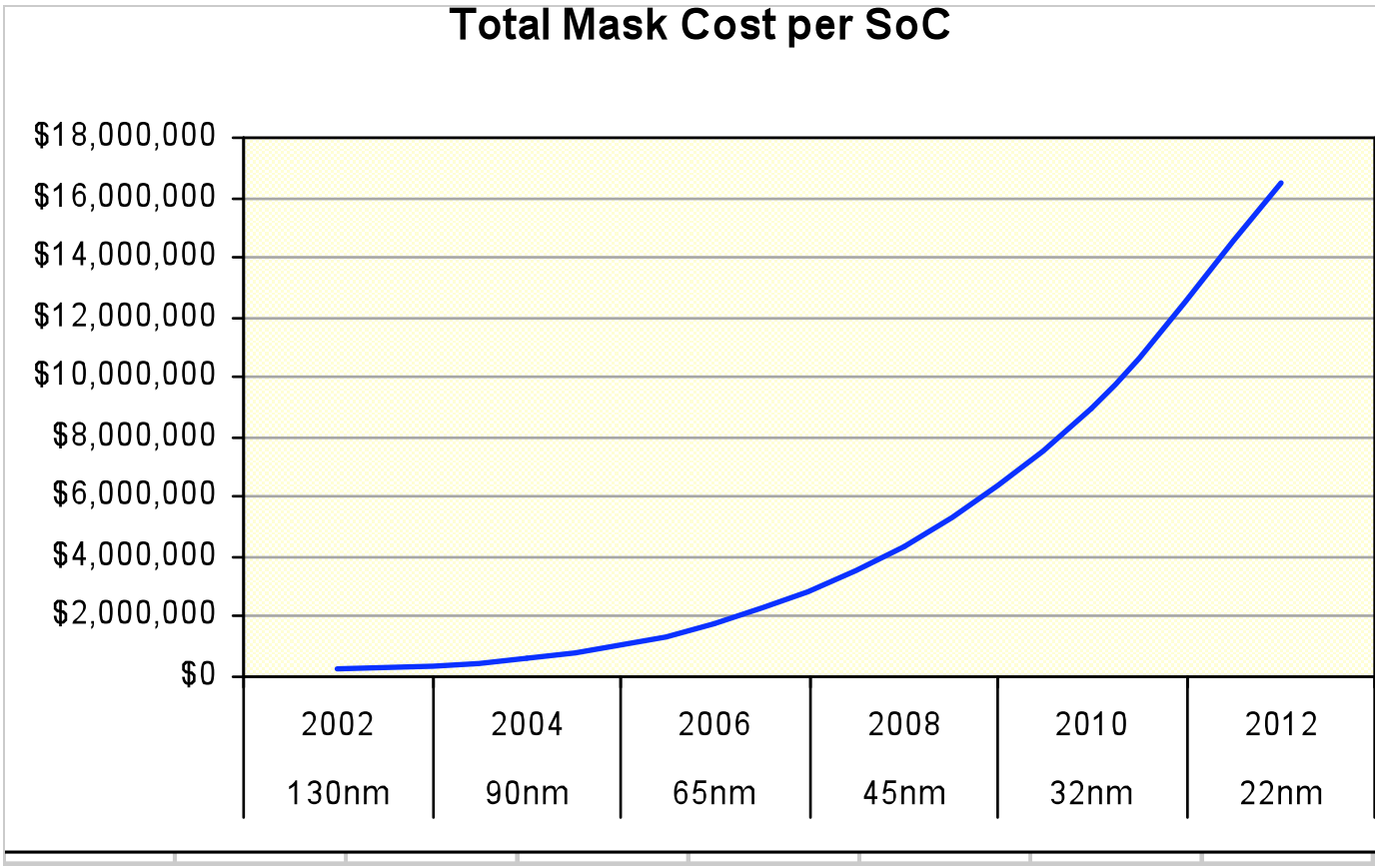

eBeam
Initiative

Beyond Light:
The Growing Importance of E-beam

Design for E-beam (DFEB) is Central to DFM

Aki Fujimura
eBeam Initiative

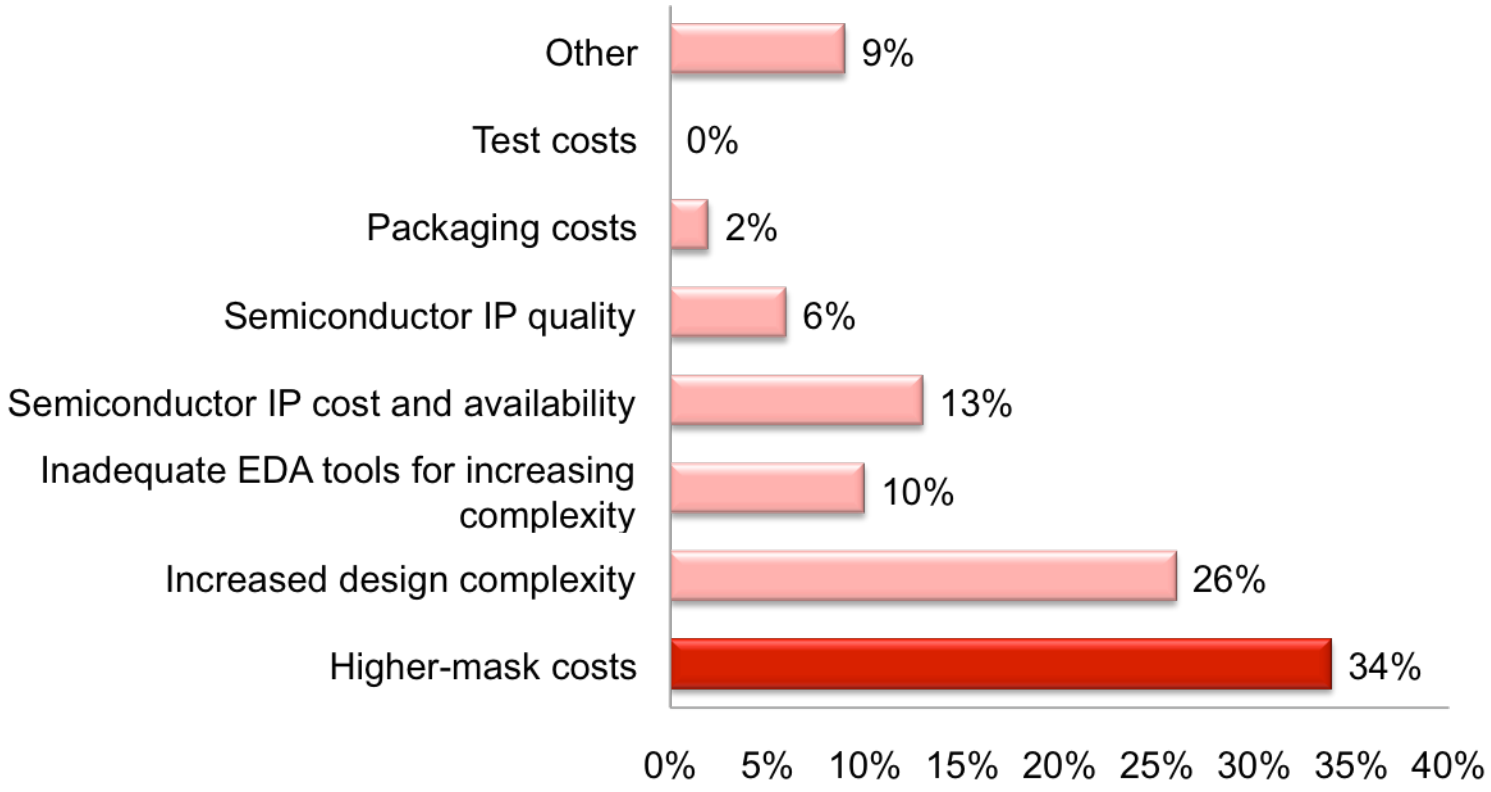
Mask Cost Explodes at 22 nm



193i Lithography at 22nm is one reason!

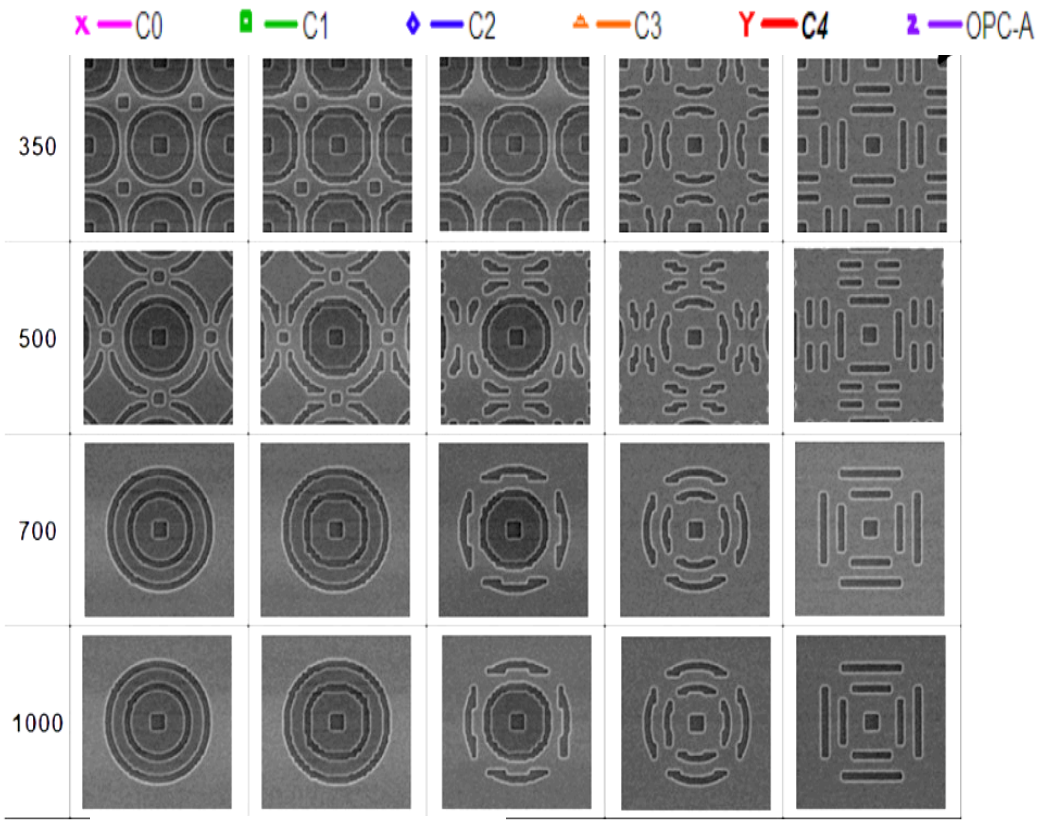
Higher Mask Cost : the Greatest Concern for Designers

Global Semiconductor Alliance 12/6/2007:
What is the biggest challenge to overcome as your company moves from one process node to the next?



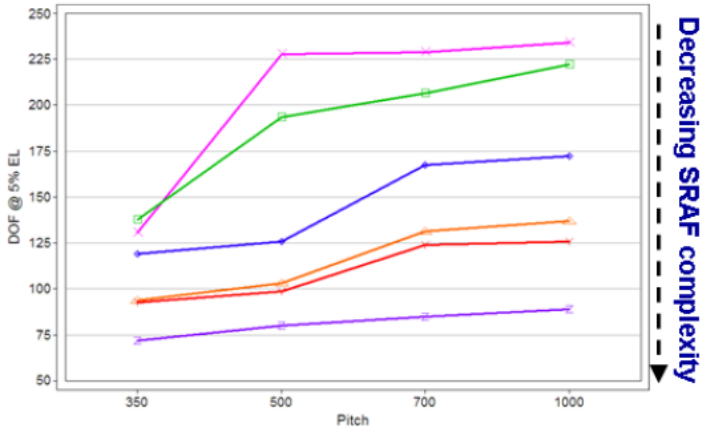
Source : Global Semiconductor Alliance

At 22nm 193i
Good Wafers = High Mask Cost

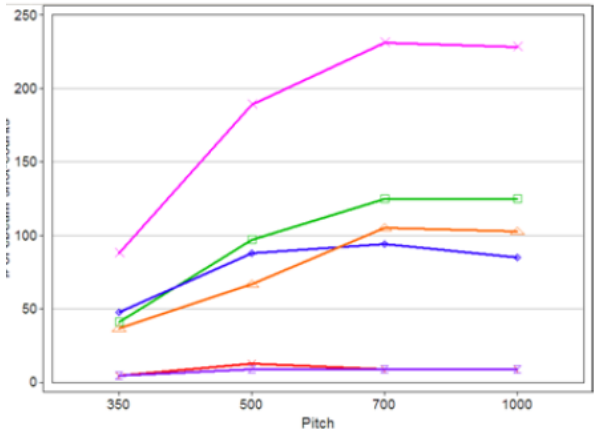


OPC A: standard OPC

DOF @ 5%EL



# of eBeam Shot-counts



Samsung study : Ref: Byung-Gook Kim, et al., PMJ 2009.

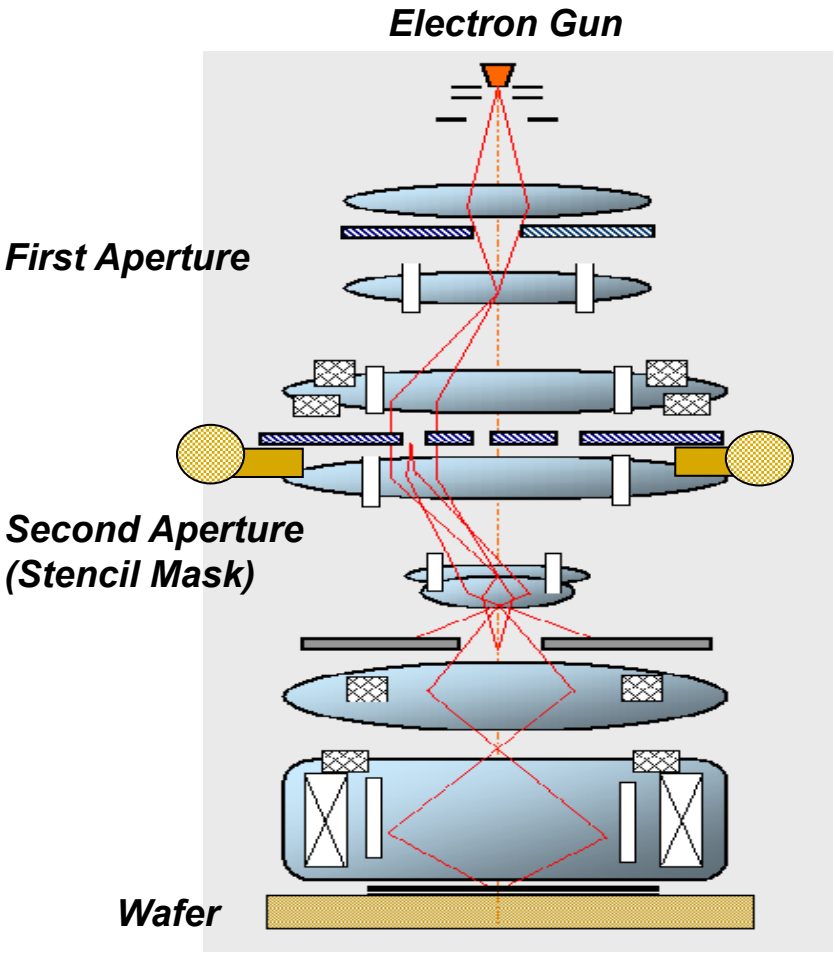
Next-Generation Lithography: Solving the Mask-Cost Problem

- Light
  - Today : 193i w/multiple patterning masks
  - Future : EUV (Extreme Ultra-Violet)
- Nano-imprint
- Electron Beam (E-beam) Lithography
  - Today : Shaped Beam and Character Projection
  - Future:
    - Multiple-beam E-beam
    - Multi-columned, single-beam
    - Multi-shaped beam (MSB)

Character Projection in Production Use at e-Shuttle

Picture Courtesy of e-Shuttle, Inc.

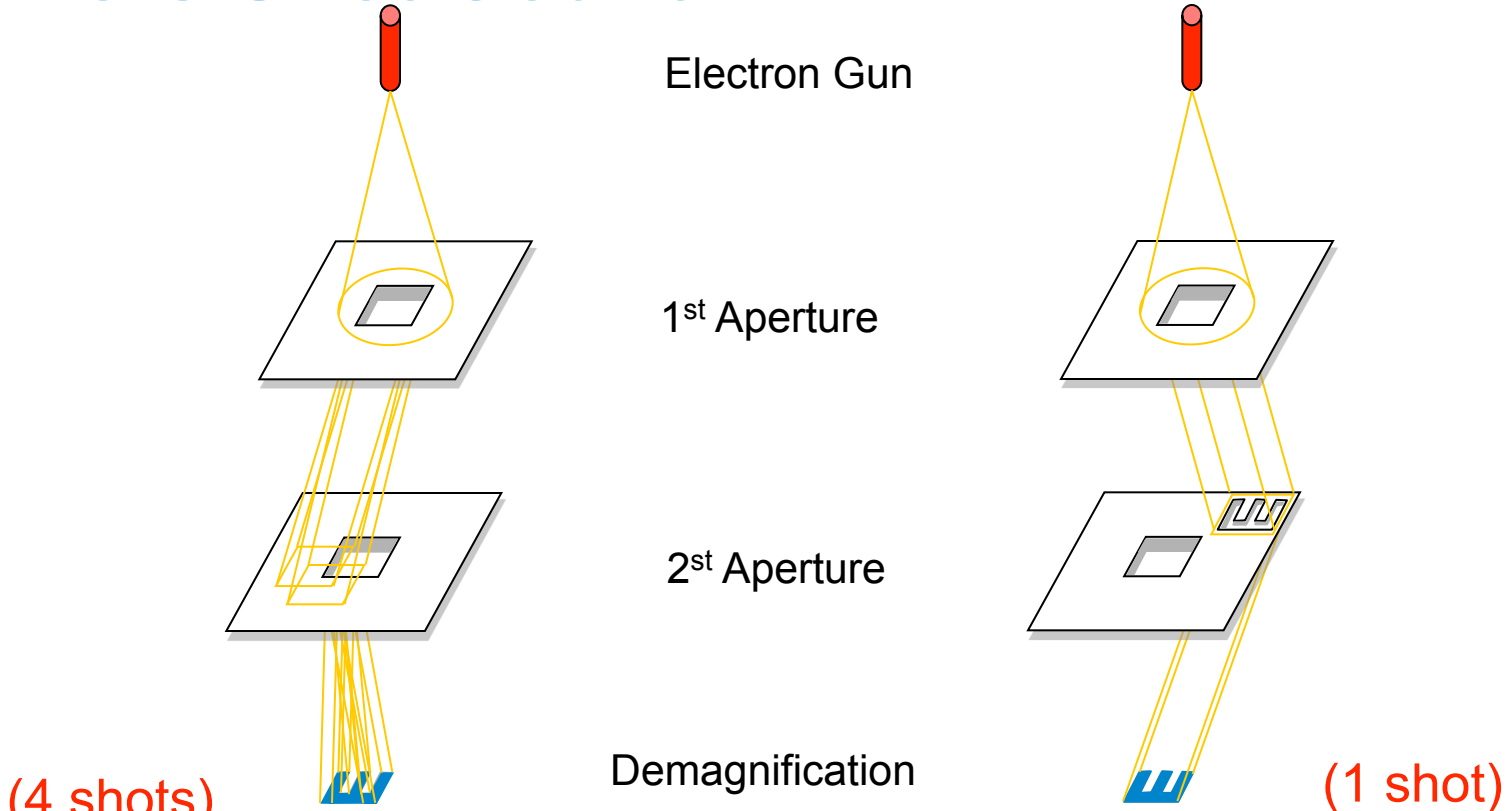
Today's E-beam Lithography



- 50kV E-beam drills great holes!
- E-beam doesn't have depth of focus (DOF) problems like light
- E-beam is very accurate compared to light
- Write time is the challenge

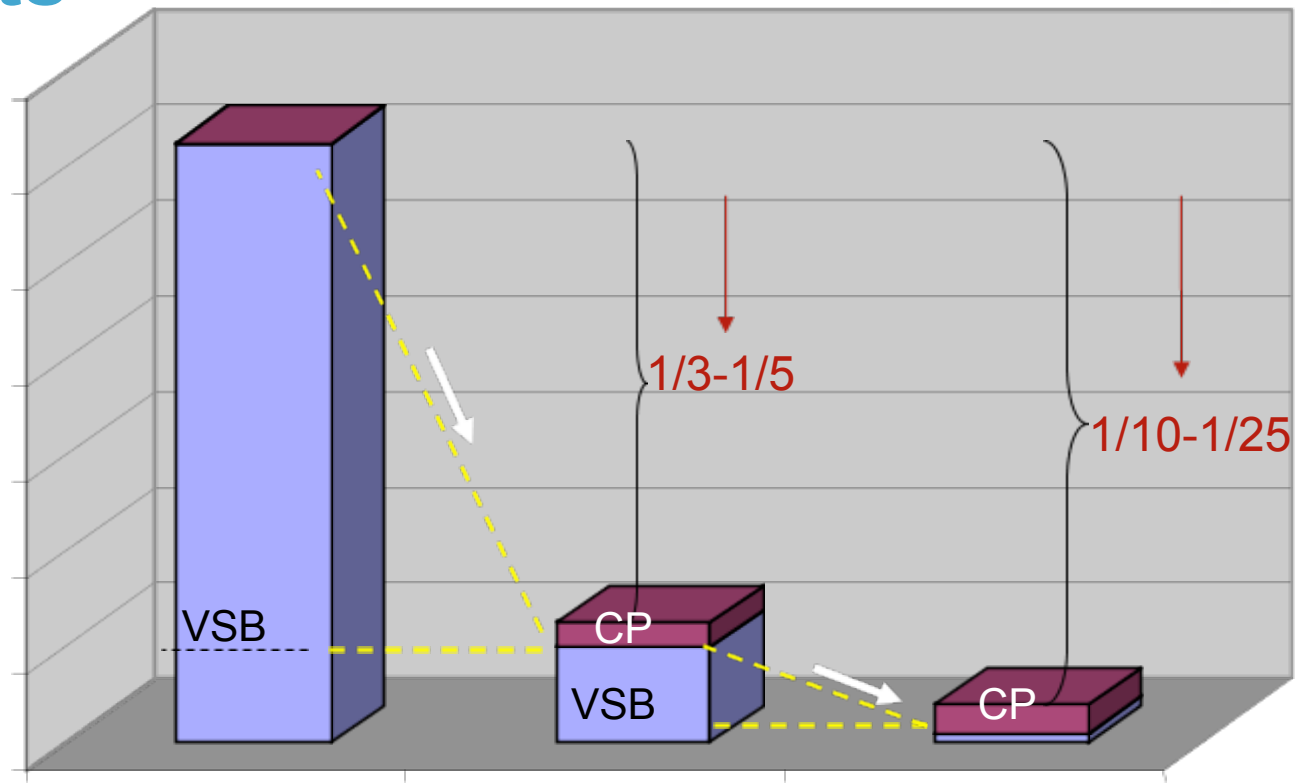
Drawing Courtesy of Advantest

Character Projection Lowers Shot Count



Drawing Courtesy of Hitachi High-Technologies

DFEB Decreases Required Shots

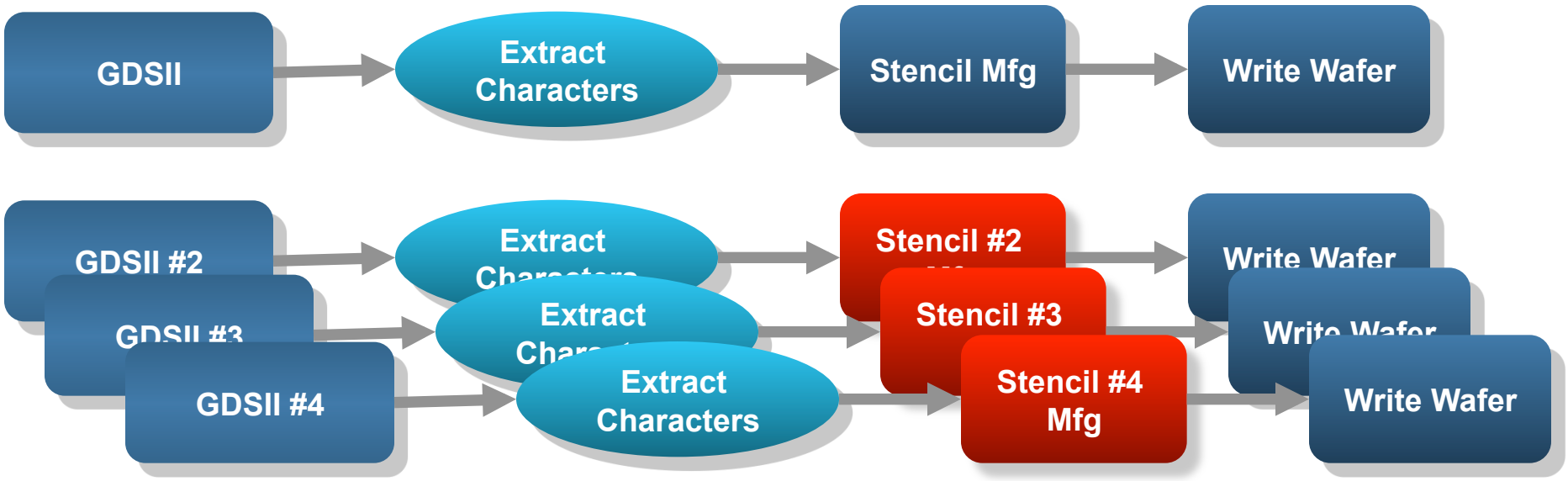


VSB	CP	CP+
Today	With CP	With DFEB and CP

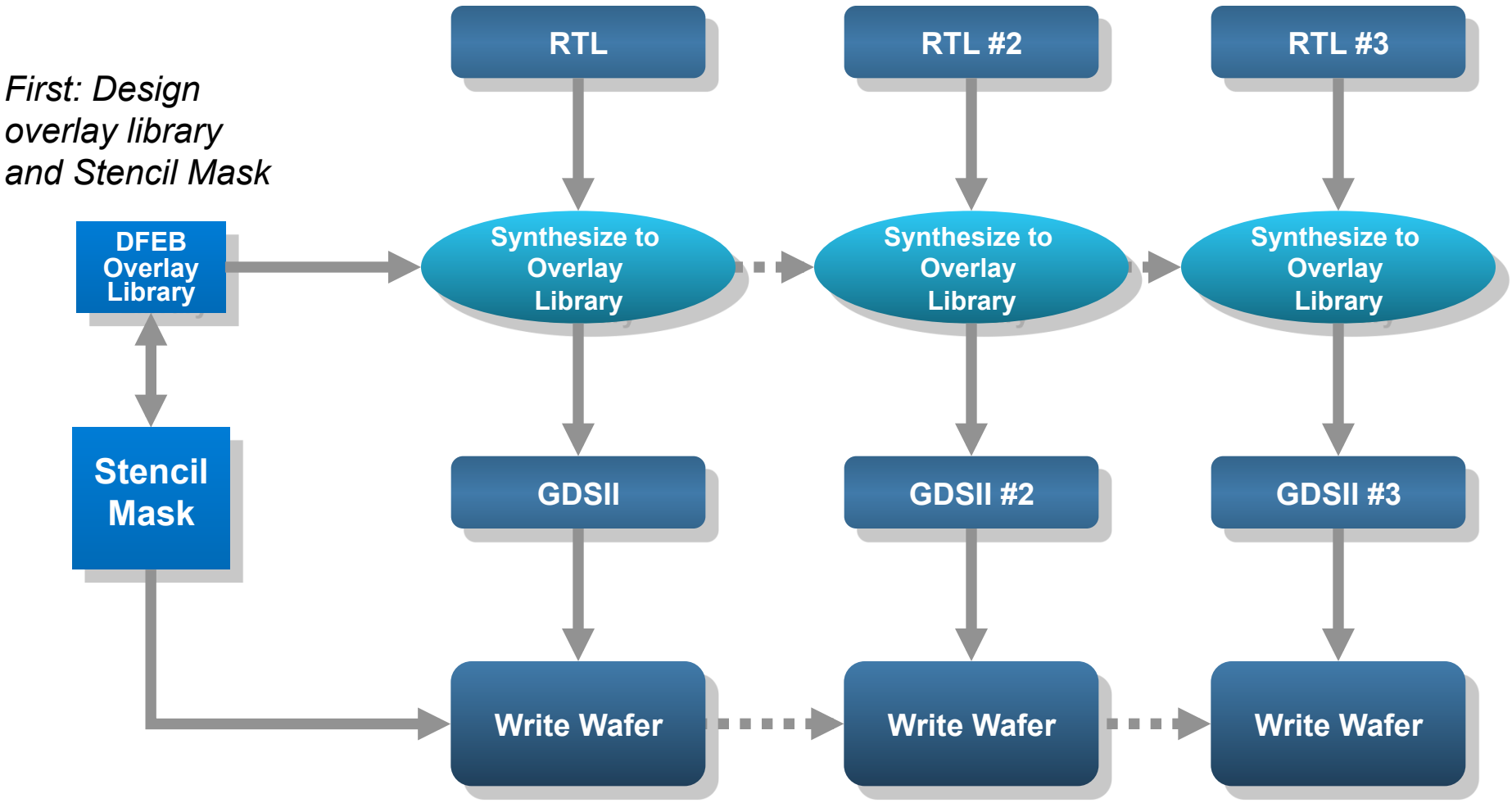
DFEB optimizes for shot count at the design stage to reduce residue VSB to achieve 10-25X reduction

Comparison Source: D2S, Inc. Computer simulation of e-beam write time on a particular test case (speed up is dependent on aperture size and utilization %)

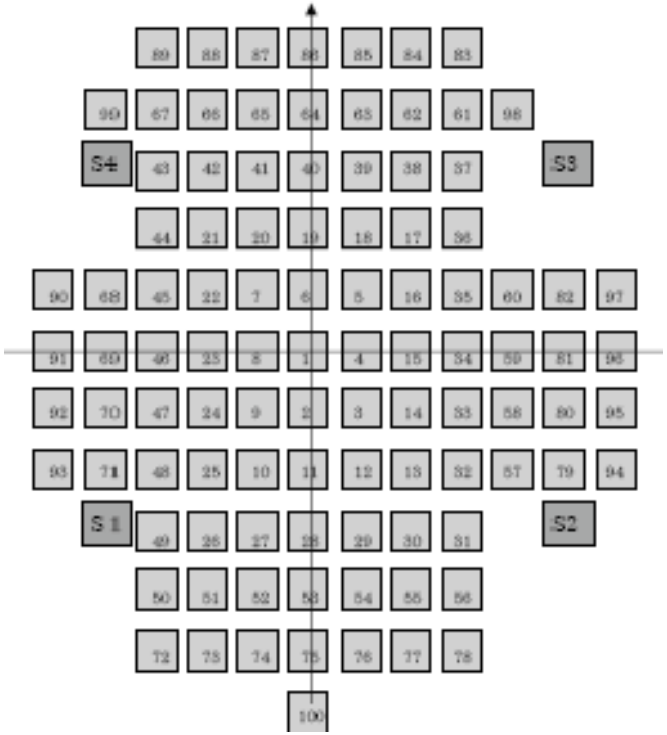
Conventional Flow with CP



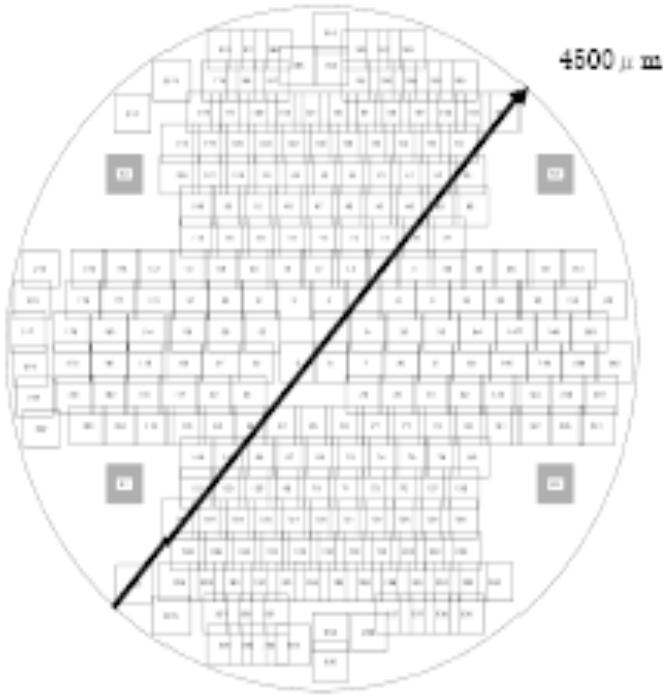
DFEB Methodology



DFEB Packed Stencils
(Advantest F3000 with D2S)

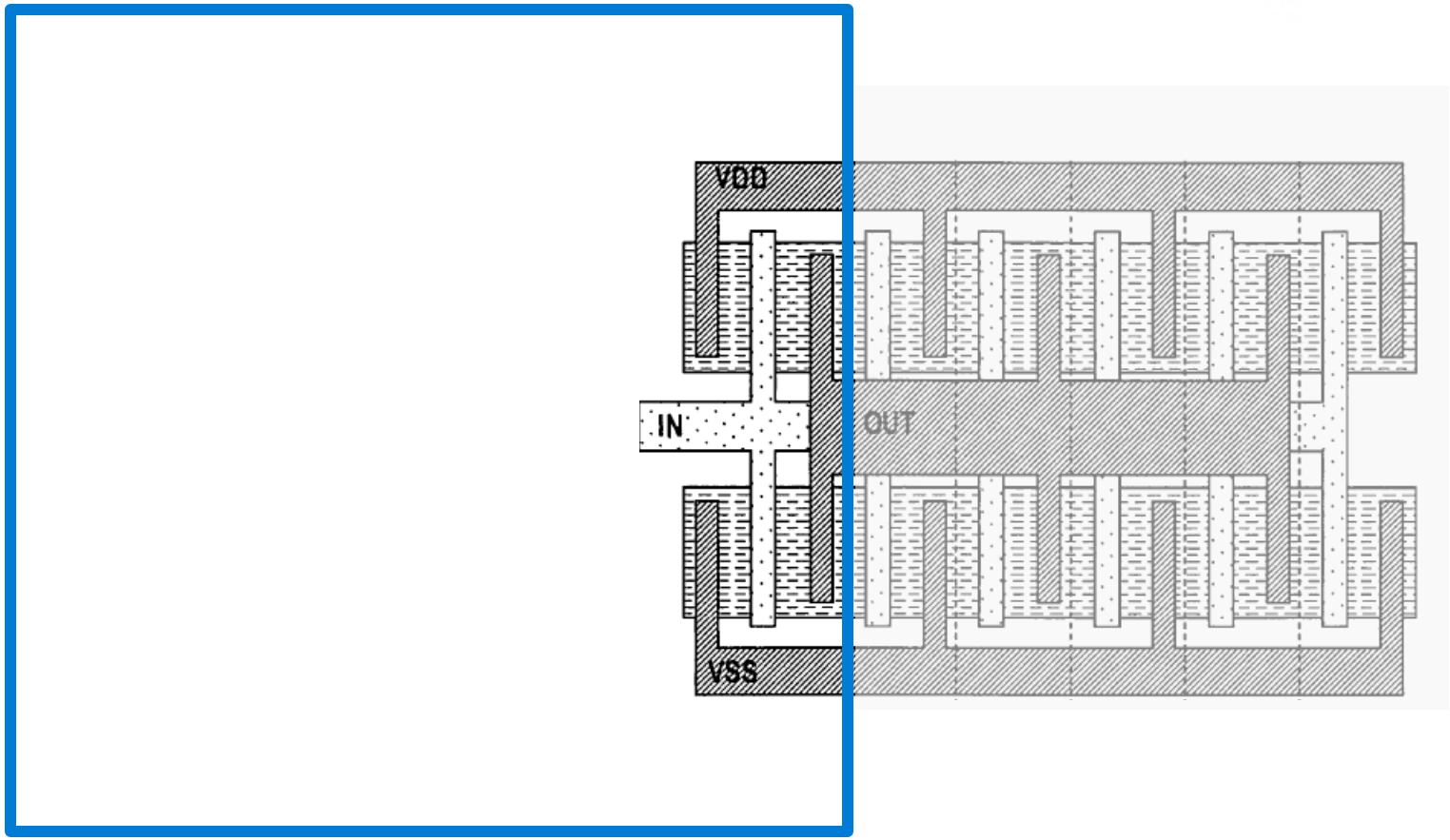


Previous specification of the F3000 character block with 100 characters



The Packed Stencil allows, for example, this packed layout of 220-280 characters

DFEB Character Sharing

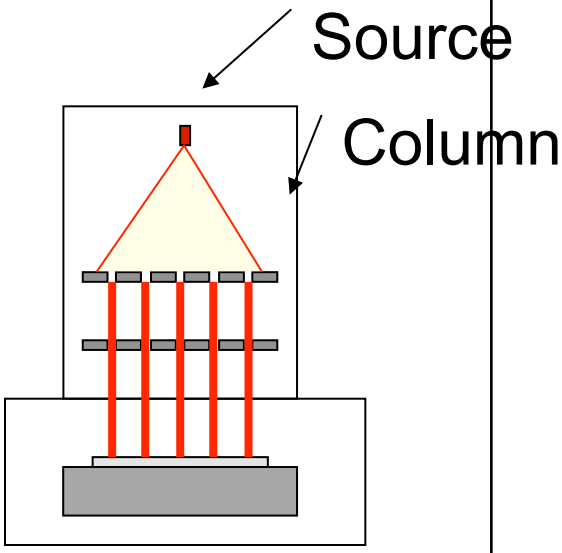
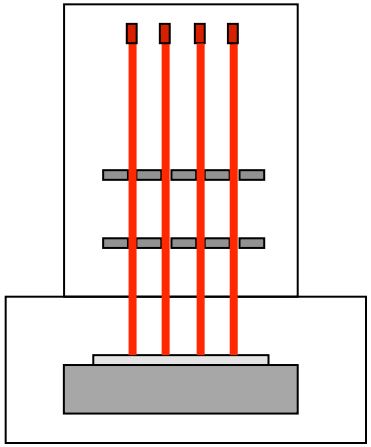
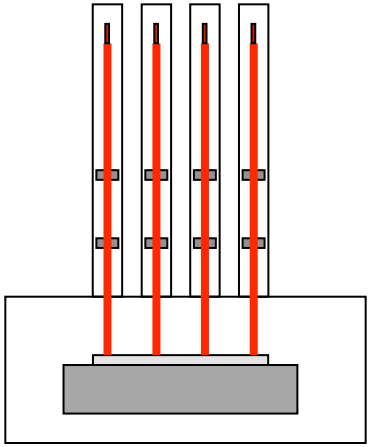


By “cutting” first aperture deflection at various positions, different drives of the cell can be shot from the same character.

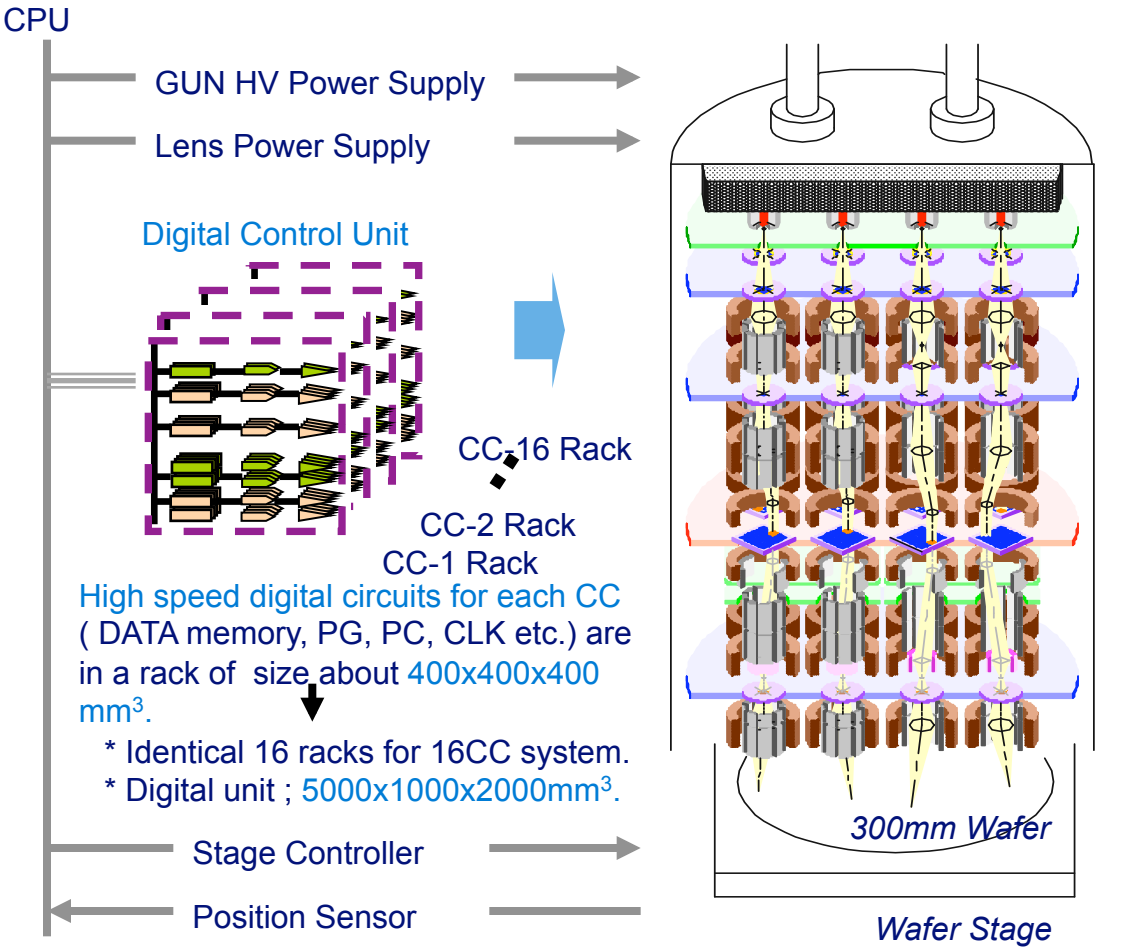
Next-Generation Lithography: Solving the Mask-Cost Problem

- Light
  - Today : 193i w/multiple patterning masks
  - Future : EUV (Extreme Ultra-Violet)
- Nano-imprint
- Electron Beam (E-beam) Lithography
  - Today : Shaped Beam and Character Projection
  - Future:
    - Multiple-beam E-beam
    - Multi-columned, single-beam
    - Multi-shaped beam (MSB)

Types of Multi-Beam Machines

Single source/ Single column	Multi source/ Single column	Multi source/ Multi column
		
PML2, MAPPER, BLA	MCC	Multibeam, others

Multi-Source/Single-Column: MCC System with 16CCs



Electron Gun (4x4)

Blanking Deflectors

Rectangular Apertures (4x4)

Pre. Mask Deflector

CP Aperture Masks (on separated stage)

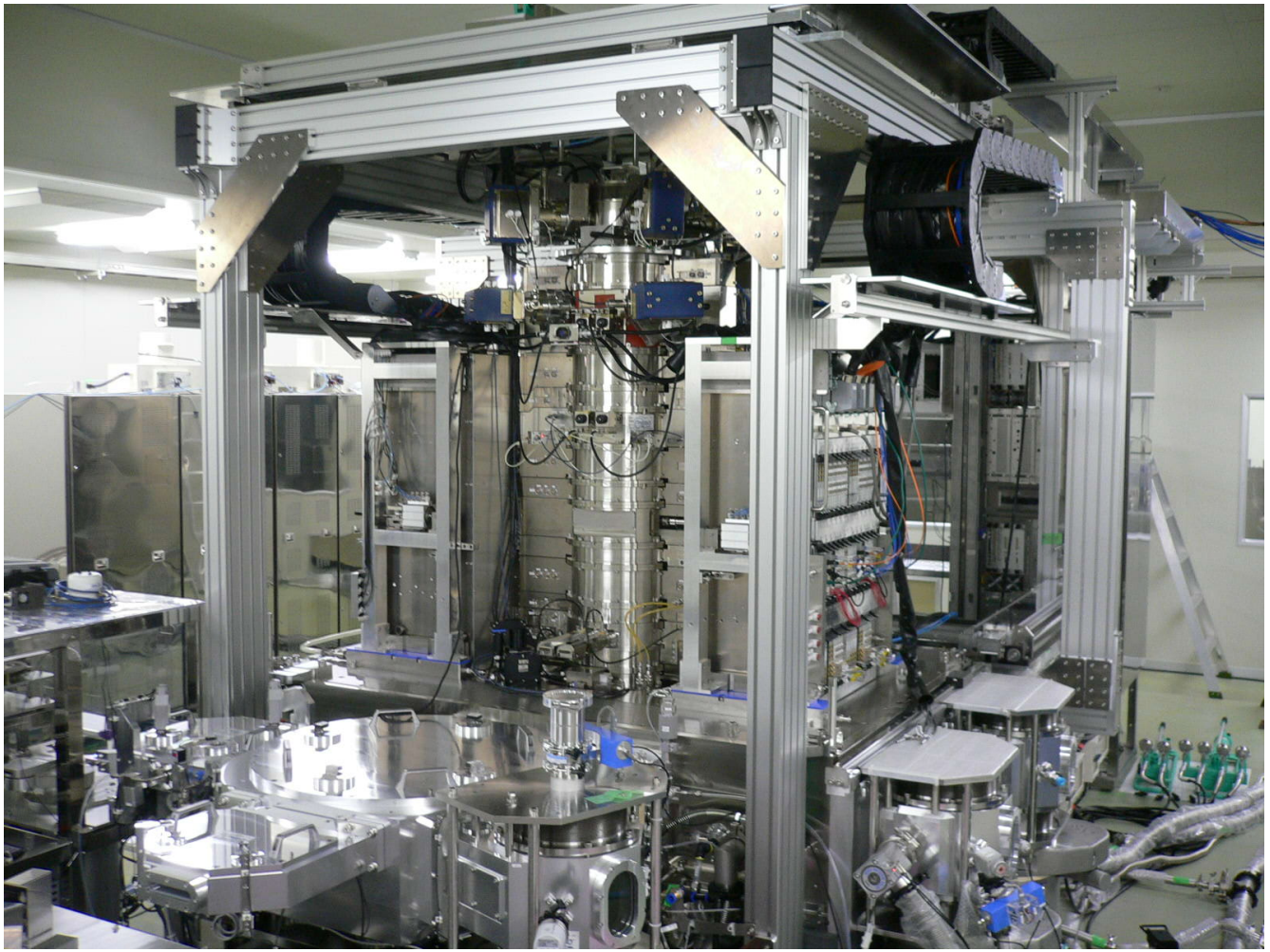
Post Mask Deflectors

Round Apertures

Major Deflector (100x100 um)
Minor Deflector (10x10 um)

Drawing Courtesy of Advantest

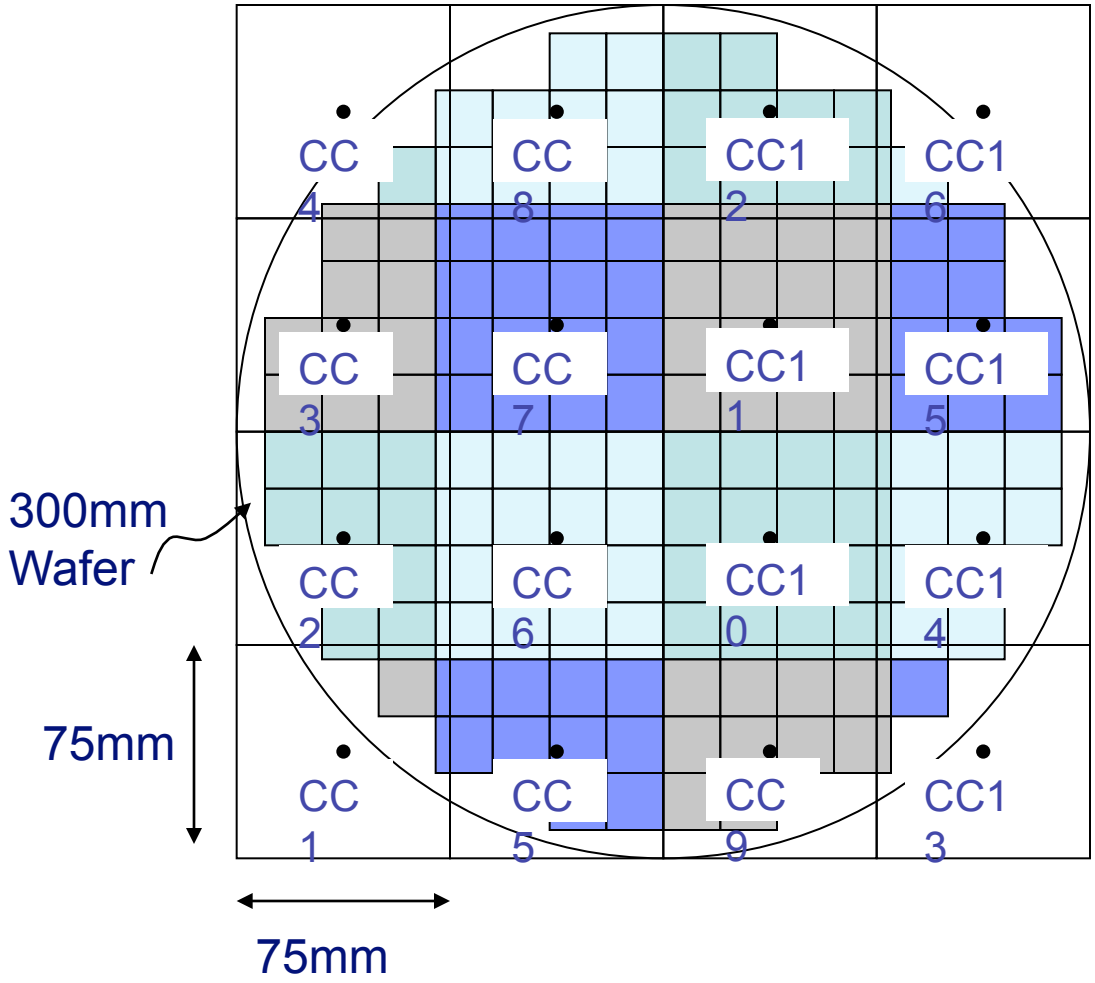
MCC-POC System



Courtesy of Advantest

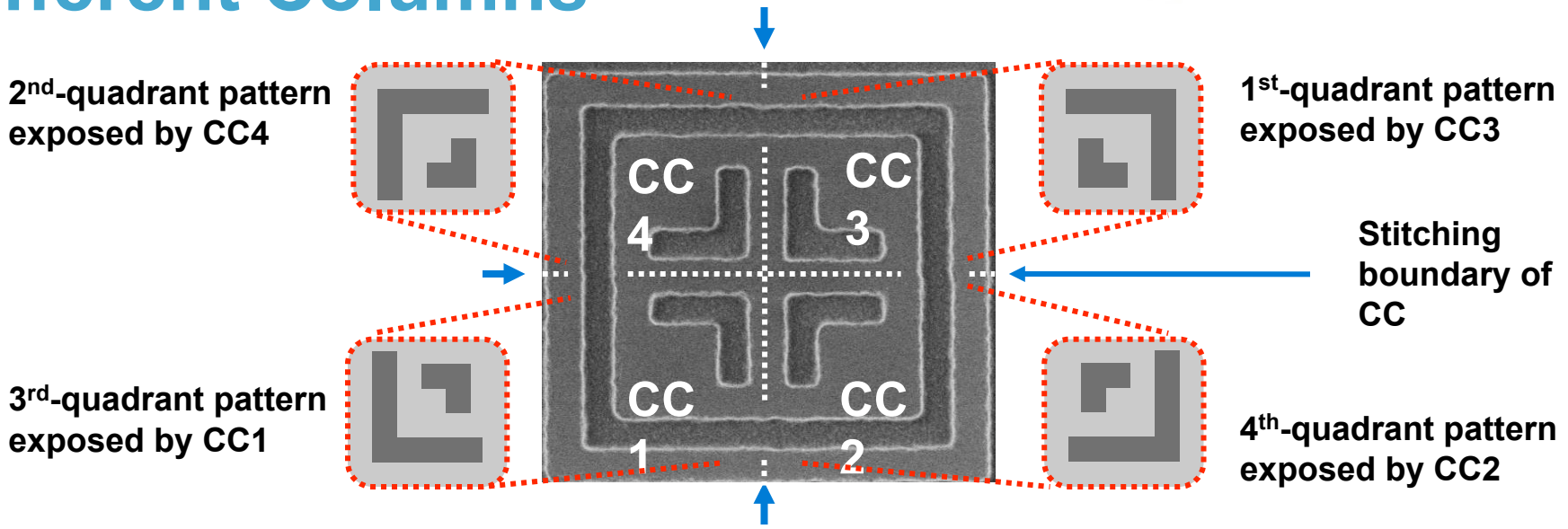
Exposing 300mm Wafer with 16CCs

- Chip Size: 20x20mm on 300mm Wafer
- Each CCn (n=1,,16) exposes the chips, whose centers are in the 75x75mm region of the CCn
- The chips of the same colors are exposed with the same corresponding CCn



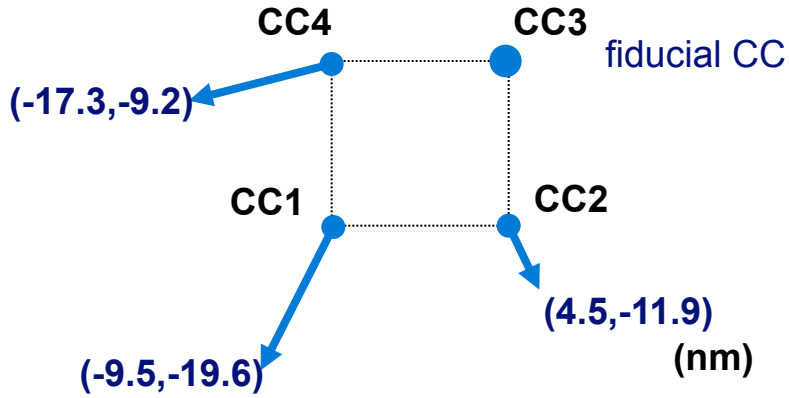
Drawing Courtesy of Advantest

Preliminary Stitching Between Different Columns



CC	X (nm)	Y (nm)
CC1-2	14.0	7.7
CC2-3	-4.5	11.9
CC3-4	-17.3	-9.2
CC1-4	-10.1	11.5

CCm-n ; Stitching errors between CCm and CCn. (m,n = 1, 2, 3, 4)



Courtesy of Advantest

The Future of Lithography? Think Beyond Light!

- E-beam is important now, critical at 22nm
- Even with light, the mask is made with E-beam!
- DFEB is central to DFM

Member Companies & Advisors

eBeam Initiative

www.ebeam.org

ADVANTEST

alchip

Altos Design Automation

cadence

D2S

Marty Deneroff
D. E. Shaw Research

DNP Dai Nippon Printing

e-Shuttle

eSilicon

FASTRACK DESIGN

Jack Harding
eSilicon

FUJITSU

GenISys GmbH

MAGMA

Colin Harris
PMC-Sierra

cea leti

Tela Innovations

Riko Radojcic
Qualcomm

TOPPAN

VIRAGE LOGIC

Vistec

Jean-Pierre Geronimi
ST


eBeam
Initiative