The Latest Development of Electron Beam Lithography as a Tool for Nanotechnology

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Why e-beam lithography?

- Highest resolution (< 5nm)
- Large substrate size (6” wafer)
- Multi-level patterning (alignment error <20nm)
- Reasonably high throughput
- High flexibility
- Fast prototyping

What are the alternatives?

- STM/AFM lithography (low throughput, small substrate size)
- X-ray lithography (need masks, high investment)
- Nanoimprint (need masters, crude alignment)
- Optical lithography (need mask, >50nm resolution)
The available tools:

- Commercial e-beam lithography systems
  - VB6-HR
  - Raith 150
  - LION-LV1
  - JEOL JBX9300FS
The capability:

- 30nm line by VB6 (Z.Cui, RAL, 1998)
- 150nm lines over 6” wafer by VB6 (Z.Cui, RAL, 1999)
- 5-7nm lines by non-commercial e-beam system (W.Chen, Cambridge University, 1997)
- 4nm line by non-commercial e-beam system (S.Yasin, Cambridge University, 2001)
- 20nm lines by VB6 (Y.Chen, RAL, 2003)
- 30nm holes by VB6 (Y.Chen, RAL, 2003)
The applications:

- Nanoelectronics
  - Nano MOSFET, single electron transistor, microwave device
- Nano devices based on carbon nano tubes
- Nano magnetic device for high density information storage
- Making master tools for nanoimprinting
- Nano surface modification for molecule self assembly
- Making nano electrode – connect nano world to micro and macro world
HEMT for >100GHz microwave circuits, where the 30nm T-gates are fabricated by e-beam lithography

J. Kretz, L. Dreeskornfeld

Y. Chen, D. Edgar, X. Li, D. Machintyre, S. Thoms

C.S. Wu, C.D. Chen, et al
• Place nanotubes to electrodes:

Electrode made by e-beam lithography, leaving 25nm gap

Two strands of bundled single-wall nanotubes bridge the nanoelectrode gap, inset is the I-V plot


• Place electrodes to nanotubes:

• Conventional magnetic recording devices rely on e-beam lithography to reduce dimension, therefore, increase storage density

Magnetic ring elements by e-beam lithography and dry etching for high density storage device

I. Maximov, E.-L. Sarwe, M. Beck, K. Deppert, M. Graczyk, M.H. Magnusson, L. Montelius

• Nanoimprinting relies on high resolution e-beam lithography to make the imprint master stamps

- Electron beam induced surface modification provides patterned sites for molecule self assembly.

G. Kaltenpoth, B. Voelkel, C. T. Nottbohm, and A. Goelzhauser

“Electrode modification by electron-induced patterning of self-assembled monolayers”
- Making connections between nano-world and micro/macro world

electrodes made by high resolution e-beam lithography and metal deposition, H. Jeong, Purdue University, 2000
The Conclusion:

Nanotechnology

Nanostructuring

Top-down | Bottom-up

E-beam lithography

Etching, coating or growing

Functional nanodevices and structures