Introduction and recent results of Multi-beam mask writer MBM-1000

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February 23rd, 2016

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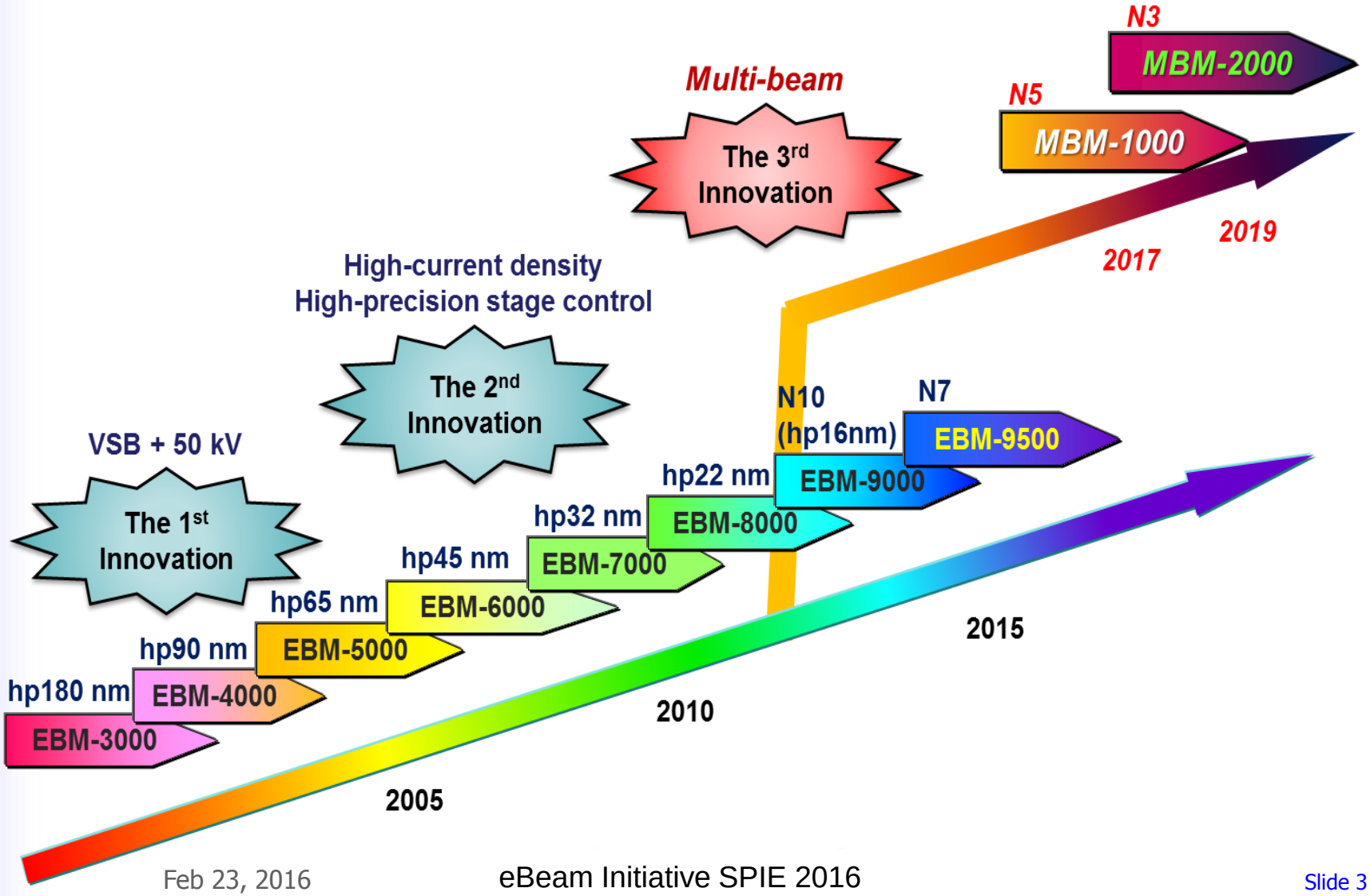
NFT's mask writer roadmap 2016

Device	Production	2016	2017	2018	2019	2020	Remarks
ITRS 2013	Logic	N10	N7	N7	N5	N5	Node name
	DRAM	22	20	18	17	15	Bit line hp (nm)
	Flash	14	13	12	12	12	Gate hp (nm)
Mask Writer	EBM-9000	2013					N14, 10
	EBM-9500	2015					N7
	MBM-1000		2017				N5
	MBM-2000				2019		N3

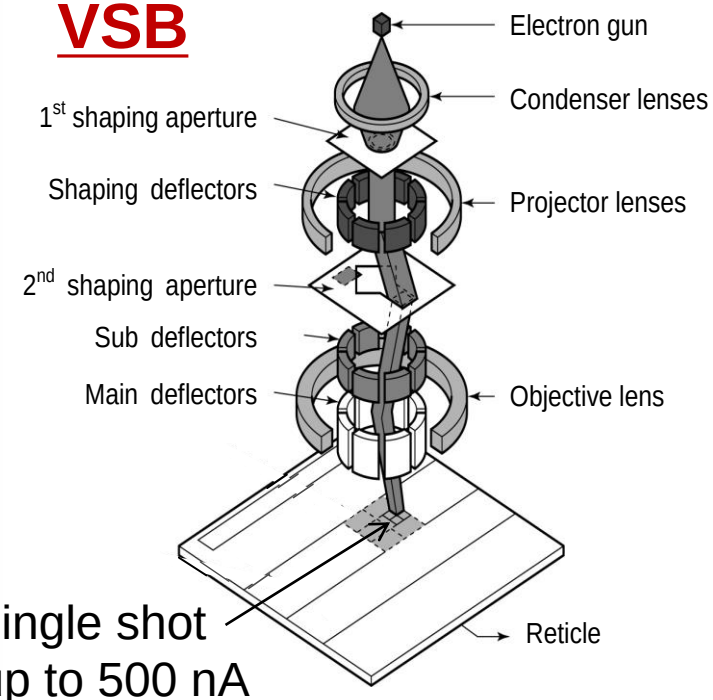
- NuFlare keeps on releasing leading-edge mask writers every two years to support semiconductor industry for more than 15 years.
- We will launch MBMW to comply with ITRS roadmap.
- ***MBM-1000*** is to be released in ***2017*** for N5.
- ***MBM-2000*** will be coming in ***2019*** for N3.

NFT's MBMW ready to launch

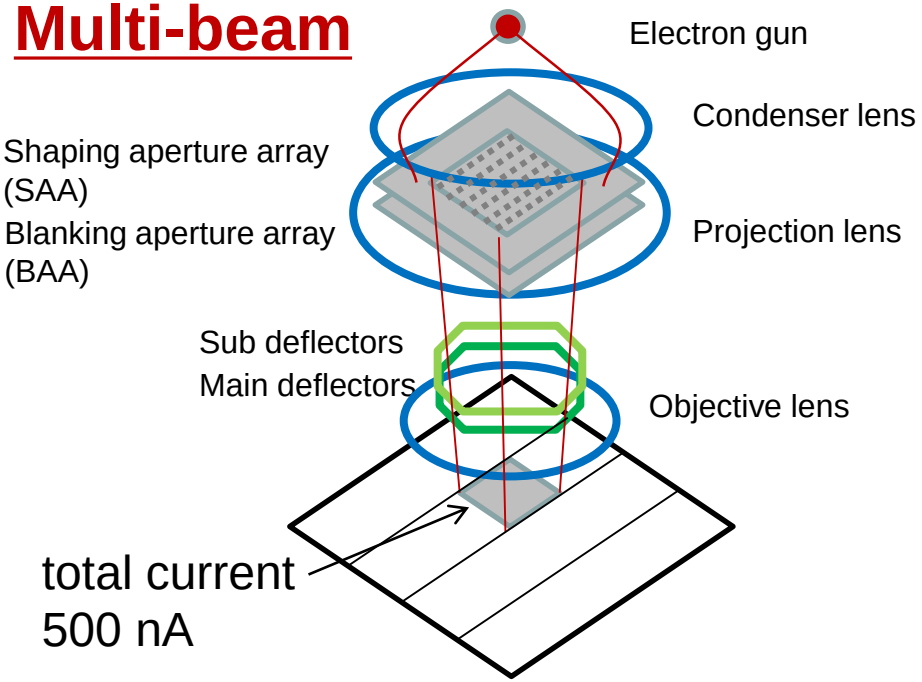
- The 3rd technical innovation for futuristic mask writing



VSB



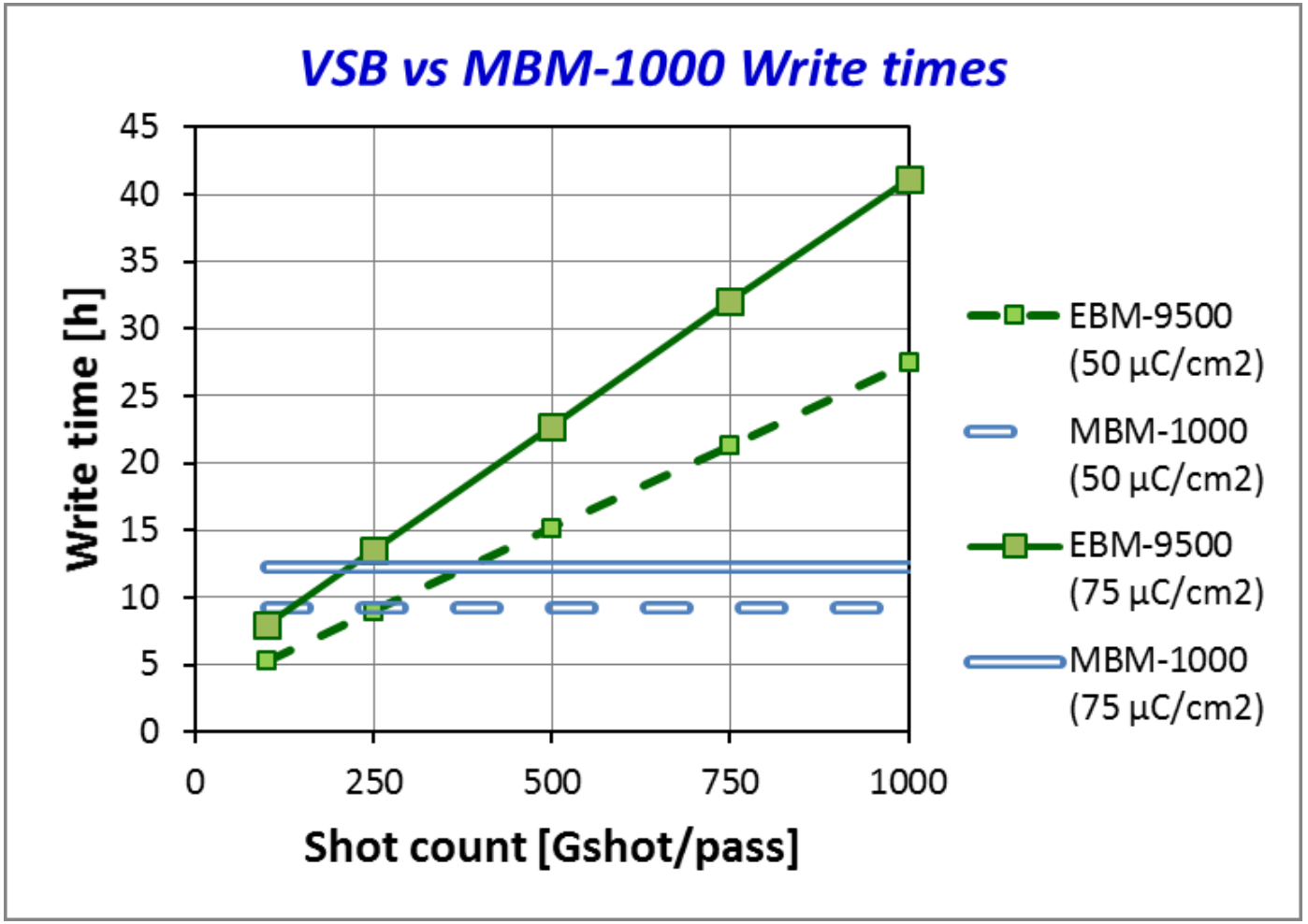
Multi-beam



	VSB	MB
Key technologies	• Single Variable Shaped Beam • High current density • High speed deflection	• Massive number of beams • High-speed data path and BAA • Gray beam writing
Advantage	• Best cost performance for Med-Low pattern density/doses	• Constant write time for all pattern densities • Enables high doses
Limitation	• High doses and pattern densities impact write time	• Not cost effective for Med-Low pattern densities and doses • Narrow process window due to gray beam

Throughput relative to Shot Count

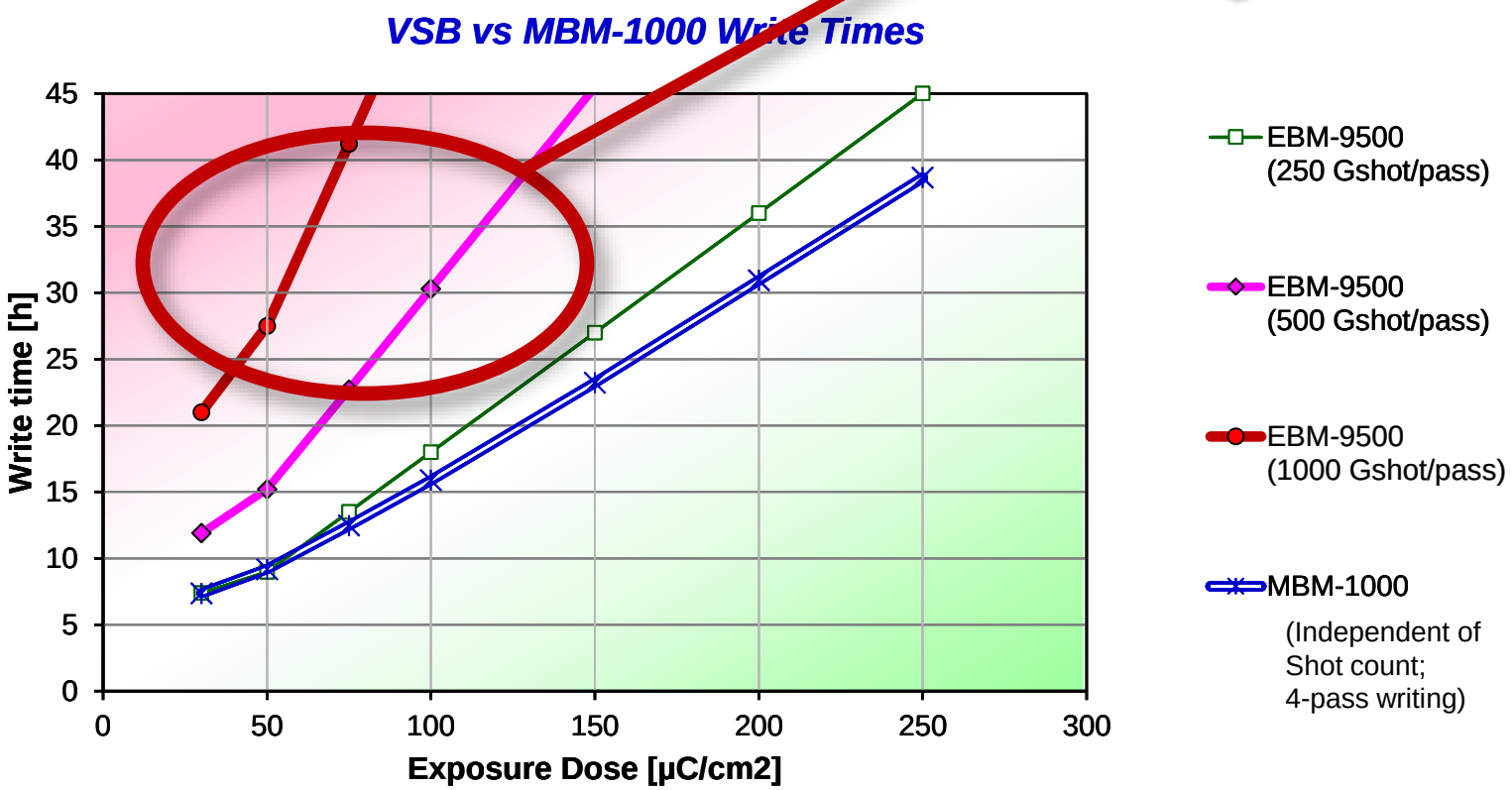
- MB is advantageous with shot counts > ~200 Gshot/pass.



Throughput relative to Dose

- MB is advantageous for
  - Shot count > 200 G/pass and
  - Resist sensitivity > 75 uC/cm^2

MBM-1000 is better for this region



Key features of NFT MBMW

- High-speed data path with 10-bit dose control
  - 1023 dose levels/pass mandatory for <0.1nm CD control accuracy
  - Gray beam writing with advanced correction methods
    - inherited from existing EBM technologies (PEC/FEC/LEC)
  - All corrections processed real-time / in-line
- 50 kV single-stage acceleration
  - High resistance to external noise through entire beam path
  - Column and BAA at ground level resulting in safe and stable operation
- Electron source
  - 2 A/cm^2 for MBM-1000, 4 A/cm^2 for MBM-2000
  - Large illumination area with high uniformity for BAA configuration
- Air bearing stage and field-proven mask holding mechanism
- EUV mask writing capability
  - GMC-TV (Position correction for mask writer holder to scanner chucking)
  - In-line EUV-PEC (1µm range corrections)

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Tool configuration (EBM, MBM)

Item	EBM-9500	MBM-1000
Accel. voltage	50 kV	50 kV
Cathode	1200 A/cm^2	2-4 A/cm^2
Beam blur	r	< r
Beam size	VSB (≤ 250 nm)	10 nm x 10 nm beamlet 82 µm x 82 µm array
Beam current	500 nA @ max shot size	500 nA in total
Stage	Frictional drive with variable speed	Air bearing stage with constant speed
Data format	VSB12i, OASIS.MASK	MBF (polygon support), VSB12i, OASIS.MASK
Corrections for writing accuracy	PEC/FEC/LEC, GMC, CEC, GMC-TV, TEC	PEC/FEC/LEC, GMC, CEC, GMC-TV, EUV-PEC

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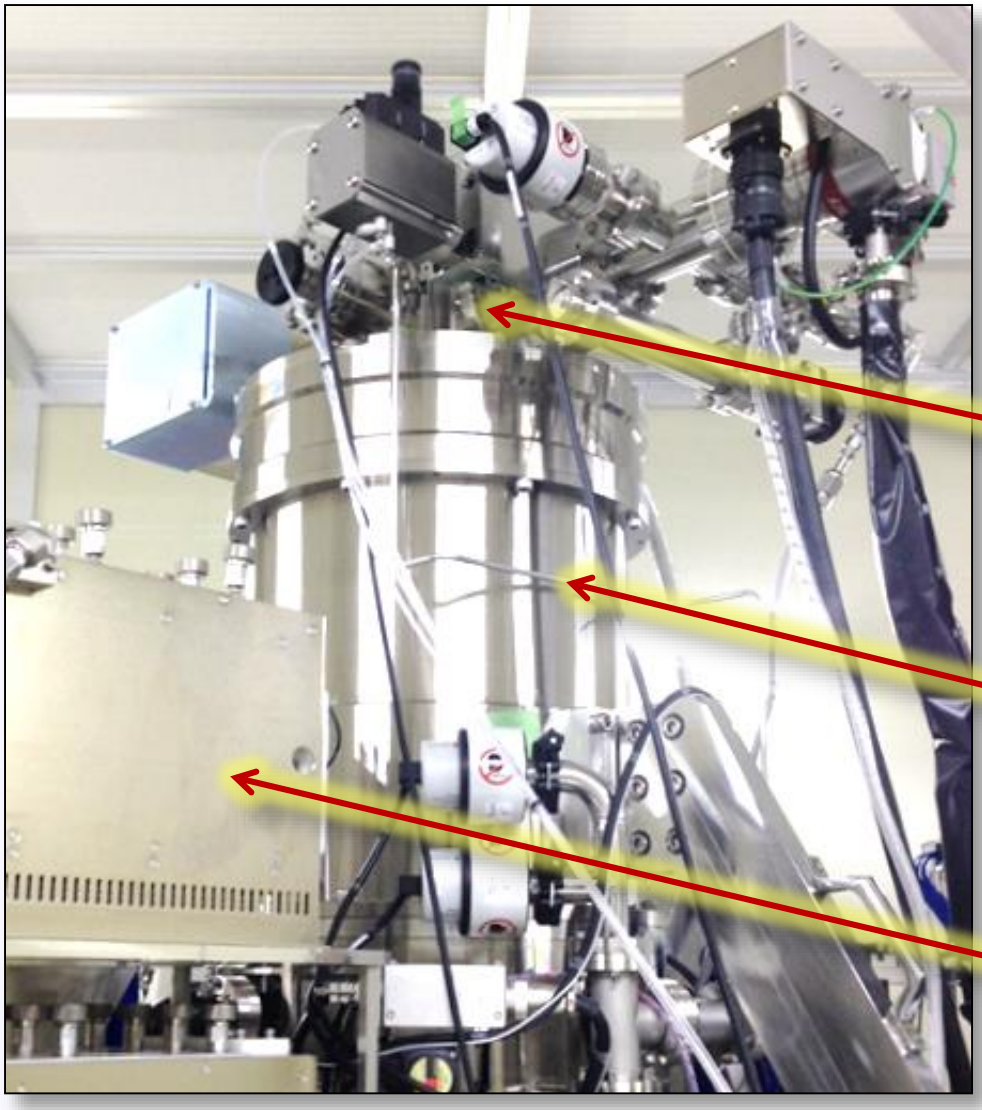
Standard specification

Specification		EBM-9000	EBM-9500	MBM-1000
Global Image Placement accuracy [nm 3σ]		3.0	2.1	1.5
CD Uniformity [nm]	Global [3σ]	3.0	2.5	1.5
	Local [3σ]	1.3	1.3	1.0
Beam blur		r	←	r' (< r) #
Mask write time [hours] (130mmx100mm)		-	-	12 @ 75 μC/cm^2
Beam size [nm]		VSB (0.1 to 250)	VSB (0.1 to 250)	10
Current density [A/cm^2]		800	1200	2

holds in the case that total beam current is sufficiently small.

MBM-1000 Alpha



Alpha tool is running at factory for verification of printing performance.

50 keV electron source

Large-area projection column with BAA/SAA

DACAMP for deflection

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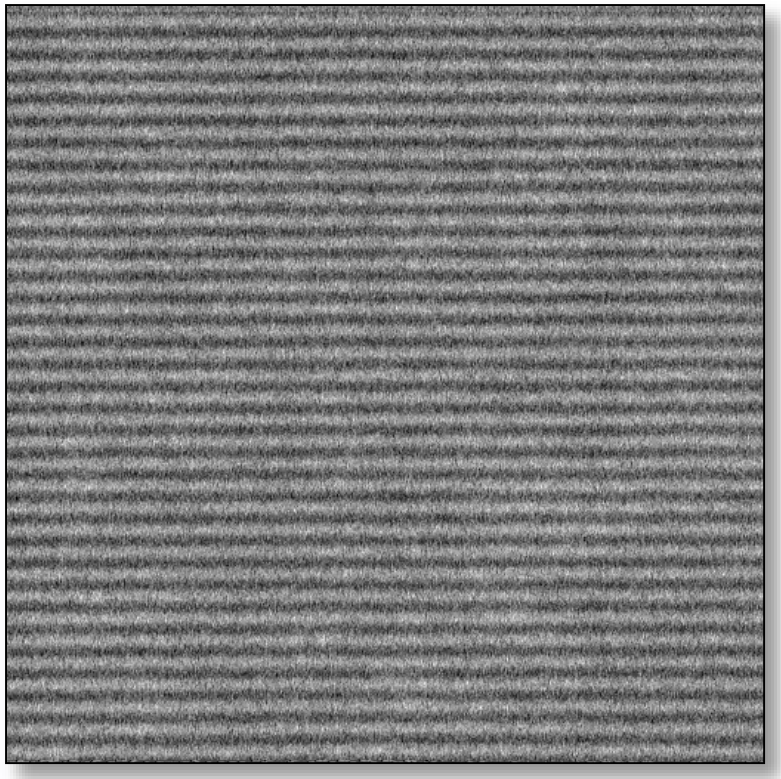
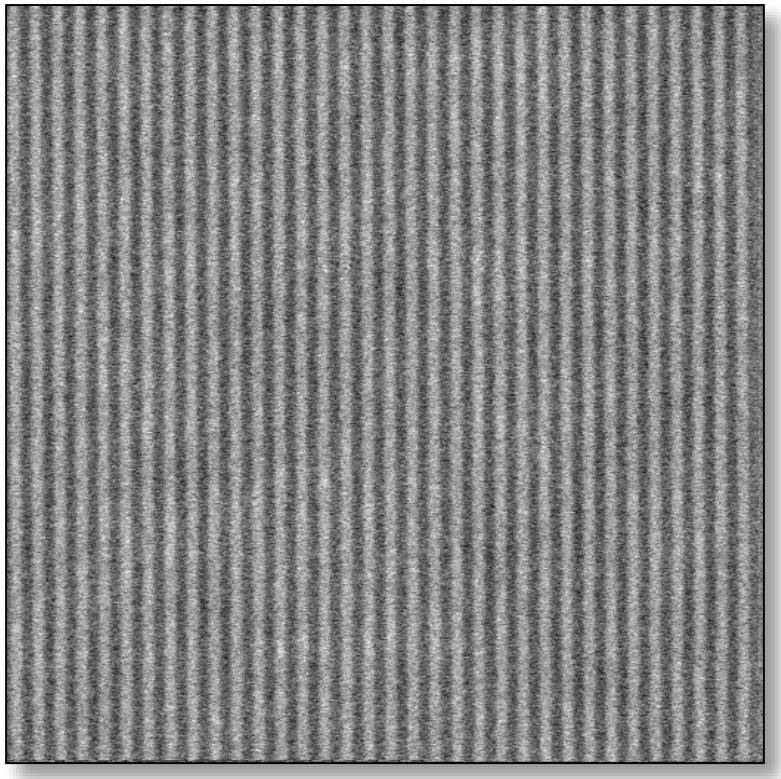
Resolution performance

- HP 20 nm 1:1 L&S patterns resolved.
  - Demonstrated better resolution than EBM series.

Resist images using ZEP520
50 nm thickness @ 160 uC/cm²





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Progress on key features

Item	MBM-1000	Current Status
Cathode	2-4 A/cm^2 (>80 µm area)	***Ready***
Beam blur	< r (smaller than 9K)	***Proven***
Beam size	square beamlet 10 nm	***Ready***
BAA	alpha version	***Ready***
	HVM version	Dec. 2016
Deflection	Two stages deflection with stage tracking	***Ready***
Stage	Air bearing stage	***Ready***
Data path	VSB12i	***Ready***
	MBF (supports curvilinear pattern)	Oct. 2016
Safety	SEMI, CE compliant	***Ready***

Schedule

- Local area writing by Alpha tool: Dec. 2015
  - Demonstrated better resolution than EBM-9500
- Test pattern full area writing : Mar. 2016
- Beta tool beam on : Jul. 2016
- *Customer pattern demo writes : Oct. 2016*
- Upgrade to high-speed data path : Q1 2017

First HVM delivery : Q4 2017

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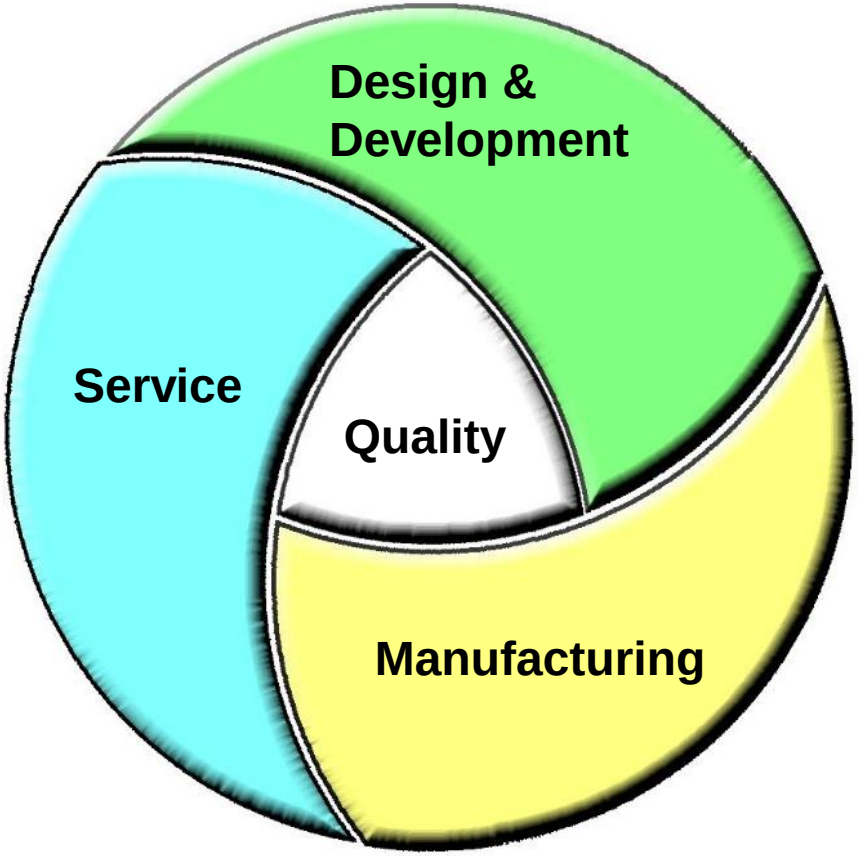
NuFlare, Integrating your needs…



THANK YOU !!!