Electron Beam Lithography Simulator

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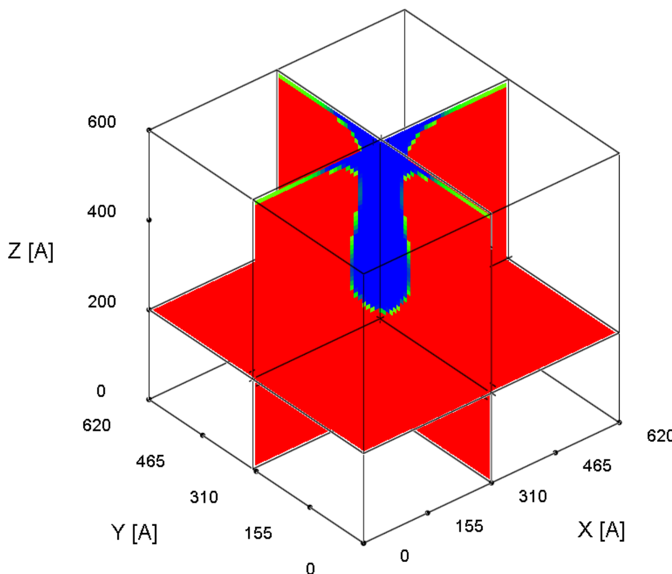
EBL Simulator is a novel tool for the prediction, visualization and analysis of electron beam lithography of features ranging from a few nanometers to the micro-scale. The simulator provides 3D modelling with one nanometer resolution for e-beam exposure fragmentation as well as for development profiles in common positive tone resists PMMA and ZEP.



EBL Simulator is helpful in:

- Providing insights into the EBL processes through detailed modeling
- Training students and staff
- Rational design of EBL nano-fabrication processes

Operating systems supported: Windows

Unique features

- Resist main-chain scission by electron beam exposure and the kinetic process of development modelling with single nanometer resolution.
- Detailed 3D scission yield distribution and dissolution profiles for PMMA and ZEP resists on various substrates.
- Engineered based on the latest studies on electron beam exposure and development of positive tone resists [1-8].
- Diverse EBL fabrication conditions for custom-designed exposure patterns can be modelled with control of over 30 simulation parameters.
- User-friendly windows design, extensive default settings, built-in help tool, and detailed case-study manual guide the user through sequential steps of writing pattern design, exposure and development setups.
- Powerful plotting tool allows visualization of the 3D distributions of scission yield, development profiles, and other simulation results. 2D cross-sections and 1D graphs can also be visualized.

Selected publications

[1] M. Aktary, M. Stepanova, and S. K. Dew, *J. Vac. Sci. and Technol. B* 24 (2006) 768-779.

[2] M.A. Mohammad, T. Fito, J. Chen, S. Buswell, M. Aktary, M. Stepanova, and S.K. Dew, *J. Vac. Sci. Technol. Letters* 28 (2010) L1-L4.

[3] M.A. Mohammad, T. Fito, J. Chen, S. Buswell, M. Aktary, M. Stepanova, and S.K. Dew, *Microelectronic Engineering* 87 (2010) 1104-1107.

[4] M.A. Mohammad, T. Fito, J. Chen, S. Buswell, M. Aktary, S.K. Dew, and M. Stepanova, in: Lithography, Michael Wang (Ed.), ISBN: 978-953-307-064-3, (INTECH, 2010, Chapter 16) Available from: http://www.intechopen.com/books/lithography.

[5] M. Stepanova, T. Fito, Zs. Szabó, K. Alti, A. P. Adeyenuwo, K. Koshelev, M. Aktary, and S. K. Dew, *J. Vac. Sci. Technol. B* 28 (2010) C6C48.

[6] M.A. Mohammad, C. Guthy, S. Evoy, S.K. Dew, and M. Stepanova, *J. Vac. Sci. Technol. B* 28 (2010) C6P36.

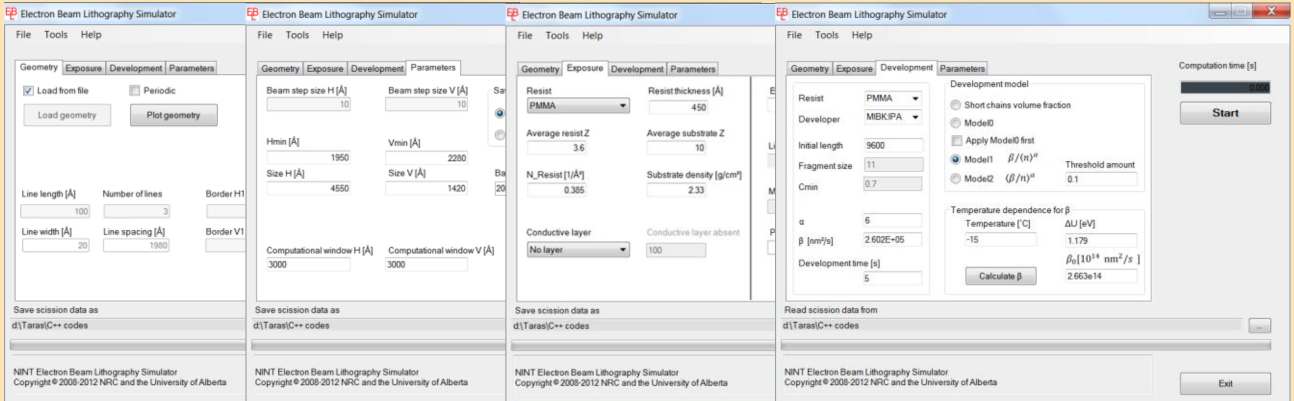
[7] K. Koshelev, M.A. Mohammad, T. Fito, K.L. Westra, S.K. Dew, and M. Stepanova, *J. Vac. Sci. Technol. B* 29 (2011) 06F306.

[8] M.A. Mohammad, K. Koshelev, T. Fito, D. Ai Zhi Zheng, M. Stepanova, and S.K. Dew, *Jpn. J. Appl. Phys.* 51 (2012) 06FC05.

[9] R. Peters, T. Fito, L. Gutierrez-Rivera, S.K. Dew, and M. Stepanova, *J. Vac. Sci. Technol*. B 31, (2013) 06F407.

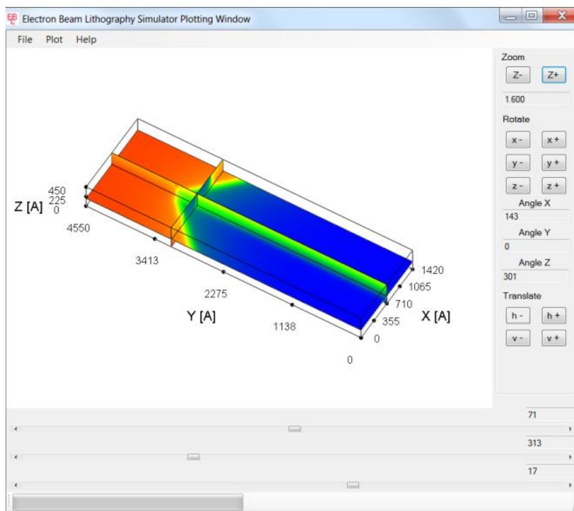
Graphical user interface

Four main tabs (Geometry, Exposure, Development, and Parameters) and other tools allow for easy parameter settings, simulation and analysis of EBL process.



Electron beam exposure

Simulations of the main chain scission yield by electron impact in PMMA and ZEP resists are supported. Individual patterns and periodic arrays of arbitrary shapes are handled with full accounting for forward and backscattering of electrons,
and for secondary electrons generation.



Variable exposure conditions include:

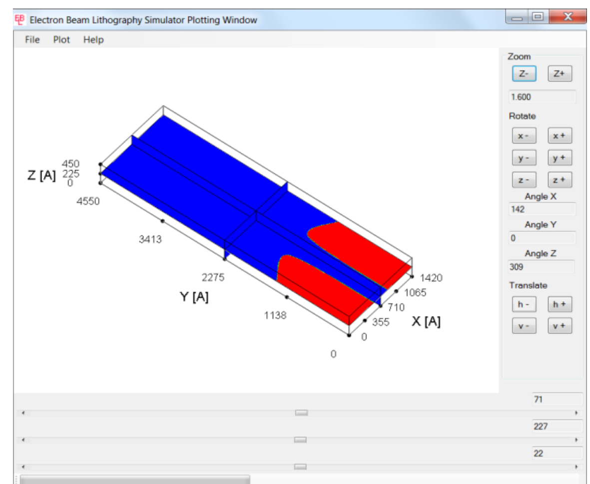
- Geometry of writing pattern;
- Exposure energy in 1-100 keV regimes;
- Line, area or point dose;
- Resist thickness;
- Substrate material;
- Optional conductive layer.

Development profiles

Resist 3D development profiles are provided by kinetic modeling of the dissolution process.

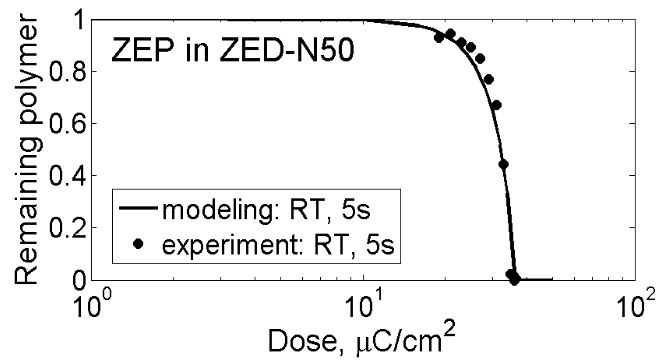
Variable development conditions include:

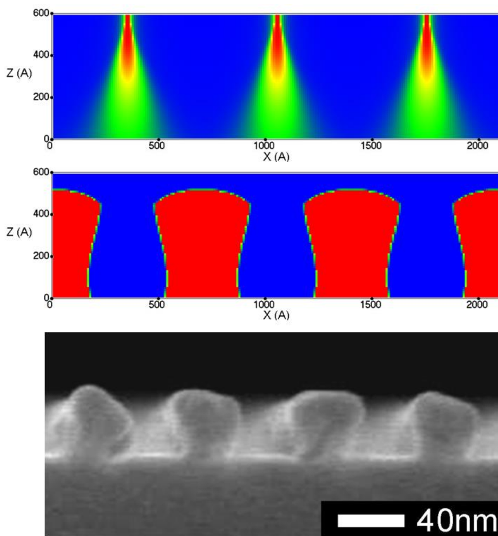
- A selection of 2 developers for each resist;
- Development time;
- Development temperature;
- Diffusion rate parameters.

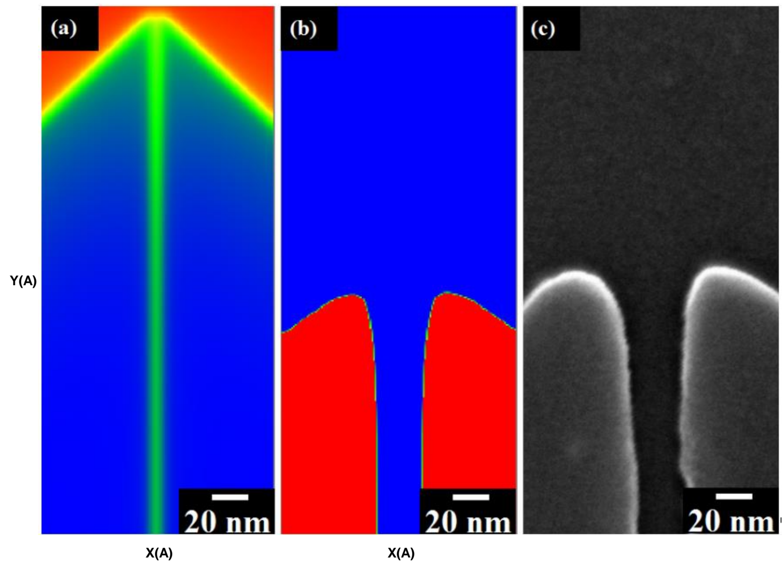


Validation

Outputs of EBL Simulator have been validated against scanning electron microscopy images and contrast curves of exposed and developed PMMA and ZEP resists [5-8].







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