Scanning-Electron-Beam Lithography

Personnel

M. Mondol, J. Goodberlet and H. I. Smith

Sponsorship

NSF, DARPA, and ARO

Figure 3 is a photograph of the scanning-electron-beam lithography system (VS-2A) located in the Scanning-Electron-Beam Lithography (SEBL) facility, Room 38-165. This instrument was obtained as a donation from IBM in 1993. Its digital pattern generator is based on a commercial high-performance array processor, which uses dual RISC processors. The system is capable of creating large-area patterns composed of multiple stitched fields. Conversion software has been developed which allows a CAD data file to be fractured and translated prior to exposure by the electron-beam tool. The VS-2A can expose substrates up to 20 cm diameter, at linewidths down to 70 nm. In order to write concentric circular patterns, such as Freznel zone plates, software was developed to generate arbitrary arcs of an annulus with user-specified start and finish radii and angles.

We recently received from IBM the VS-6 SEBL system, whose electron-optical column provides a beam diameter of approximately 15 nm. We are in the process of installing the VS-6 column on the VS-2A chamber. This hybrid VS2/6 system should enable us to write sub 50 nm patterns on substrates up to 20 cm in diameter.

The SEBL facility also houses a Raith Turnkey 150 system as shown in Figure 4. Its electron-optical column is essentially identical to that of a Gemini SEM, and provides a beam diameter as fine as 5 nm. Linewidths of 17 nm have been written with the system as illustrated in Figure 5.

The goals of the SEBL facility are to: (1) provide the MIT research community with an in-house SEBL capability for writing directly on experimental device substrates; (2) advance the state-of-the-art in SEBL, particularly with regards to pattern placement accuracy and long-range spatial-phase coherence; and (3) pattern X-ray nanolithography masks for in-house use.

The VS2A is heavily used in a variety of projects, both mask making and direct write. These have included: 3-D, 2-D, and 1-D photonic bandgap structures; optical-communication filters; arrays of Fresnel zone plates; electrical contacts to bismuth nanowires; high-density magnetic nanodots for information storage; distributed-feedback lasers; sub-100 nm electronic devices; dual-gate sub-100nm MOSFETs; diffractive optical elements; and magnetic random access memory devices. Masks have been made for X-ray nanolithography and intimate-contact photolithography.

Both VS-2A and the Raith 150 are used in a program to develop spatial-phase-locked e-beam lithography. The objectives of this program are to achieve sub-1 nm pattern-placement accuracy, and to reduce the cost and complexity of SEBL. In a conventional SEBL system costing several million dollars pattern placement accuracy is typically much worse than 10 nm.

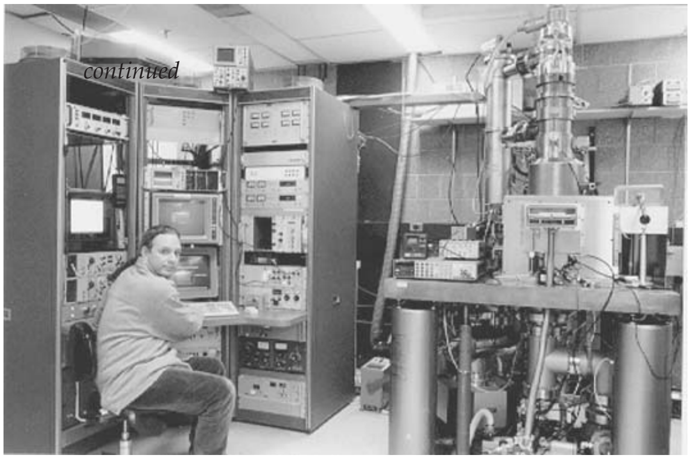
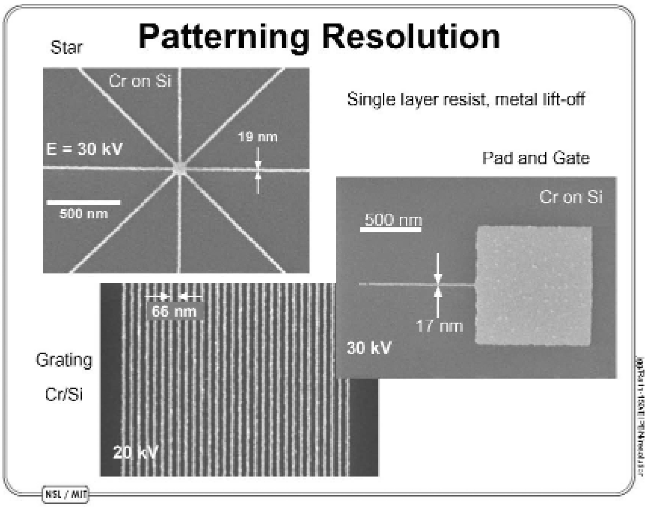


Fig. 3: Photograph of the VS-2A scanning-electron-beam lithography system. The operator is Research Specialist Mark Mondol.

continued

Fig. 3: The Raith-150 electron-beam lithography system. This tool provides sub-20-nm patterning resolution, and will be used to demonstrate nanometer pattern-placement accuracy via spatial phase locking. The operator is graduate student J. Todd Hastings.



Patterning Resolution

Single layer resist, metal lift-off

Fig. 5: Scanning electron micrography illustrating the resolution of the Raith 150 SEBL system.