



Developing Electron Beam Lithography at Nanoscale Device Laboratory

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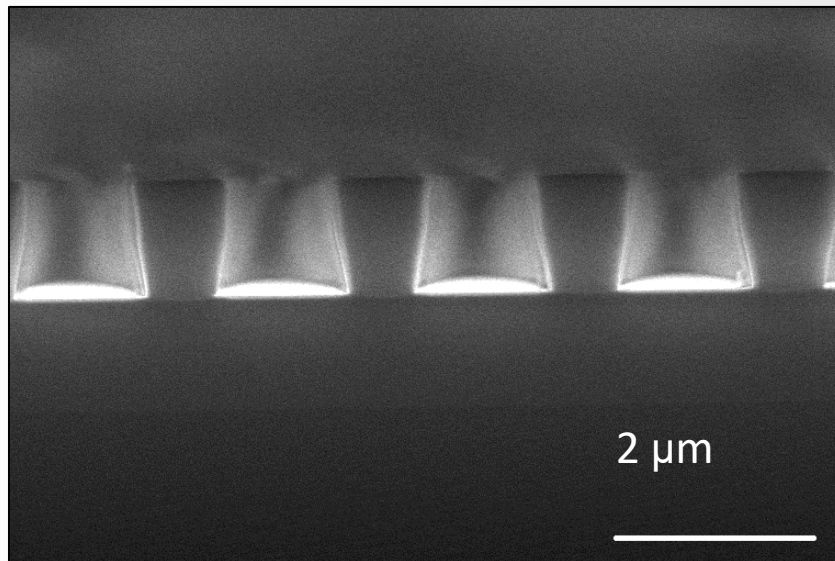
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T.-C. Shen (Mentor)

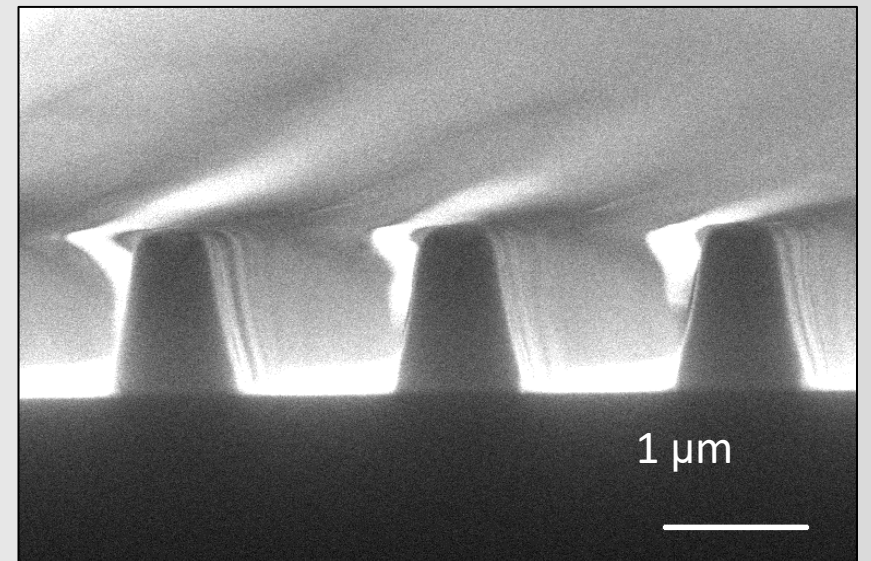
Why Electron Beam Lithography (EBL)?

Photolithography is limited by optical resolution. The minimal linewidth of a broadband mask aligner is >800 nm.

Negative Photoresist

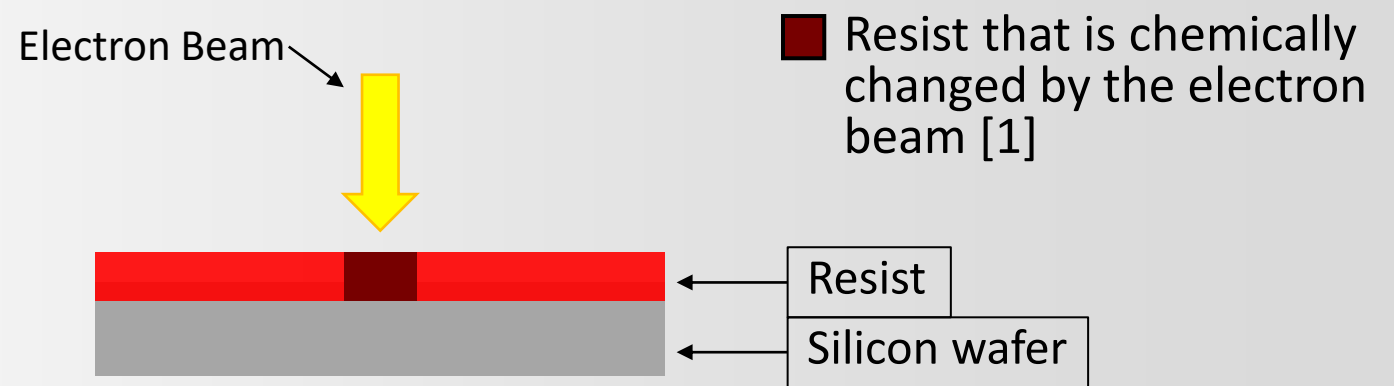
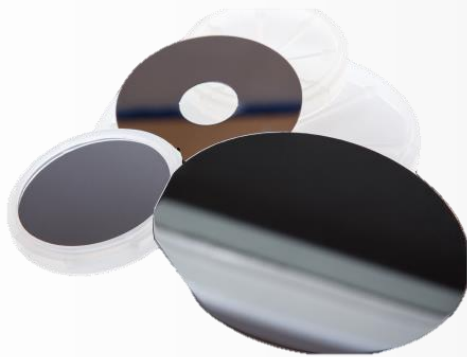


Positive Photoresist



Basics of Electron Beam Lithography

Electron beam lithography (EBL) is a lithography method used to create pattern sizes of ~ 50 nm linewidth.

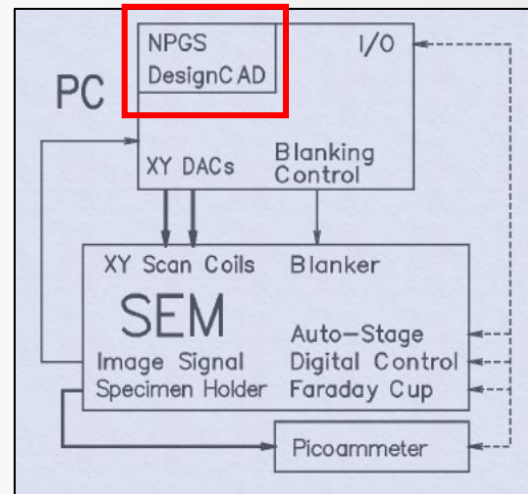


EBL employs a beam of electrons from either a e-beam writer or an adapted scanning electron microscope (SEM).

Nano Pattern Generation System (NPGS)

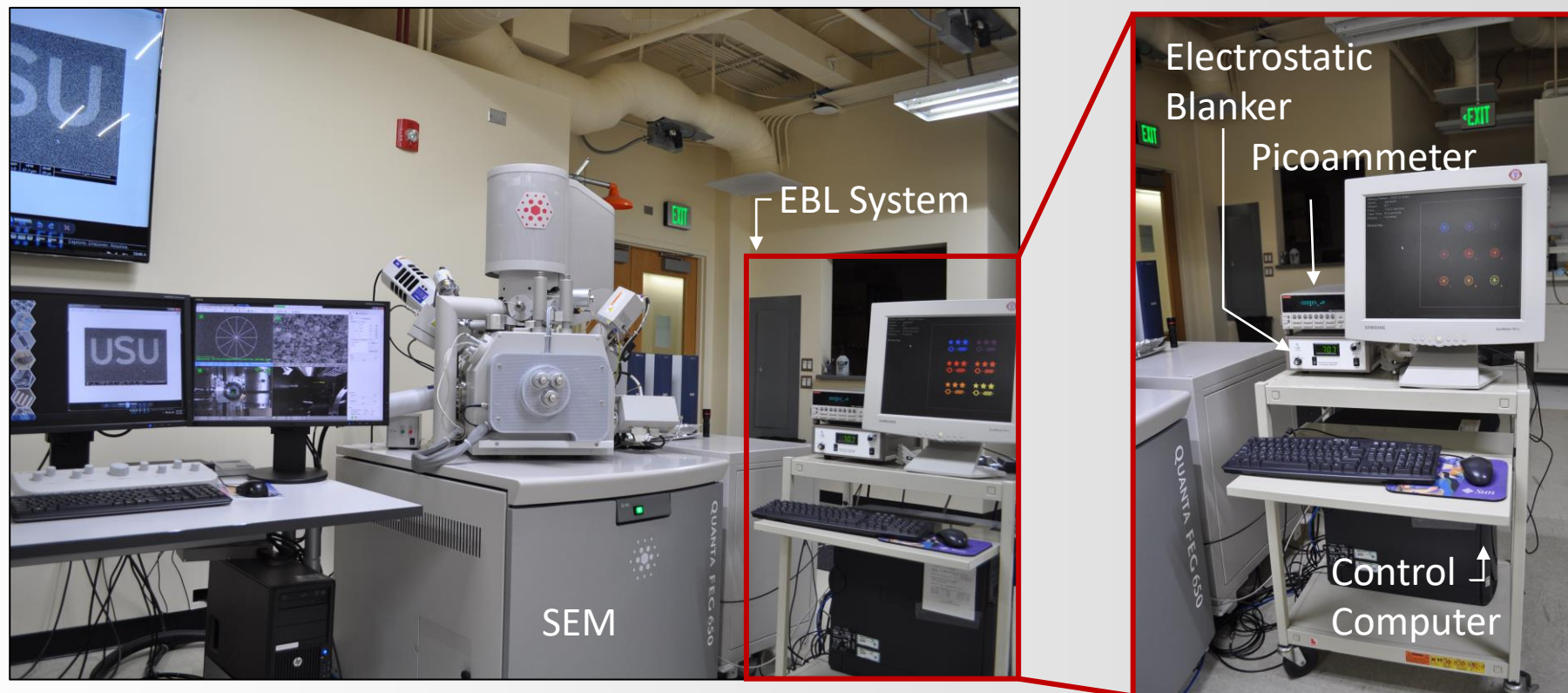
NPGS is a lithography system developed by Joe Nability in 1988 [2]. NPGS is the system that allows us to perform EBL using a commercial SEM.

Hardware overview of the NPGS setup. The red square highlights the NPGS system (right) [3]



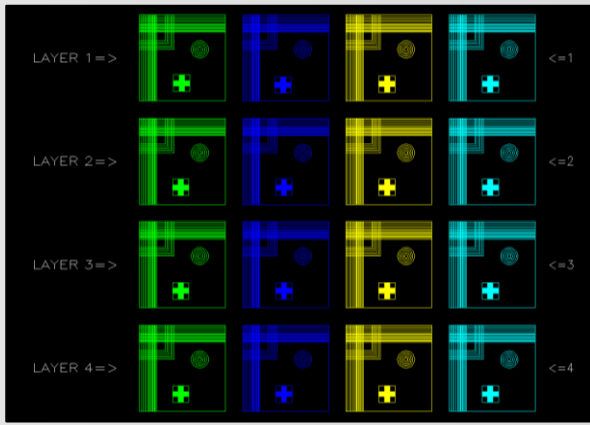
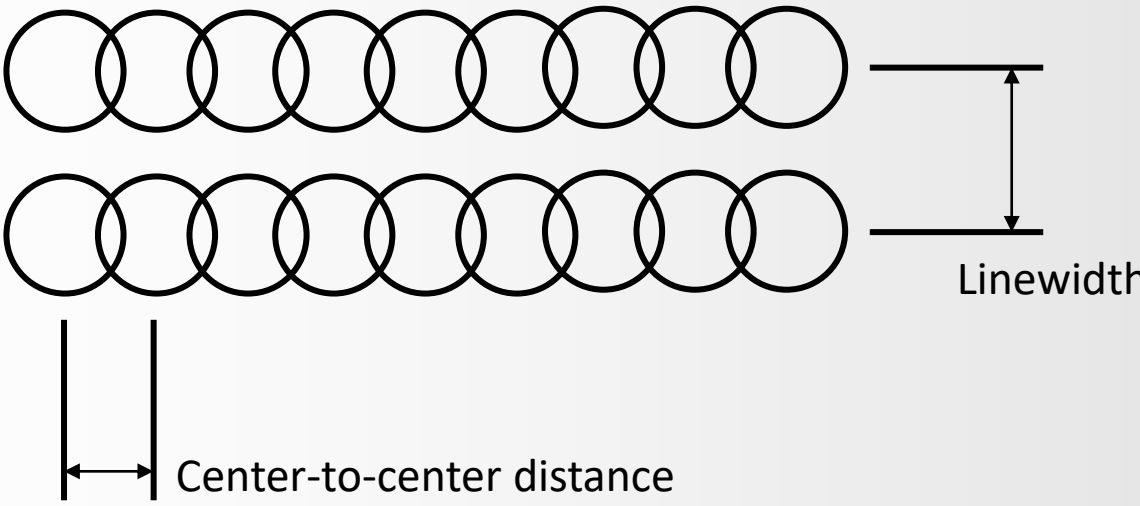
The object of this research is to integrate NPGS with a Quanta 650 SEM to achieve very fine lithography of 50 nm linewidth.

EBL System at USU



Pattern Design with DesignCAD

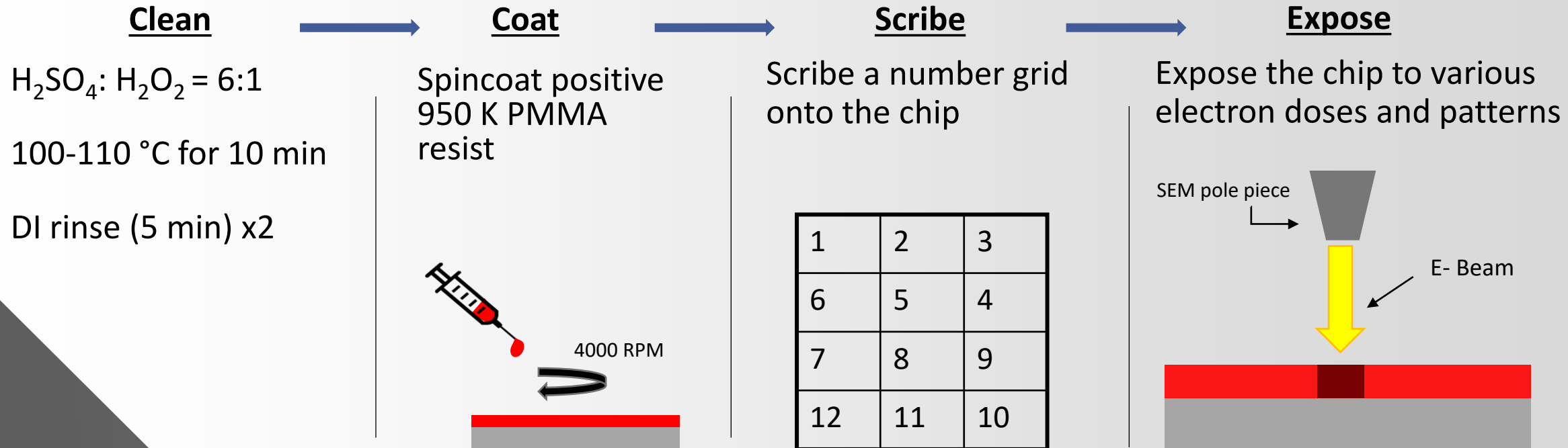
DesignCAD is a program that allows us to make patterns so that it may be written by the SEM. An important takeaway is the difference between linewidth and center-to-center distance.



An exposure test pattern design

Sample Preparation and EBL

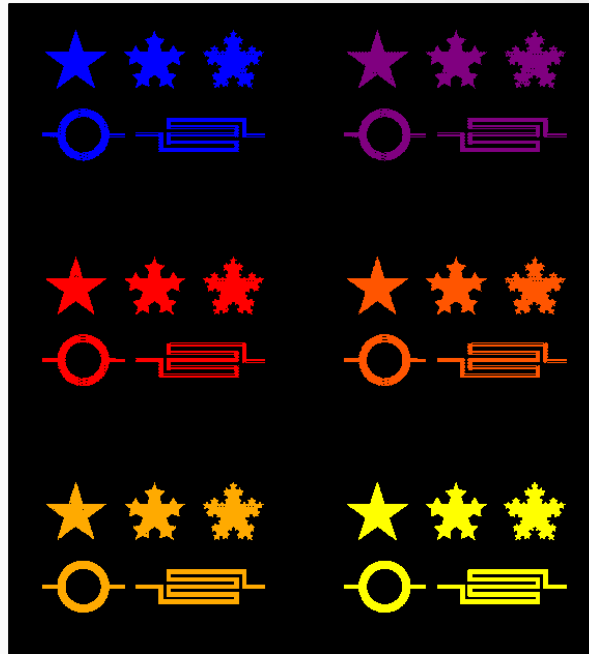
Before a pattern can be written, a silicon piece must be prepared first.



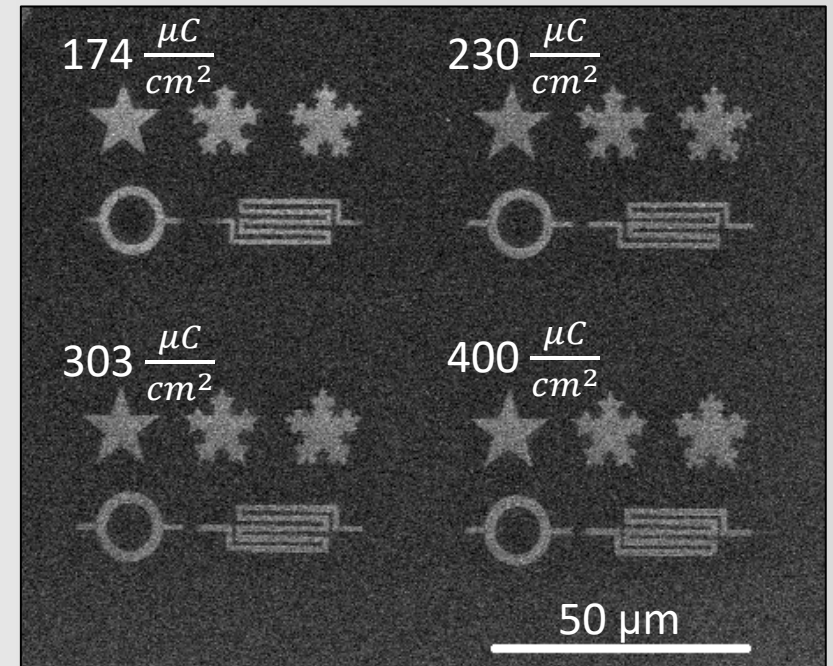
Development

MIBK : Isopropanol = 1:3 for 1.5 min

Isopropanol rinse



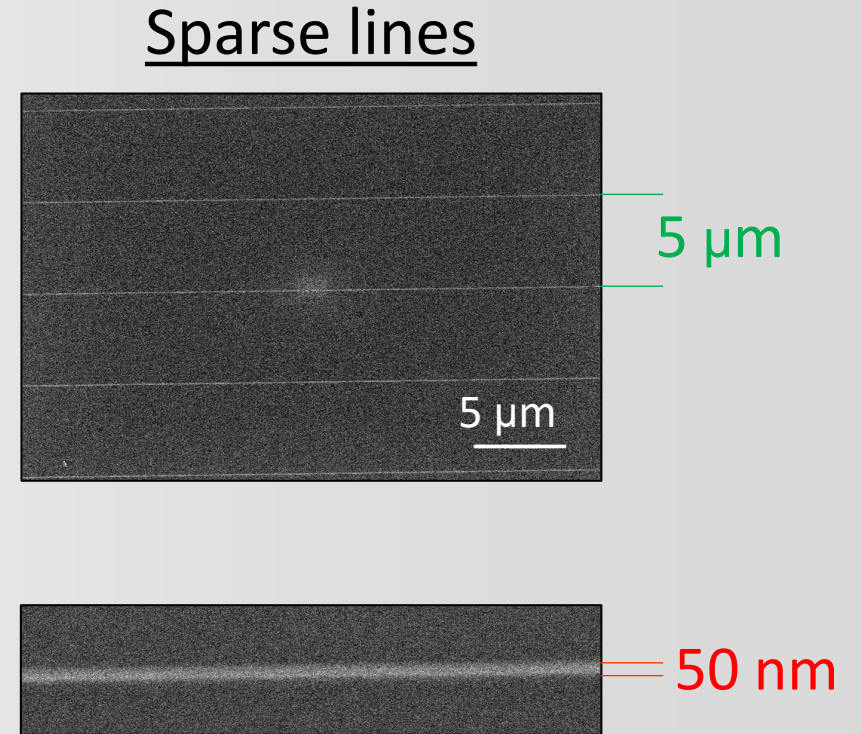
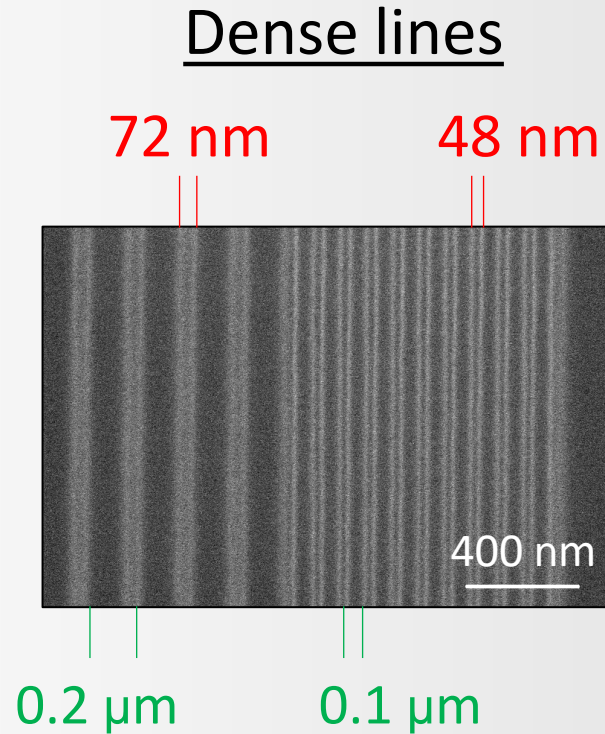
Pattern design



Pattern written

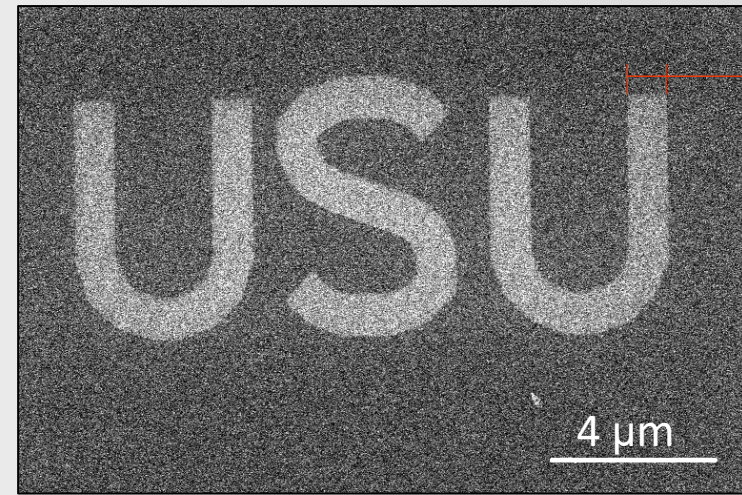
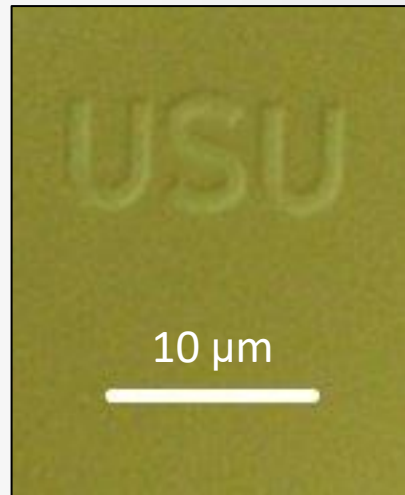
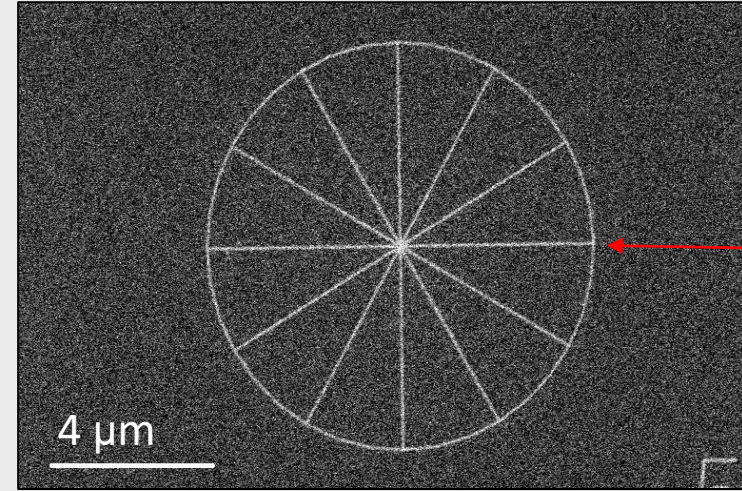
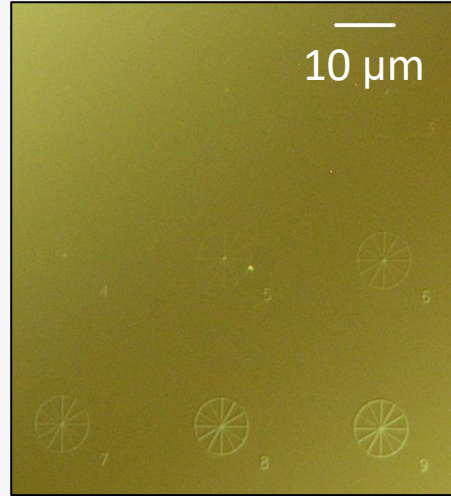
Proximity Effect

Back scattered electrons from nearby lines can effectively increase the line dose from the design of an isolated line.



Charging effect from PMMA deteriorates SEM focusing so the linewidth is not accurate.

Image Gallery



Conclusions

- We have rebuilt a computer with NPGS software, established communication with the SEM, written and developed PMMA patterns on Si with linewidth ~ 50 nm.
- We observed proximity effect of EBL. More study will continue to establish the writing conditions with various resist and patterns.
- Need to develop bi-layer liftoff and etch process with PMMA to create metal patterns on Si to facilitate more accurate linewidth measurements.
- It is important to develop a process to integrate photolithography with EBL to build patterns from microns to nanometers for research.

Acknowledgements

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References

- [1] Berčič, B. (2006). Introduction to Electron Beam Lithography. Jožef Štefan Institute.
- [2] Nability, J. C. (2021). NPGS overview. Retrieved from <https://www.jcnability.com/overview.htm>
- [3] Nability, J. C. (2010, May). Nanometer Pattern Generation System User's Manual for NPGS v9 [PDF]. Bozeman: J.C. Nability Lithography Systems.