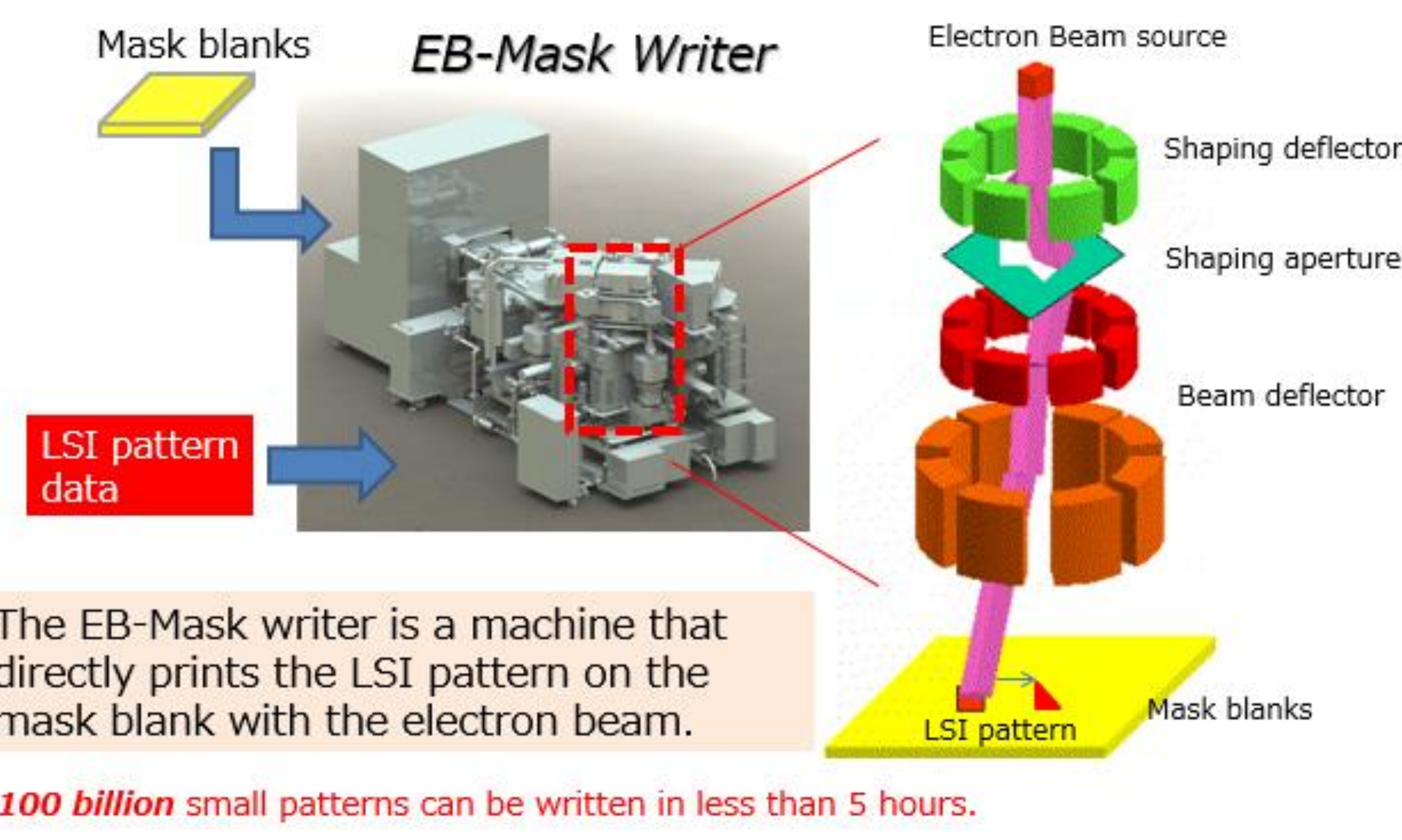


Electron Beam Mask Writer EBM-8000P for High throughput

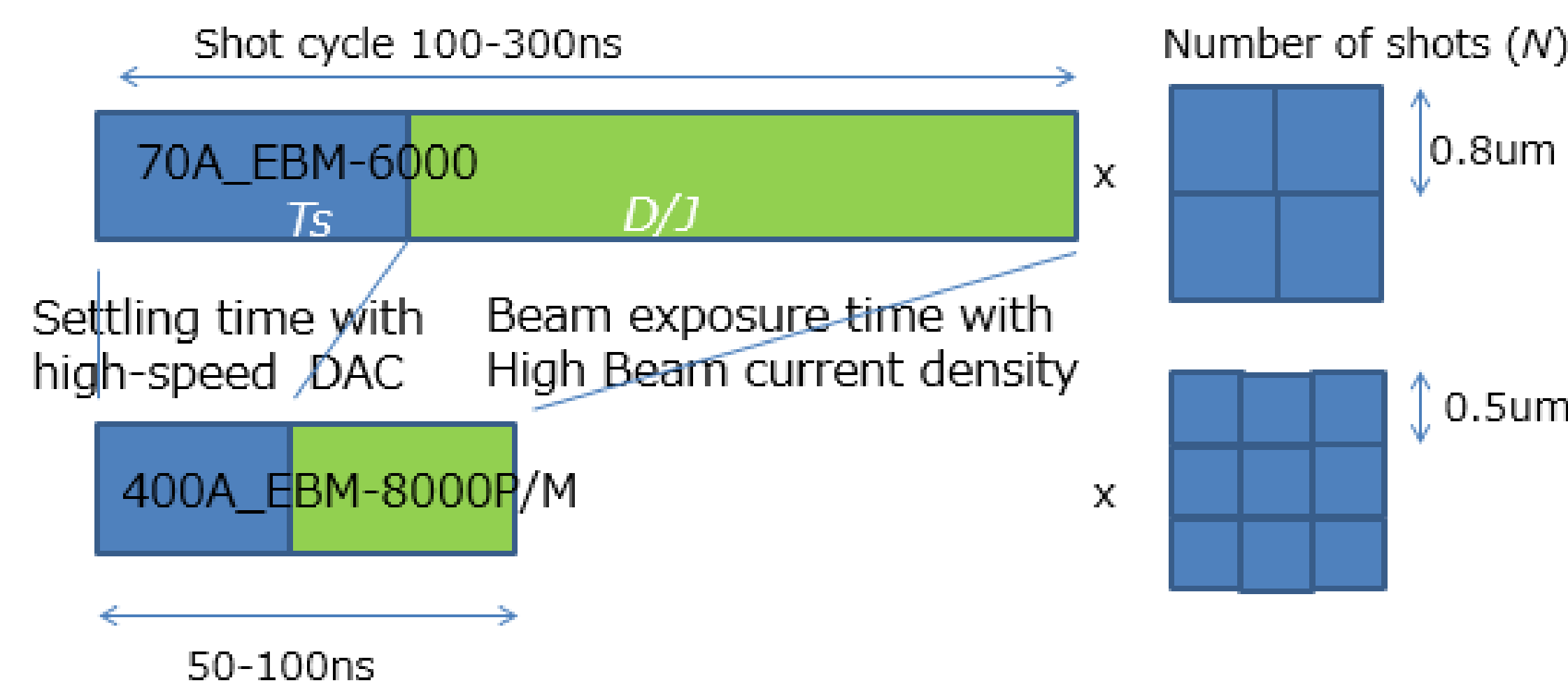
Tomohiro Iijima, Satoshi Nakahashi, Ryo Iikubo, Takahiro Honbu, Shinsuke Nishimura, Syoji Mori, Hirohiko Honda, Tsuyoshi Yamashita, Tetsuro Nishiyama, Osamu Kawami, Takao Tamura, Kenji Ohtoshi and Hirokazu Yamada.

What is an Electron Beam-Mask Writer?



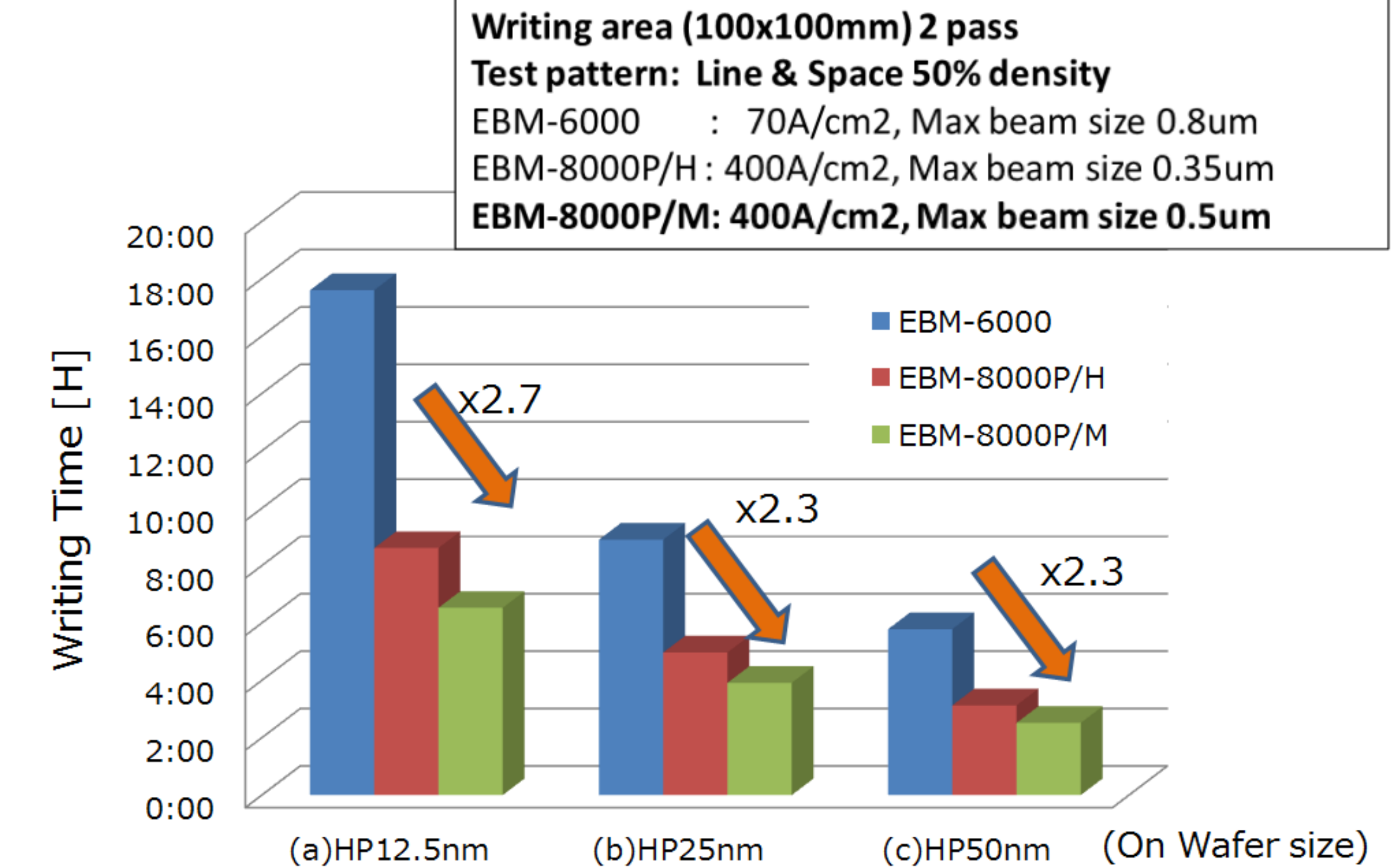
Key for High Throughput Mask Writing

$$\text{Writing time} \propto \text{Shot cycle} \times \text{Number of shots} \\ (D/J + T_s) \times N$$



Even if the number of shots slightly increases, high throughput can be achieved by significantly reducing shot cycle time through high current density.

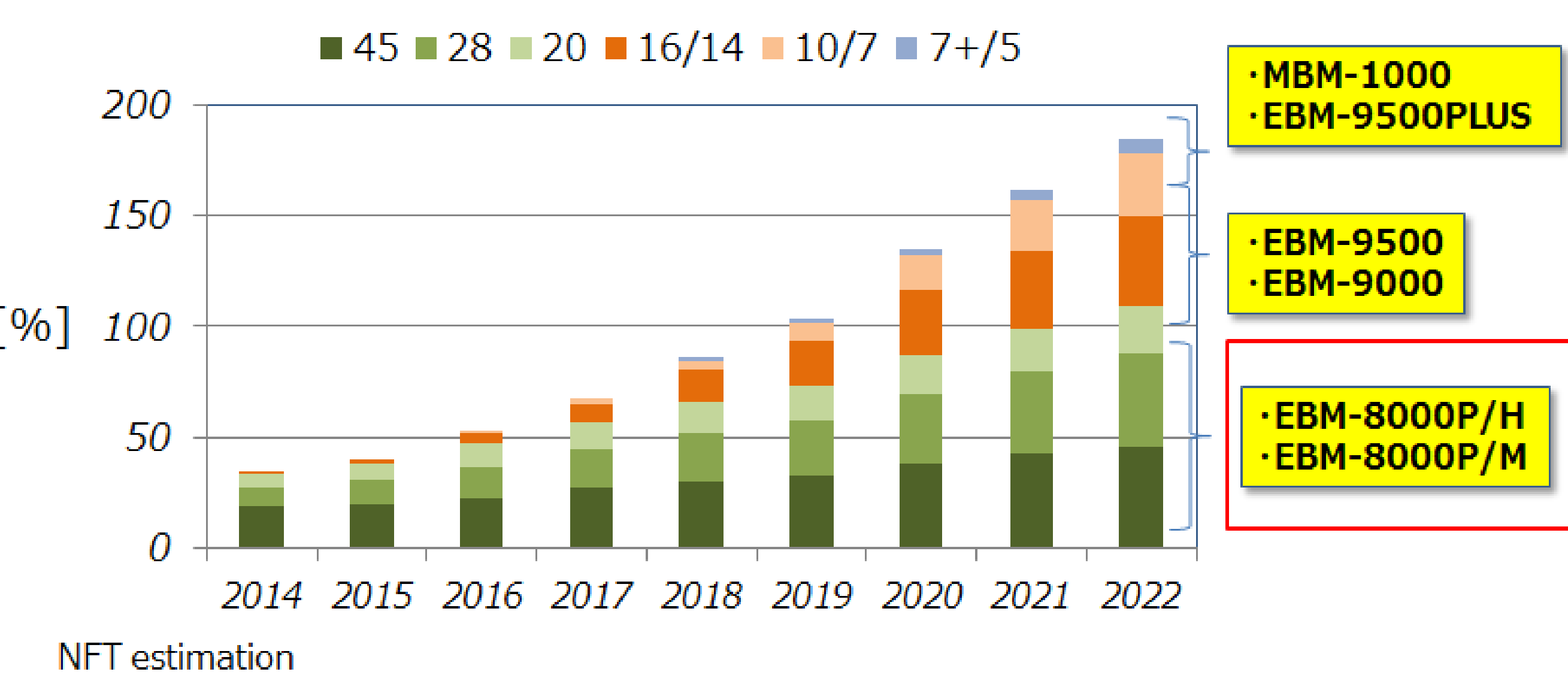
Throughput (EBM-8000P/M)



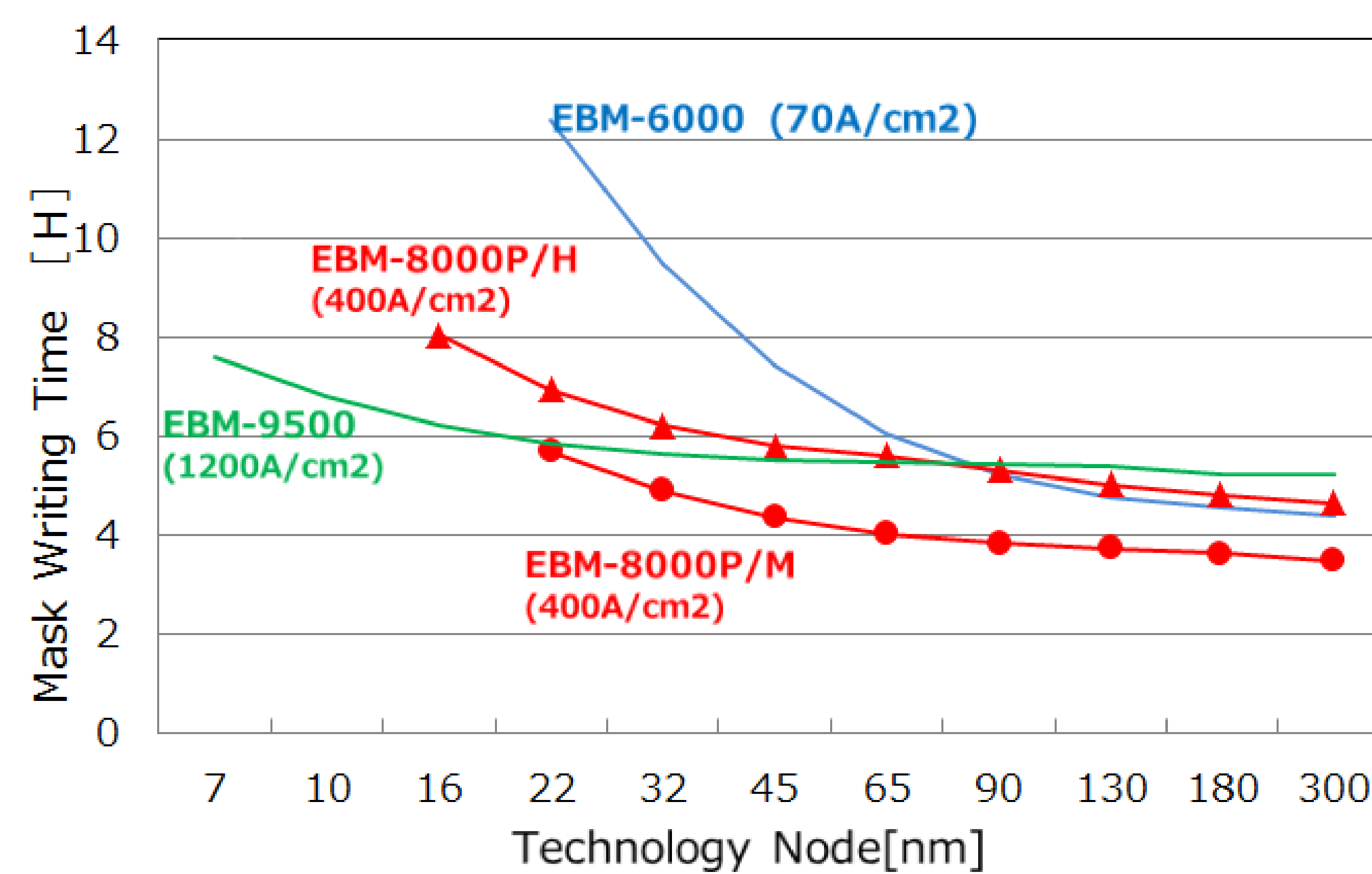
EBM-8000P/M can write ~2 times faster than conventional EBM-6000.

Mask growth trend

- Not only advanced nodes but also mature nodes such as node 20nm-45nm are rapidly growing.
 - Mature node will cover about 50% share of the total mask delivery in 2022.
- NuFlare's EBM writers can cover all node generations.



EBM-8000P Throughput (estimation)



EBM-8000P/M is the fastest EB Mask Writer for mid-range technical node.

Accuracy (EBM-8000P/M)

| | unit | Spec (/M) | 2pass | | Memo |
|-------------------|---------|-----------|------------|----------|--|
| | | | Horizontal | Vertical | |
| Image placement | [nm]3σ | 6 | 3.0 | 3.7 | 1 st order distortion removed |
| Overlay | [nm]3σ | 6 | 2.9 | 3.1 | 1 st order distortion removed |
| Local uniformity | [nm]3σ | 2.5 | 1.8 | 2.1 | @128 nm L/S |
| Global uniformity | [nm]3σ | 5 | 2.6 | 2.8 | @128 nm L/S |
| X-Y difference | [nm]max | 2 | 1.9 | 1.1 | @128 nm L/S |
| Edge roughness | [nm]3σ | 8 | 5.1 | 5.2 | @200 nm L/S |
| PEC | [nm]max | 5 | 1.3 | 1.7 | 3 category (density) errors |

| Image placement | Overlay |
|--|--|
| X: [nm] mean: 0.00 3s: 3.04 max: 2.70 min: -3.15 | X: [nm] mean: 0.37 3s: 2.90 max: 2.04 min: -3.22 |
| Y: [nm] mean: 0.00 3s: 3.71 max: 2.47 min: -2.95 | Y: [nm] mean: 0.34 3s: 3.08 max: 2.53 min: -3.50 |
| Xpitch: 0.00 Ypitch: 0.00 Xrotate: 0.000 Yrotate: 0.000 | Xpitch: 0.00 Ypitch: 0.02 Xrotate: 0.001 Yrotate: 0.000 |

NuFlare's strategy for EBM-8000P

- EBM-8000P series are developed to meet mask industry's strong demand for N20nm-45nm grade writers, based on state-of-the-art technology.
- EBM-8000P/M (2019/Q3)
 - Designed for N20nm-45nm lithography
 - Current density = 400A/cm², Max. shot size=500nm
 - Write time is 2-3 times faster than EBM-6000, released in 2006
 - Pattern fidelity is compatible with EBM-6000
- EBM-8000P/H (2020/Q1)
 - Designed for N14nm/16nm lithography
 - Current density = 400A/cm², Max. shot size=350nm
 - Pattern fidelity is compatible with EBM-8000
- Upgradable to EBM-8000P/H from EBM-8000P/M
- Common platform with EBM-9000 series
 - DAC-AMP, data path, mask transfer system and stage

Specification table of EBM-8000P

| | EBM-6000 | EBM-8000 | EBM-8000P | | EBM-9500PLUS |
|--------------------------------------|----------|----------|-----------|------|--------------|
| | | | /M | /H | |
| Current Density (A/cm ²) | 70 | 400 | 400 | 400 | 1200 |
| Acceleration Voltage(kV) | 50 | 50 | 50 | 50 | 50 |
| Max shot size(um) | 0.8 | 0.35 | 0.5 | 0.35 | 0.25 |
| smallest field size(um) | 32 | 10 | 10 | 10 | 0.6 |
| Positioning Accuracy | | | | | |
| Image placement (nm, 3σ) | 8 | 4.3 | 6 | 4.3 | 1.8 |
| Overlay (nm, 3σ) | 7 | 4.3 | 6 | 4.3 | 1.8 |
| CD Accuracy* | | | | | |
| Local uniformity (nm, 3σ) | 2.5 | 1.3 | 2.5 | 1.3 | 1.3 |
| Difference (X-Y) (nm, 3σ) | 2.0 | 1.4 | 2.0 | 1.4 | 1.4 |

Conclusion

- EBM-8000P is ready for sale.
 - 1st tool was already shipped to a customer.
 - Received several purchase orders.
 - Receiving many inquiries.
 - Reasonable pricing with high productivity.
 - Standard lead-time is 12 months ARO.

NuFlare Technology, Inc.