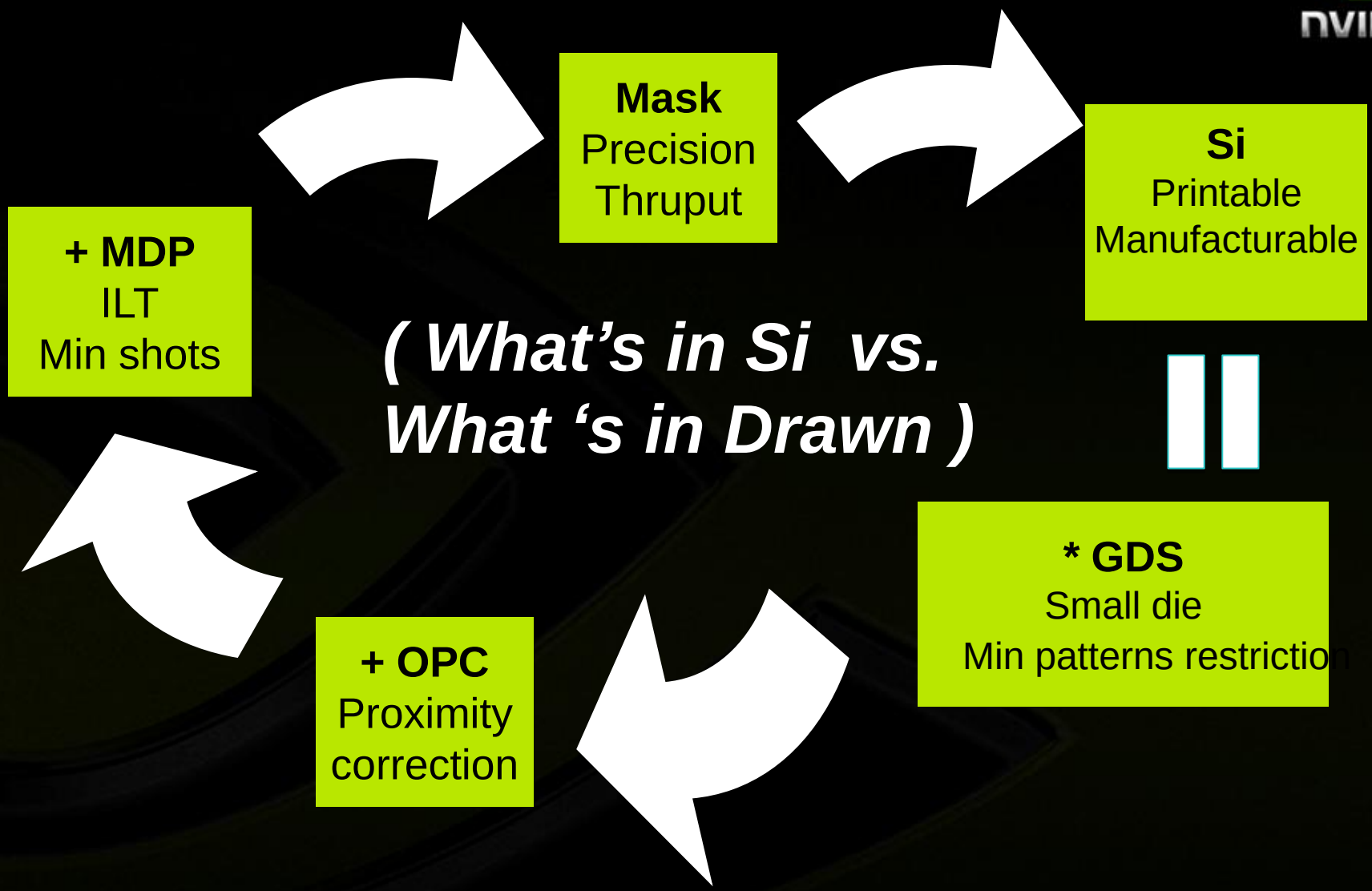


MB-MDP Shots



- **Margins gained by using ILT w/MB-MDP (Model Based Mask Data Preparation)**

Ref: G.S.Chua, SPIE vol.8166, 2011

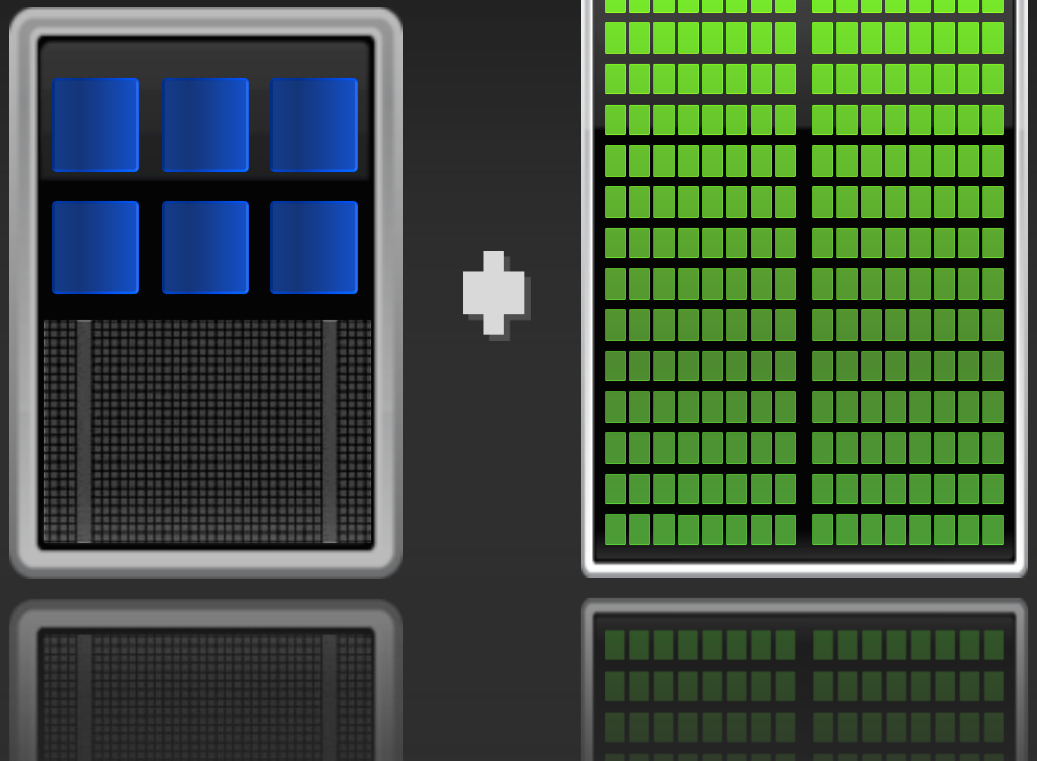


Accelerated Computing

Multi-core plus Many-cores

CPU
Optimized for
Serial Tasks

GPU Accelerator
Optimized for
Many Parallel
Tasks



10x Performance
5x Energy Efficiency