SPIE Advanced Lithography

e Beam Initiative

SPIE Advanced Lithography 2011 paper 7970-1

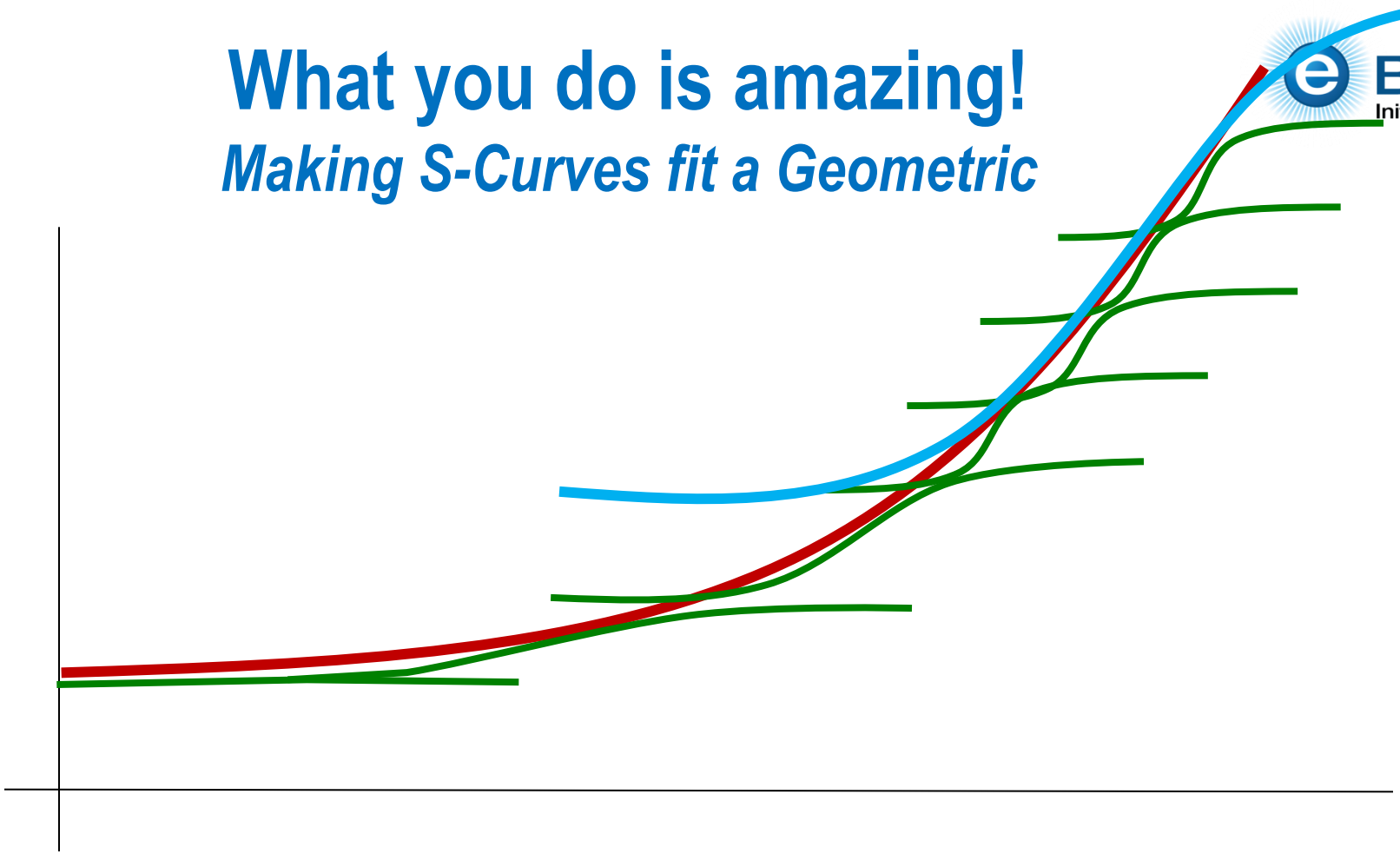
e-Beam Direct Write of Wafers

Aki Fujimura, D2S, Inc

D2S™

What you do is amazing!

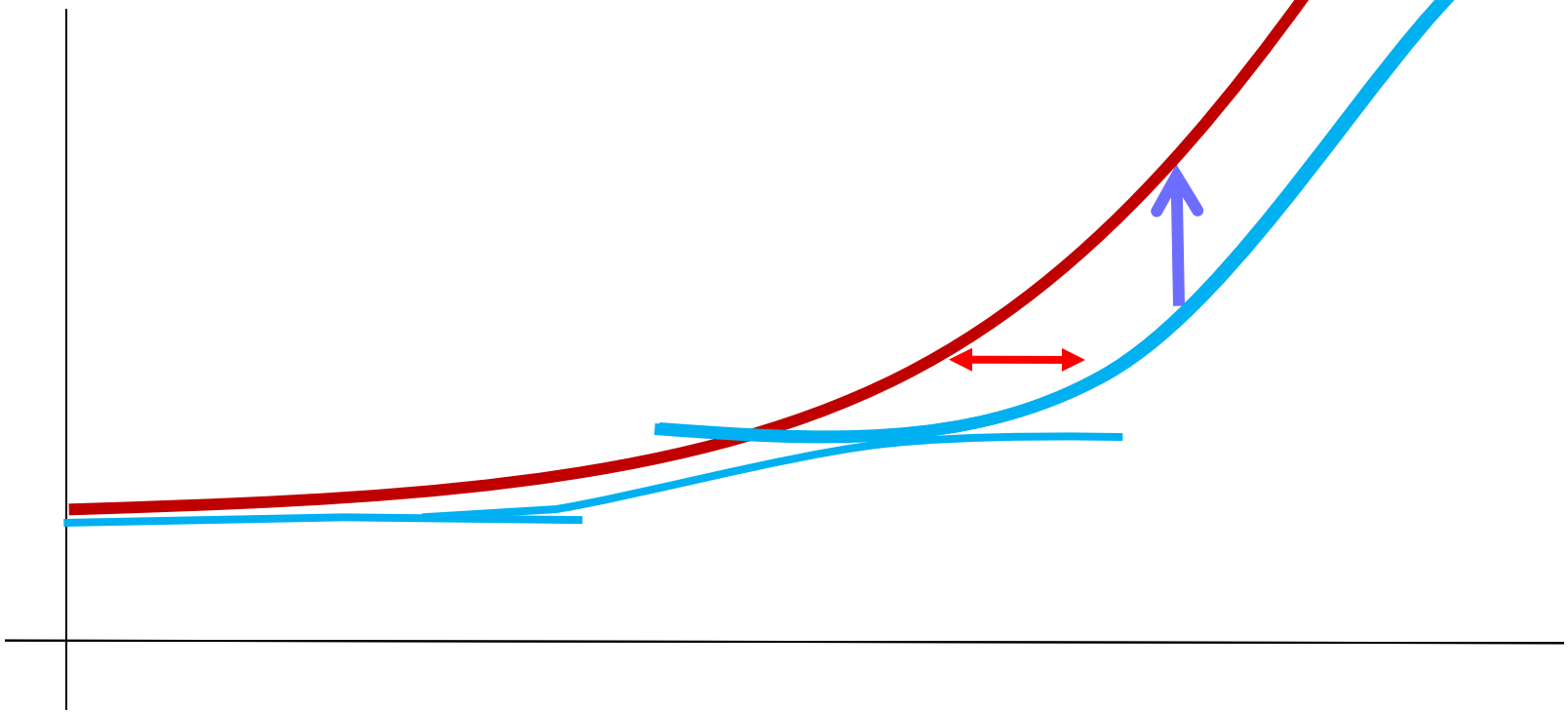
Making S-Curves fit a Geometric



If you have small S-Curves, you have to stack them one after another

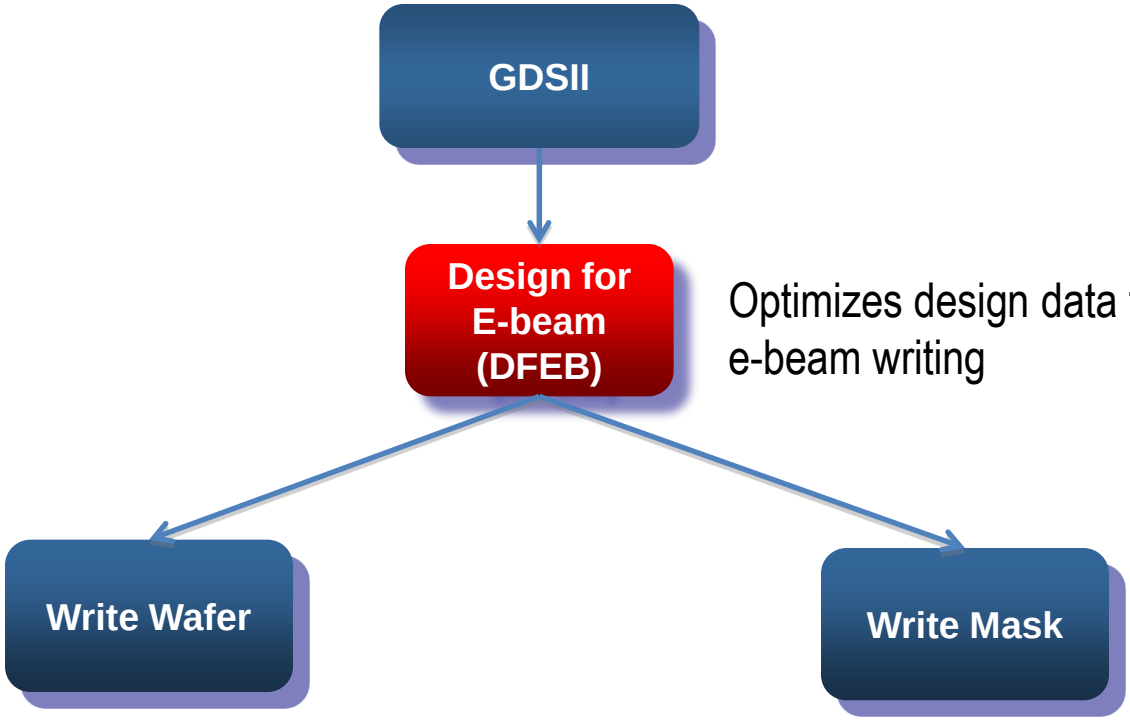
If you are blessed with a big S-Curve, you get to ride it for a long time

“EbDW is always 1-2 generations behind”



But that means it HAS kept up with Moore’s Law… Just needs to catch up

Direct-Write or Mask?
Either Way, e-Beam Writes All Chips!

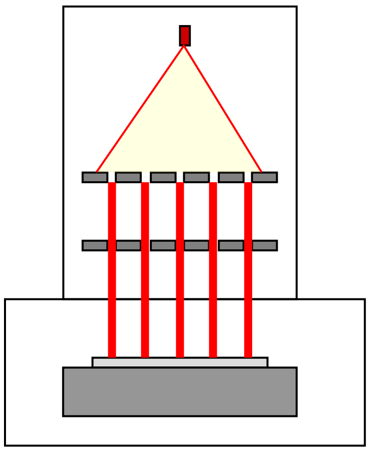
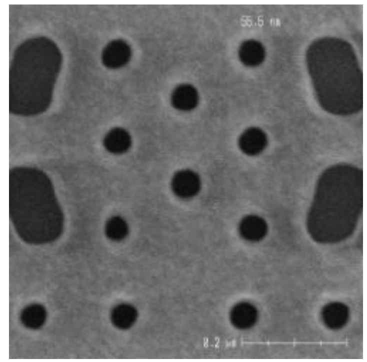


Similar but different…

Need	Mask	Wafer
Size	4x	1x
Accuracy	Highest (MEEF)	High (less source of error)
Data volume	Huge (SRAF)	Huge x 10 (no OPC; whole wafer)
Write Time	8-40 hours	1 ~ 100 WPH
Writing Space	Rectangle (efficient)	Circle (inefficient)
# passes	2, 4 (accuracy)	1 (write time)
Characters	Circles	1000's useful
Market now	Solid but flat	Zero but big potential

NIL Mask Master is a blend of both

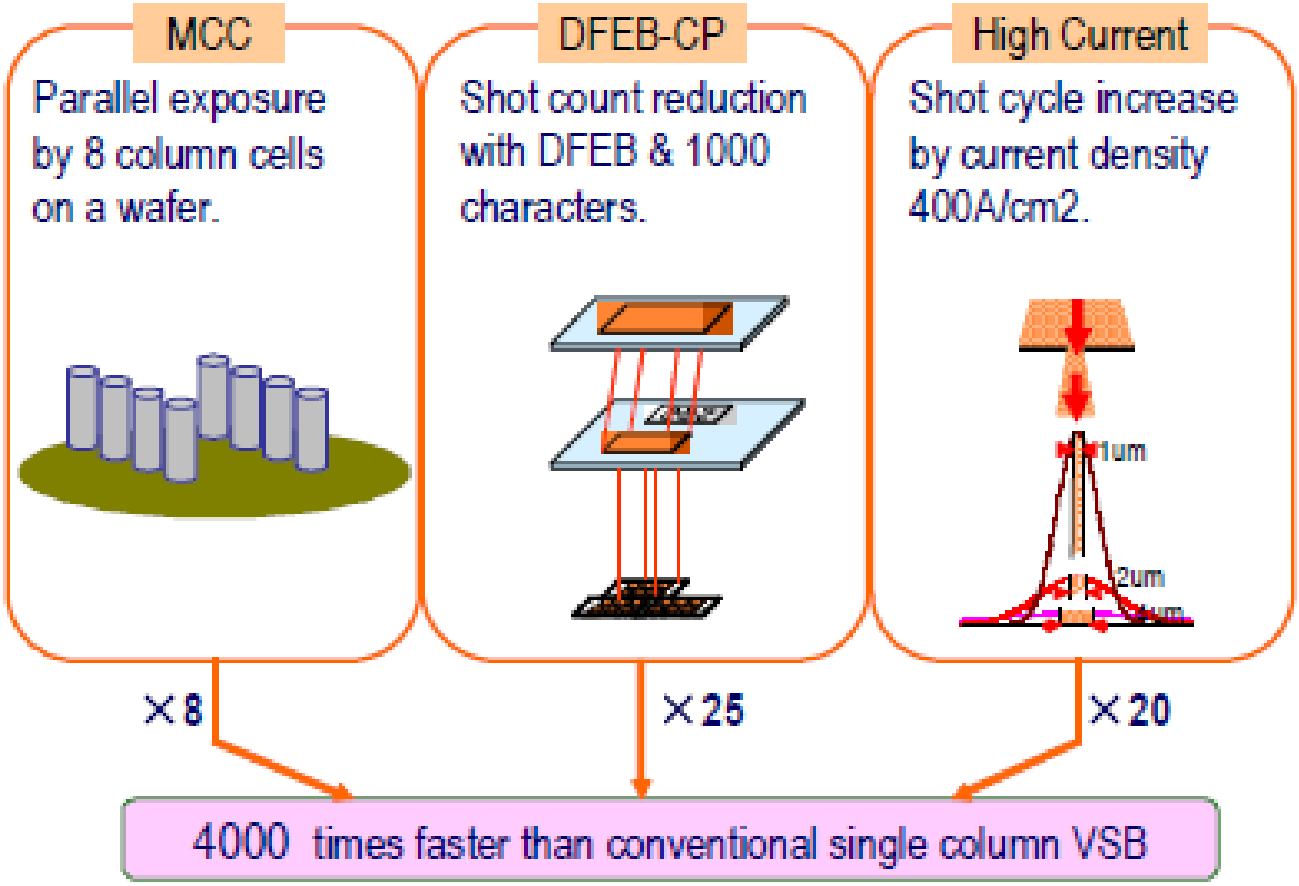
eBeam Speed-Up techniques

Split Beam	Character Proj.	General
 MSB		Multiple Source Clustering Source Current Resist Sensitivity Regular Design Rules Borodovsky Method *Other Limits:* Stage Data Transfer Calibration Settling Time …
DFEB = Data Compression	DFEB = 10X Speed-up	
Maximum flexibility in shape being written	Maximum transfer of energy for all shapes	

Drawing Courtesy of Advantest

Advantest MCC8

Realistic with limited budget is to extend

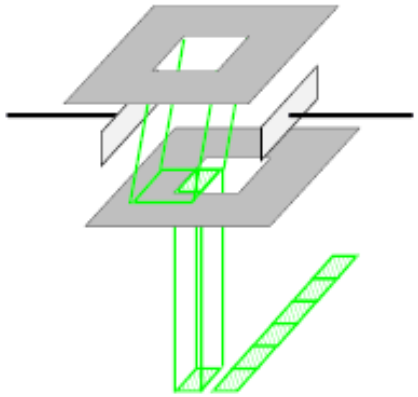


X 10 Cluster

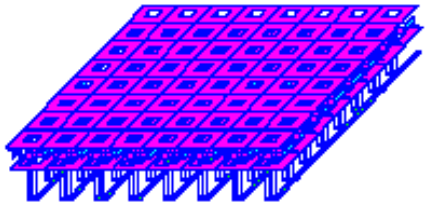
Vistec MSB

Hybrid like Prius is the best way to transition

Single
Variable Shaped Beam

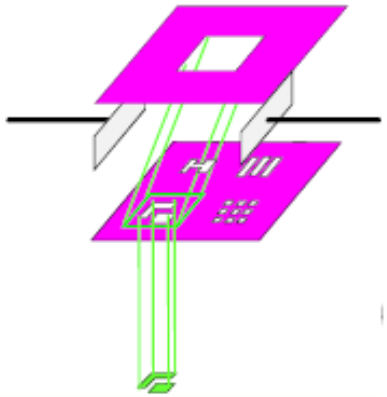


Vistec's Multi Shaped Beam approach:
MSB technology &
single VSB including Cell Projection



(array of 64 Shaped Beams shown)

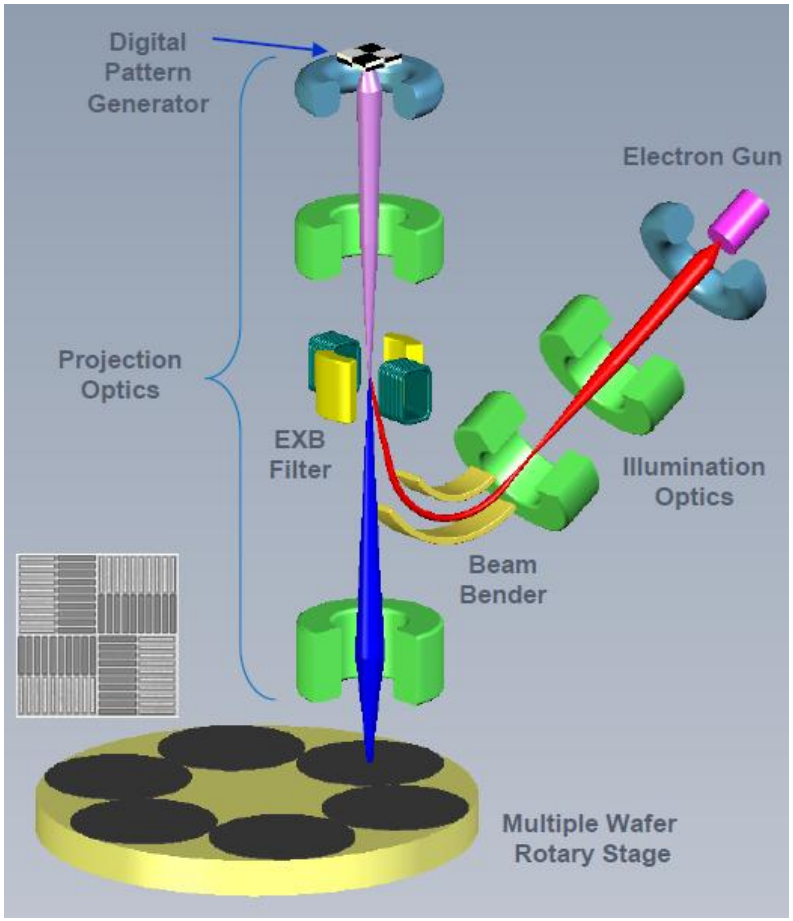
&



MSB maintains the parallel pixel exposure advantage of shaped beams (average >100 pixels / beamlet) resulting in thousands of pixels per flash.

IMS, KLA-T REBL, Mapper, Multibeam

Take on the bigger S-Curve



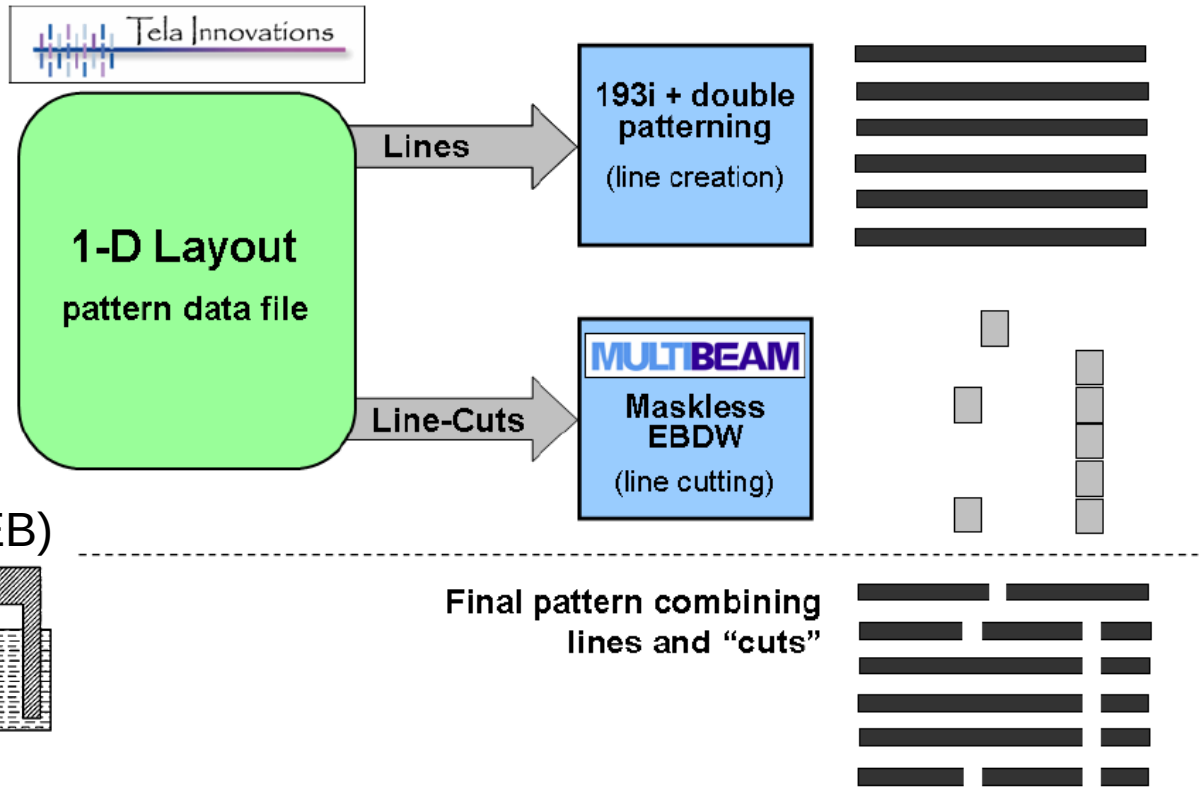
Multiple beams individually controlled by various means

Innovation in stage, data pipeline and column taken as a system

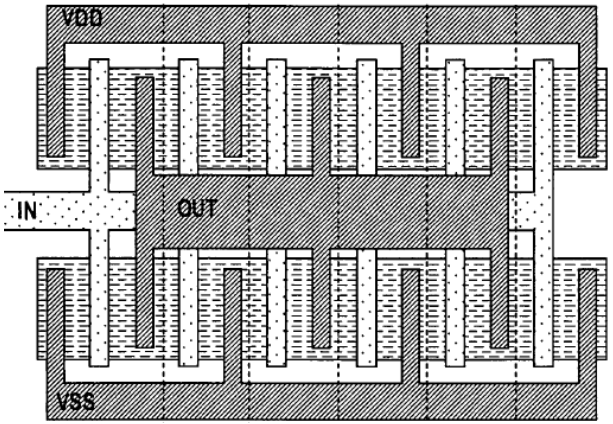
Expensive but worth it

Design to Manufacturing collaboration

Focus to succeed : The "Borodovsky method"



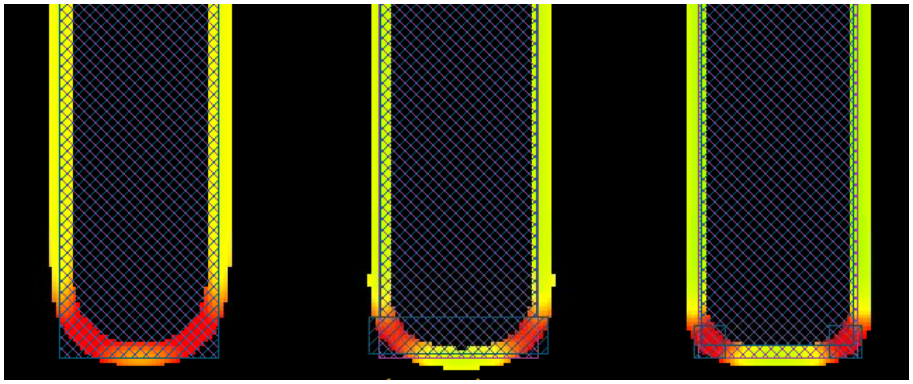
Design for E-Beam (DFEB)



ASELTA, CEA/Leti, D2S, EQUIcon, Fraunhofer, Technolution, TSMC

Software help is essential for this resolution

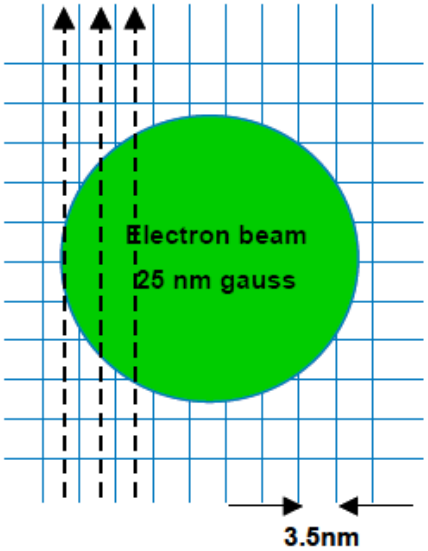
MB-MDP on 80nm L:S for mask

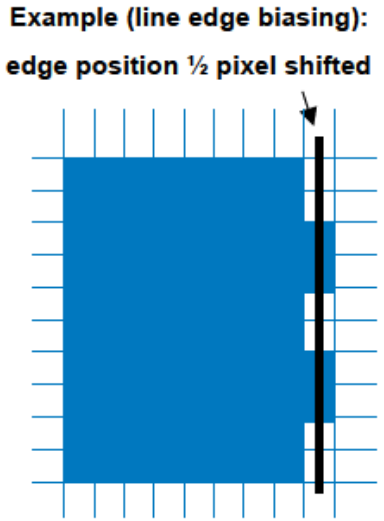


Even eBeam writing is hard at these nodes

- MB-MDP
- MPC
- eRIF
- EBPC

Mapper data prep for 3.5nm resolution



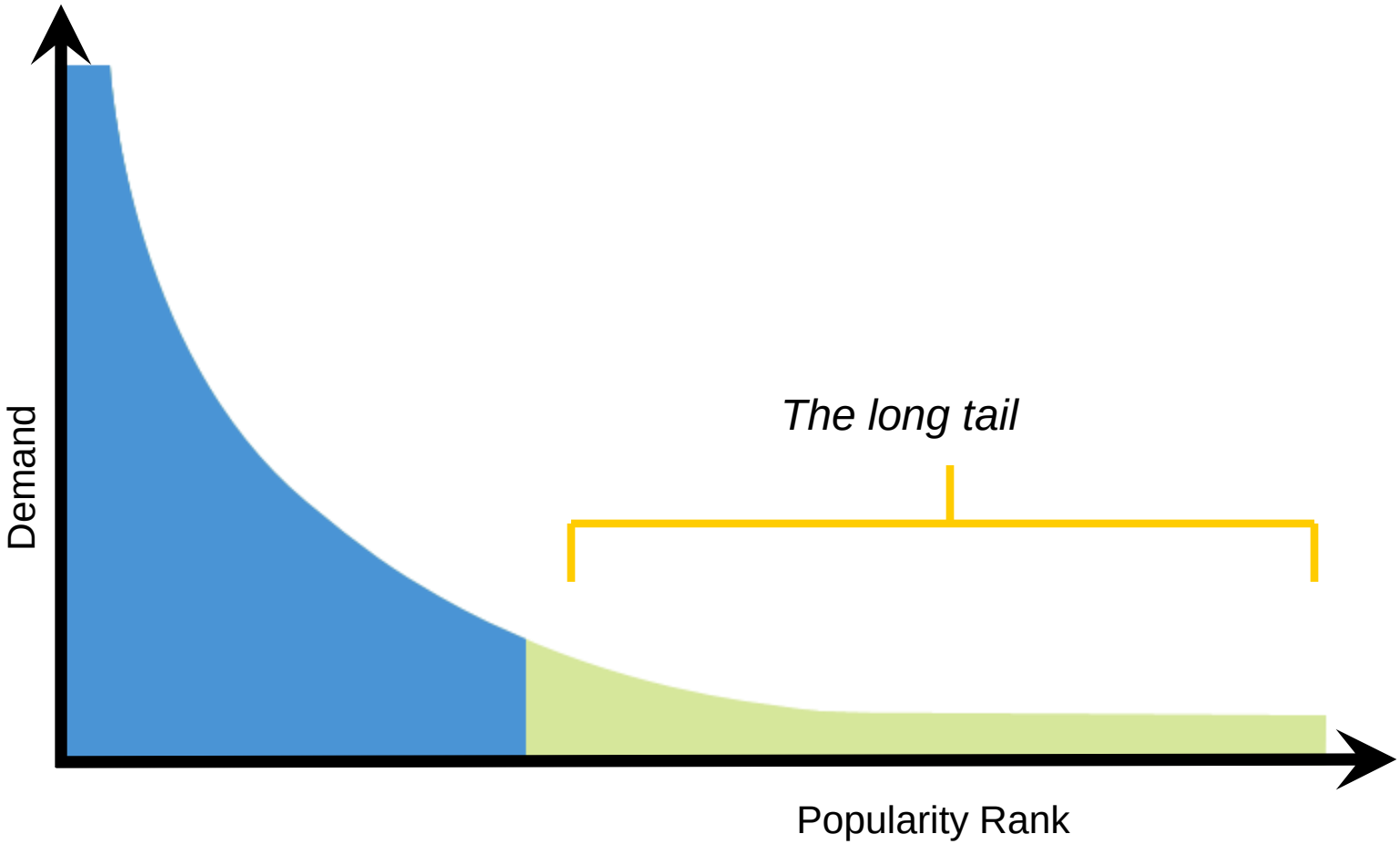


Themes and Approaches

EbDW : we can do this….

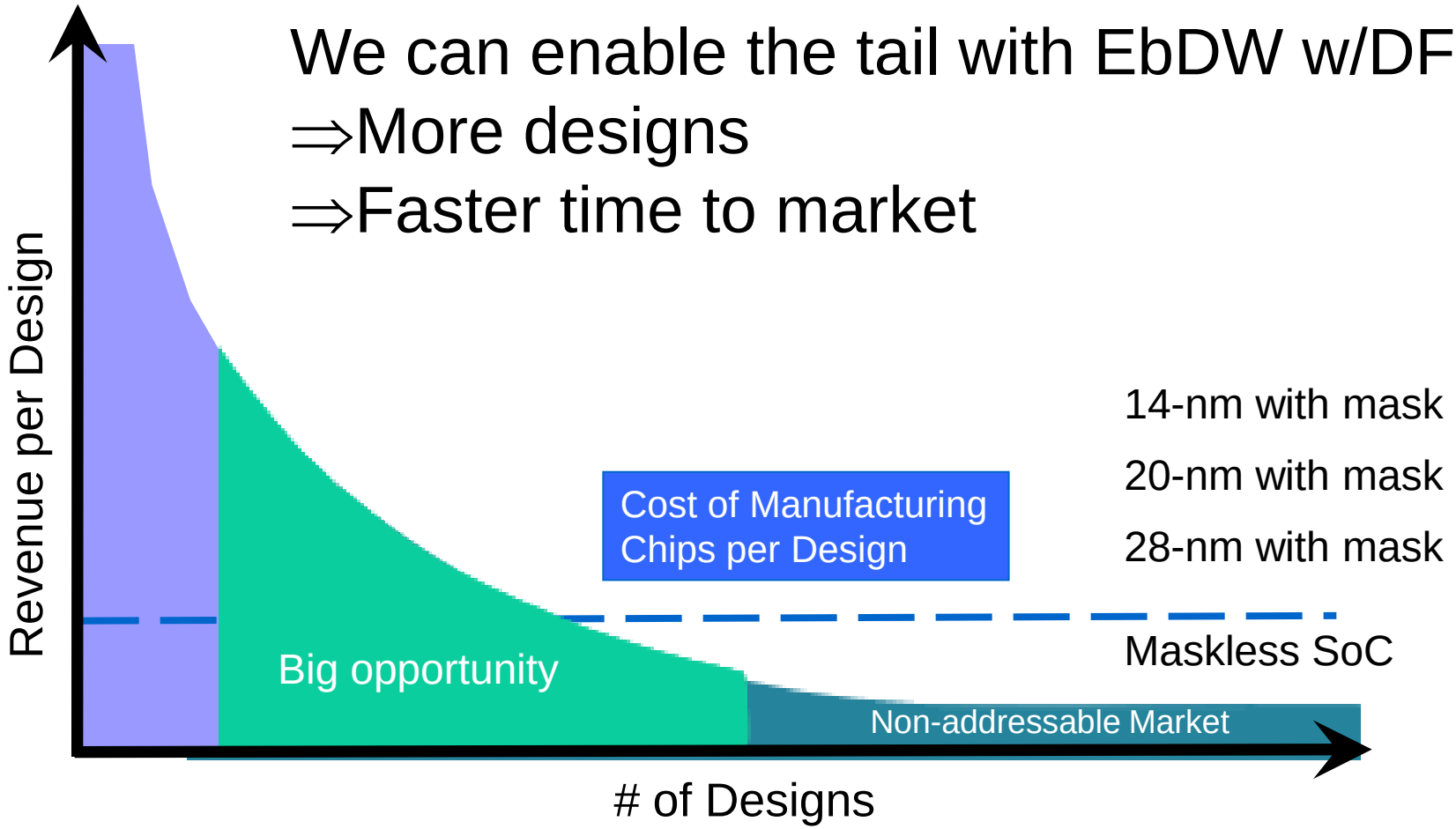
- **Monetize from the Existing Mask Market**
  - D2S, IMS, SEMATECH, Vistec
  - "Current density advances will not be enough" – Tom Faure, IBM
- **EbDW for high volume with clusters**
- **EbDW can also enable the long tail**
- **Government funding is deserved**
  - EbDW will help boost design starts
  - That's good for everyone in the supply chain

Enabling the Long Tail of SoCs



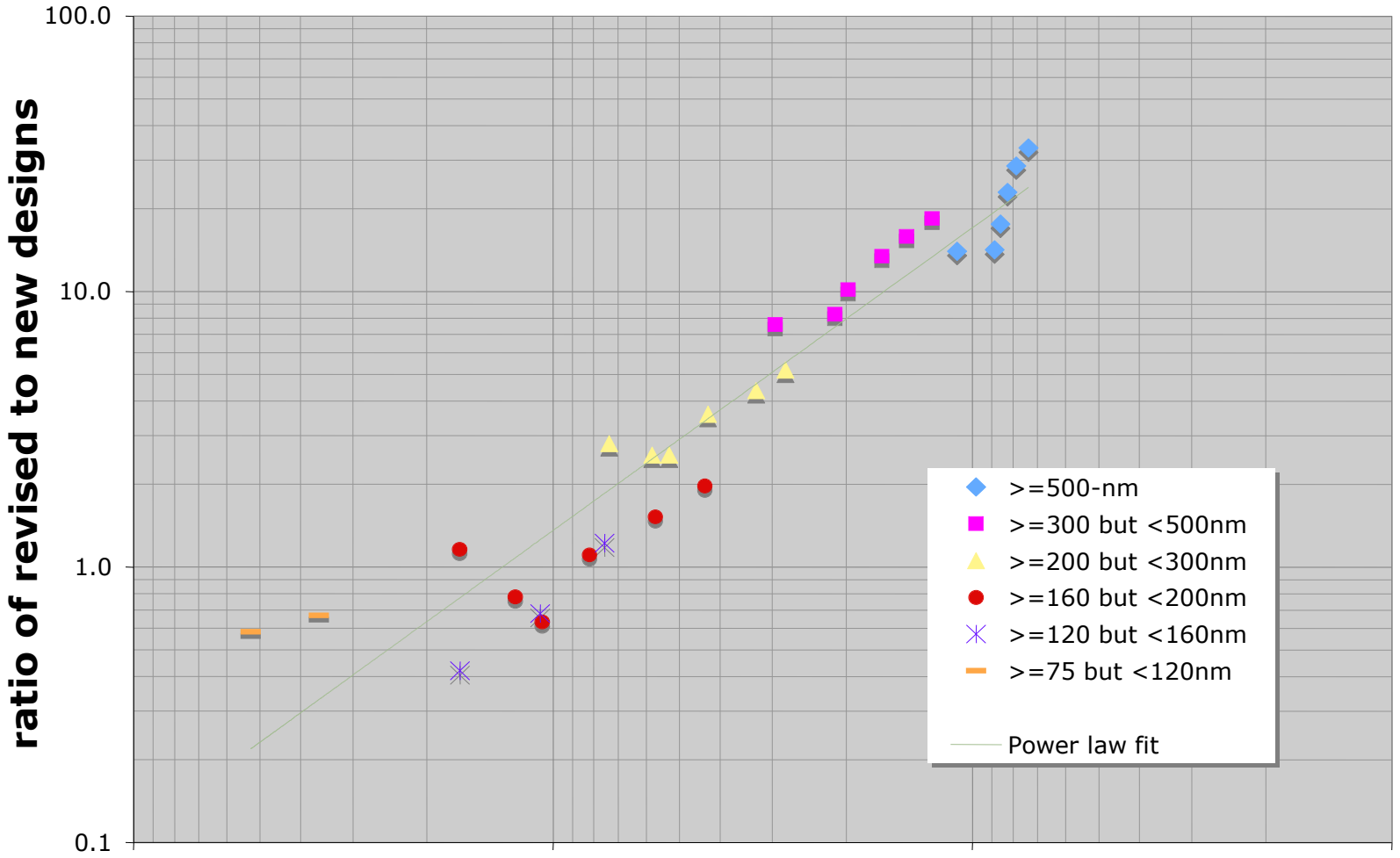
The Tail is Getting Shorter

We can enable the tail with EbDW w/DFEB
⇒More designs
⇒Faster time to market



Derivatives have low design cost

10x reduction in mask cost increases derivatives by 10x



Electron Beam Direct Write

- Great for R&D : process, design, systems
- Great for lower-volume : minimal mask cost
- Volume Production? : 50 WPH cluster in 2014

- Please attend these great sessions and learn about the potential of e-beam technologies

Session 3: Maskless Lithography I

Date: **Tuesday 1 March** Time: **1:20 PM - 3:10 PM**

Session Chairs: Hans Loeschner, IMS Nanofabrication AG (Austria);
Timothy R. Groves, Univ. at Albany

E-beam lithography development, outlook, and critical challenges *(Invited Paper)*

Paper 7970-9 Time: **1:20 PM - 1:50 PM**
Author(s): Hans C. Pfeiffer, HCP Consulting Services (United States)

MCC8: throughput enhancement of EB direct writer

Paper 7970-10 Time: **1:50 PM - 2:10 PM**
Author(s): Hideaki Komami, Masaki Kurokawa, Akio Yamada, Advantest Corp. (Japan)

eMET: 50 keV electron multibeam mask exposure tool

Paper 7970-11 Time: **2:10 PM - 2:30 PM**
Author(s): Christof Klein, Jan Klikovits, Hans Loeschner, Elmar Platzgummer, IMS Nanofabrication AG (Austria)

Scanning exposures with a MAPPER multibeam system

Paper 7970-12 Time: **2:30 PM - 2:50 PM**
Author(s): Bert J. Kampherbeek, Christiaan van den Berg, Vincent Kuiper, Niels Vergeer, Stijn Bosschker, Thomas Ooms, Alexandra Tudorie, Remco J. Jager, MAPPER Lithography (Netherlands); Sjoerd Postma, DEMCON (Netherlands); Guido de Boer, MAPPER Lithography (Netherlands)

Multishaped beam: development status and update on lithography results

Paper 7970-13 Time: **2:50 PM - 3:10 PM**
Author(s): Ines A. Stolberg, Matthias Slodowski, Hans-Joachim Doering, Wolfgang H. Dorl, Vistec Electron Beam GmbH (Germany)

Session 8: Maskless Lithography II

Date: **Wednesday 2 March** Time: **3:30 PM - 5:40 PM**

Session Chairs: Lloyd C. Litt, SEMATECH Inc.; Laurent Pain, CEA-LETI (France)

Fast mask writer: technology options and considerations *(Invited Paper)*

Paper 7970-32 Time: **3:30 PM - 4:00 PM**

Author(s): Lloyd C. Litt, SEMATECH Inc. (United States); Timothy R. Groves, Univ. at Albany (United States); Gregory P. Hughes, SEMATECH, Inc. (United States)

IMAGINE: an open consortium to boost maskless lithography take off: first assessment results on MAPPER technology

Paper 7970-33 Time: **4:00 PM - 4:20 PM**

Author(s): Laurent Pain, Serge V. Tedesco, Beatrice Icard, Mickael Martin, Christophe Constancias, Lab. d'Electronique de Technologie de l'Information (France); Bert J. Kampherbeek, MAPPER Lithography (Netherlands)

Influence of massively parallel e-beam direct-write pixel size on electron proximity correction

Paper 7970-34 Time: **4:20 PM - 4:40 PM**

Author(s): Shy-Jay Lin, Taiwan Semiconductor Manufacturing Co. Ltd. (Taiwan)

Data path development for massive electron-beam maskless lithography

Paper 7970-35 Time: **4:40 PM - 5:00 PM**

Author(s): Faruk Krecinic, Jack J. Chen, Shy-Jay Lin, Burn J. Lin, Taiwan Semiconductor Manufacturing Co. Ltd. (Taiwan)

EBDW to complement optical lithography for 1D GDR patterning

Paper 7970-36 Time: **5:00 PM - 5:20 PM**

Author(s): David K. Lam, David Liu, Multibeam Corp. (United States); Michael C. Smayling, Tela Innovations, Inc. (United States); Ted Prescop, Multibeam Corp. (United States)

Model-based mask data preparation and impact on resist heating

Paper 7970-37 Time: **5:20 PM - 5:40 PM**

Author(s): Aki Fujimura, D2S, Inc. (United States); Takashi Kamikubo, NuFlare Technology, Inc. (Japan); Ingo Bork, D2S, Inc. (United States

Session 10: Maskless Lithography III

Date: **Thursday 3 March** Time: **10:20 AM - 12:10 PM**

Session Chairs: Lloyd C. Litt, SEMATECH Inc.; Hans Loeschner, IMS Nanofabrication AG (Austria)

New advances with REBL for maskless high-throughput EBDW lithography *(Invited Paper)*

Paper 7970-43 Time: **10:20 AM - 10:50 AM**

Author(s): Paul Petric, Chris Bevis, Mark A. McCord, Allen Carroll, Alan D. Brodie, Upendra Ummethala, Luca Grella, Regina Freed, KLA-Tencor Corp. (United States)

Large-scale eRIF implementation for sub-22-nm e-beam lithography

Paper 7970-44 Time: **10:50 AM - 11:10 AM**

Author(s): Luc Martin, Lab. d'Electronique de Technologie de l'Information (France); Serdar Manakli, Sébastien Bayle, ASELTA Nanographics (France); Kang-Hoon Choi, Manuela S. Gutsch, Fraunhofer-Ctr. Nanoelektronische Technologien (Germany); Laurent Pain, Lab. d'Electronique de Technologie de l'Information (France)

Demonstration of real-time pattern correction for high-throughput maskless lithography

Paper 7970-45 Time: **11:10 AM - 11:30 AM**

Author(s): Marco J. Wieland, Ton van de Peut, Martijn Sanderse, MAPPER Lithography (Netherlands); Edwin Hakkennes, Nol Venema, Ard Wiersma, Mark Hoving, Sijmen Woutersen, Technolution B.V. (Netherlands)

EBPC for multibeams low-kV electron projection lithography

Paper 7970-46 Time: **11:30 AM - 11:50 AM**

Author(s): Jérôme Belledent, Sebastien Soulan, Laurent Pain, Commissariat à l'Énergie Atomique (France)

Fast characterization of line-end shortening and application of novel LES correction algorithms in e-beam direct write

Paper 7970-47 Time: **11:50 AM - 12:10 PM**

Author(s): Martin Freitag, Manuela S. Gutsch, Kang-Hoon Choi, Christoph K. Hohle, Fraunhofer-Ctr. Nanoelektronische Technologien (Germany); Michael Krüger, EQUIcon Software GmbH Jena (Germany); Ulf Weidenmüller, Vistec Electron Beam GmbH (Germany)

It's time to make it happen…

- **EbDW will scale, once it catches a node**
- **Need to collaborate and coordinate even more**
  - Too many teams in the league is diluting the quality and funding
  - Column, stage, data-path and integration should share
- **EbDW projects need more funding**
  - Will help boost design starts at the leading edge nodes
  - Good for everyone in the supply chain
  - Spurs more silicon innovation
  - Fuels more systems innovation


eBeam
Initiative