In the forefront of nanotechnology development, NASA´s Jet Propulsion Laboratory in Pasadena, Calif., has acquired one of the world´s finest electron beam lithography systems, one that will allow researchers to work on the sub-molecular scale.

For NASA, this means breakthroughs in miniaturization that could lead to significant reductions in mass and cost of spacecraft to look for traces of life on distant planets. For researchers, it means access to one of only three such systems in the world, and the only one in the public sector devoted to pure research for building the nano-scale devices of the future.

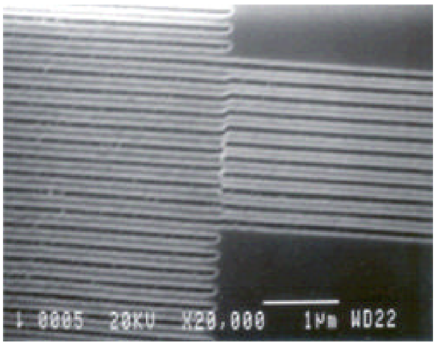
The enabling tool for nano-lithography at JPL is the JEOL JBX-9300FS electron beam lithography system shown in the photo below. This state-of-the-art system is housed in JPL's Microdevices Laboratory, a 38,000-square-foot facility that includes cleanrooms for device processing, material deposition, and conventional laboratories for characterization. The operating specifications of the 9300FS E-beam tool are listed in Table I. Using the JEOL JBX-9300FS and its predecessor the JEOL JBX-5DII, JPL has been developing expertise in electron-beam lithography for over 15 years. This expertise has benefited many projects at JPL, NASA, and collaborating laboratories and commercial companies. Shown below are some images of E-beam fabricated nanoscale patterns and device structures for JPL's Bio-Nano Technology Program. In addition to binary nanolithography, we have developed analog-dose E-beam lithography techniques that enable fabrication of three-dimensional surface profiles with sub-100 nm depth control (see image of diffractive optic). Such 3D profiles can be fabricated on non-flat substrates (convex/concave) with up to 3.5 mm of height variation (see image of convex grating).

U.S. parties interested in using the system should send e-mail to Daniel.W.Wilson@jpl.nasa.gov.

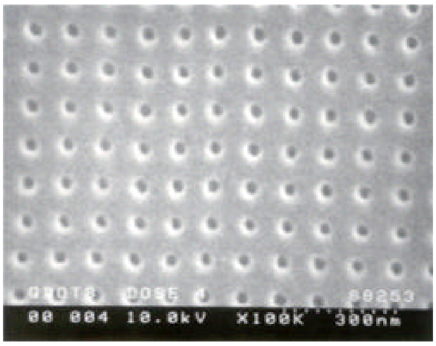
Parameter	JEOL JBX-9300FS	
Voltage	100 kV	50 kV
Minimum Spot Size	4 nm	7 nm
Beam Current for 100 nm spot	175 nA	125 nA
10 nm spot	10 nA	4 nA
Field Size	500 µm	1000 µm
Writing Grid	1 nm	2 nm

Field Stitching Accuracy	20 nm
Write Area	9 inch square
Wafer Size	12 inch diameter
Electron Source	ZrO/W Field Emission Gun
Deflection System	Dual Deflector Low-speed 19-bit DAC High-speed 12-bit DAC Dynamic focus Dynamic astigmatism
Fine-Pitch Control	±5%
Height Control	White-light measurement Auto-correction direct-write, ±0.2 mm Manual via Jobdeck, ±1.75 mm
Cabling	Ethernet
Computer Control	3 Internal DEC Alpha CPUs

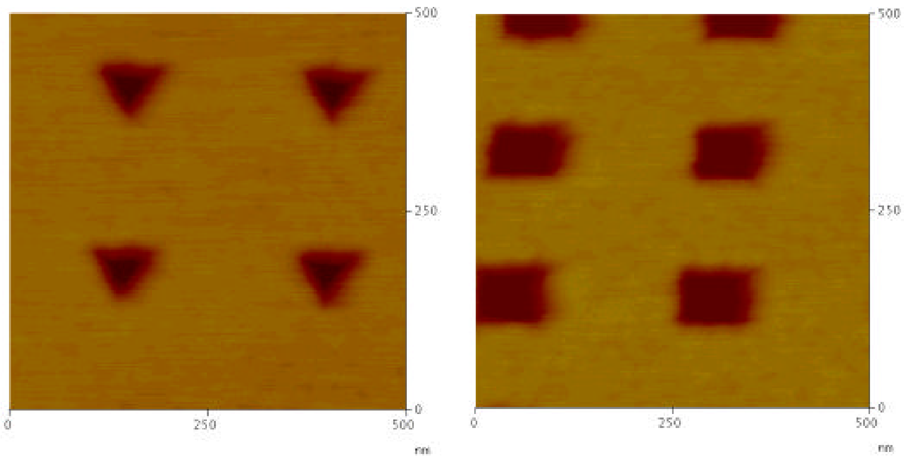
Examples of E-beam Nanolithography



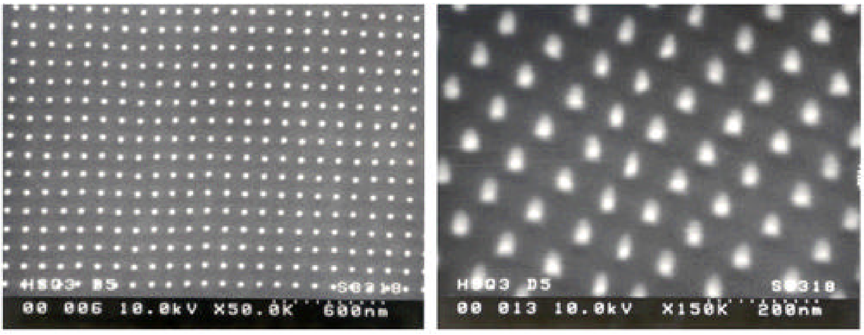
Vernier patterns demonstrating consistent sub-20 nm E-beam field stitching across a wafer



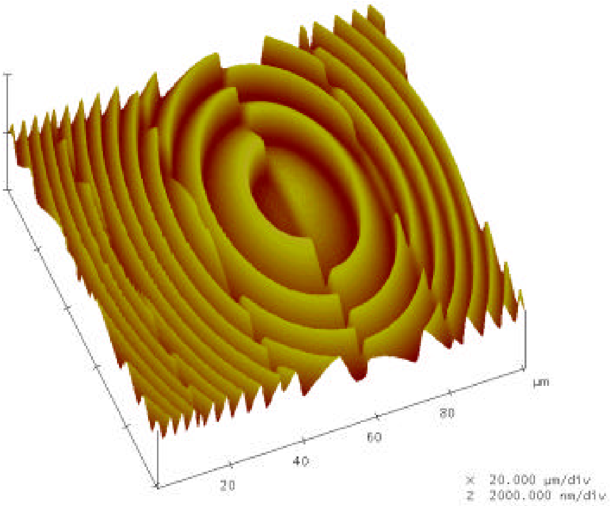
Holes in ZEP-520 positive resist, sub-30 nm diameter



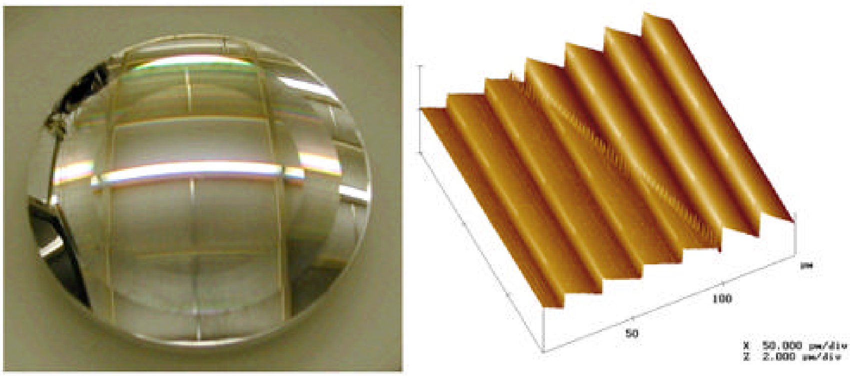
Shaped holes in ZEP-520 resist, sub-100 nm in size



Dots in FOx-12 (HSQ) negative resist, 25 nm diameter x 70 nm tall



Diffractive optic fabricated by analog-dose E-beam lithography, depths are controlled to sub-100 nm precision and lateral pattern is composed of 200 nm pixels.



High-efficiency dual-sawtooth-blaze diffraction grating fabricated by direct-write E-beam lithography on a convex substrate. Similar gratings have been delivered for use in the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) instrument that is scheduled to fly on the NASA Mars Reconnaissance Orbiter in 2005.