

# Journal Papers on PYRAMID Project

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1. S.-Y. Lee, "Analytic Study of Exposure Contrast over Feature Edge in Electron-beam Lithography," *J. Vac. Sci. Technol.*, B41(6), 062606, Nov/Dec 2023.
2. S.-Y. Lee and M. N. Hasan, "Generalized Performance Optimization for Massively-Parallel Electron-beam Systems," *J. Vac. Sci. Technol.*, B41(4), 042603, Jul/Aug 2023.
3. M. N. Hasan, S.-Y. Lee, B.-S. Ahn, J. Choi and J.-S. Park, "Reduction of Exposing Time in Massively-Parallel Electron-beam Systems," *J. Vac. Sci. Technol.*, B40(3), 032602, Nov/Dec 2022.
4. D. Li, S.-Y. Lee, J. Choi, S.-B. Kim, and C.-U. Jeon, "Estimation of Critical Dimension and Line Edge Roughness using a Neural Network," *J. Vac. Sci. Technol.*, B39(3), 032602, May/Jun 2021.
5. D. Li, S.-Y. Lee, J. Choi, S.-B. Kim, and C.-U. Jeon, "3D Modeling of Electron-beam Lithographic Process from Scanning Electron Microscope Images," *J. Vac. Sci. Technol.*, B 39(1), 012603, Jan/Feb 2021.
6. M. N. Hasan, S.-Y. Lee, B.-S. Ahn, J. Choi and J.-S. Park, "Effectiveness of Multipass and Multirow Writing Methods for Massively-Parallel Electron-beam Systems," *J. Vac. Sci. Technol.*, B38(6), 062601, Nov/Dec 2020.
7. M. N. Hasan, S.-Y. Lee, B.-S. Ahn, J. Choi and J.-S. Park, "Shape and Dose Control for Proximity Effect Correction on Massively-Parallel Electron-beam Systems," *J. Vac. Sci. Technol.*, B38(6), 062603, Nov/Dec 2020.
8. M. N. Hasan, S.-Y. Lee, B.-S. Ahn, J. Choi, S.-B. Kim, and C.-U. Jeon, "Effects of Abnormal Beams on Writing Qualities in Massively-Parallel Electron-Beam Systems," *J. Vac. Sci. and Technol.*, B37(6), 061609, Nov/Dec 2019.
9. S.-Y. Lee, B.-S. Ahn, J. Choi, S.-B. Kim, and C.-U. Jeon, "Multirow Writing Method for Massively-Parallel Electron-Beam Systems," *J. Vac. Sci. and Technol.*, B37(6), 061602, Nov/Dec 2019.
10. H. Ji and S.-Y. Lee, "Designing an Anisotropic Noise Filter for Measuring Critical Dimension and Line Edge Roughness from Scanning Microscope Images," *J. Vac. Sci. and Technol.*, B36(6), 06JA06, Nov/Dec 2018.
11. S.-M. Moon, S.-Y. Lee, J. Choi, S.-B. Kim, I.-K. Shin, and C.-U. Jeon, "Effects of Lithographic Parameters in Massively-parallel Electron-beam Systems," *J. Vac. Sci. and Technol.*, B36(6), 06JA03, Nov/Dec 2018.

12. H. Ji, S.-Y. Lee, J. Choi, S.-B. Kim, I.-K. Shin, and C.-U. Jeon, "Effects of Stochastic Exposure on Critical Dimension in Electron-beam Lithography," *J. Vac. Sci. and Technol.*, B35(6), 06G503, Nov/Dec 2017.
13. D. Li, R. Guo, S.-Y. Lee, J. Choi, S.-H. Park, S.-B. Kim, I.-K. Shin, and C.-U. Jeon, "Noise Filtering for Accurate Measurement of LER and CD from SEM images," *J. of Vac. Sci. and Technol.*, B34(6), 60K604, Nov/Dec 2016.
14. R. Guo, S.-Y. Lee, J. Choi, S.-H. Park, I.-K. Shin, and C.-U. Jeon, "Analytic Estimation of LER for Large-Scale Uniform Patterns in Electron-beam Lithography," *J. of Vac. Sci. and Technol.*, B34(6), 60K605, Nov/Dec 2016.
15. R. Guo, S.-Y. Lee, J. Choi, S.-H. Park, S.-B. Kim, I.-K. Shin, and C.-U. Jeon, "A Practical Approach to Modeling Scanning Electron Microscope Images for Minimization of Line Edge Roughness and Critical Dimension Error," *J. of Vac. Sci. and Technol.*, B34(1), 011601, Jan/Feb 2016.
16. R. Guo, S.-Y. Lee, J. Choi, S.-H. Park, I.-K. Shin, and C.-U. Jeon, "Analytic Derivation and Minimization of Line Edge Roughness in Electron-beam Lithography," *J. of Vac. Sci. and Technol.*, B 33(6), 06FD07-1, Nov/Dec 2015.
17. X. Zhao, S.-Y. Lee, J. Choi, S.-H. Lee, I.-K. Shin, B.-G. Kim, C.-U. Jeon and H.-K. Cho, "Dependency Analysis of Line Edge Roughness in Electron-beam Lithography," *Microelectronic Engineering*, 133, 78-87, 2015.
18. Q. Dai, R. Guo, S.-Y. Lee, J. Choi, S.-H. Lee, I.-K. Shin, B.-G. Kim, C.-U. Jeon and H.-K. Cho, "A Fast Path-based Method for 3-D Resist Development Simulation in Electron-beam Lithography," *Microelectronic Engineering*, 127, 86-96, 2014.
19. X. Zhao, S.-Y. Lee, J. Choi, S.-H. Lee, I.-K. Shin and C.-U. Jeon, "Minimization of Line Edge Roughness and CD Error in Electron-beam Lithography," *J. Vac. Sci & Technol.*, B32, 06F505, 2014.
20. X. Zhao, Q. Dai, S.-Y. Lee, J. Choi, S.-H. Lee, I.-K. Shin and C.-U. Jeon, "Determination and Analysis of Minimal Dose for Achieving Vertical Sidewall in Electron-beam Lithography," *J. Vac. Sci & Technol.*, B32, 06F508, 2014.
21. S.-Y. Lee, J. Choi, S.-H. Lee, I.-K. Shin, C.-U. Jeon, and S.-C. Jeon "Experimental Verification of Achieving Vertical Sidewall for Nanoscale Features in Electron-beam Lithography," *J. Vac. Sci & Technol.*, B32, 06F510, 2014.
22. R. Guo, S.-Y. Lee, J. Choi, S.-H. Lee, I.-K. Shin, B.-G. Kim, C.-U. Jeon and H.-K. Cho, "Analytic Model of Line Edge Roughness from Stochastic Exposure Distribution in Electron-beam Lithography," *J. Vac. Sci & Technol.*, B31(6), 06F408, Nov/Dec 2013.
23. X. Zhao, S.-Y. Lee, S.-H. Lee, B.-G. Kim and H.-K. Cho, "Fast Simulation of Stochastic Exposure Distribution for LER Study," *J. Vac. Sci & Technol.*, B30(6), November/December 2012.
24. Q. Dai, S.-Y. Lee, S.-H. Lee, B.-G. Kim and H.-K. Cho, "New Types of Dose Distributions for Vertical Sidewall Minimizing Total Dose in Electron-beam Proximity Effect Correction of Nanoscale Features," *J. Vac. Sci & Technol.*, B30(6), November/December 2012.

25. Q. Dai, S.-Y. Lee, S.-H. Lee, B.-G. Kim, and H.-K. Cho, "Experiment-based Estimation of Point Spread Function in Electron-beam Lithography," *Microelectronic Engineering*, 88(10), pp.3054-3061, 2011.
26. Q. Dai, S.-Y. Lee, S. H. Lee, B.-G. Kim and H.-K. Cho, "Estimation of Resist Profile for Line/Space Patterns using Layer-based Exposure Modeling," *Microelectronic Engineering*, 88(6), pp.902-908, 2011.
27. D. Liu, S. Morshed, B. Zhou, B. Prorok, and S.-Y. Lee, "Fabrication of Polynomial 3-D Nanostructures in Si with a Single-Step Process," *Journal of Micro-Nanolithography, MEMS, and MOEMS (JM3)* 10 (1), 010501, 2011.
28. S.-Y. Lee, Q. Dai, S.-H. Lee, B.-G. Kim, and H.-K. Cho, "Enhancement of Spatial Resolution in Generating Point Spread Functions by Monte Carlo Simulation in Electron-beam Lithography," *J. Vac. Sci & Technol.*, B29(6), November/December 2011.
29. Q. Dai, S.-Y. Lee, S.-H. Lee, B.-G. Kim, and H.-K. Cho, "Three-dimensional Proximity Effect Correction for Large-scale Uniform Patterns," *J. Vac. Sci & Technol.*, B29(6), November/December 2011.
30. Nak H. Kim and S.-Y. Lee, "Vision-based Approach to Automated Analysis of Structure Boundaries in Scanning Electron Microscope Images," *J. Vac. Sci & Technol.*, B29(1), January/February 2011.
31. P. Li, S.-Y. Lee, S. C. Jeon, J. S. Kim, K. N. Kim, M. S. Hyun, J. J. Yoo, and J. W. Kim, "Step Width Adjustment in Fabrication of Staircase Structures," *J. Vac. Sci & Technol.*, B28(1), pp.30-35, January/February 2010.
32. S.-Y. Lee, S. C. Jeon, J. S. Kim, K. N. Kim, M. S. Hyun, J. J. Yoo, and J. W. Kim, "Spatial Dose Control for Fabrication of Saw-tooth Structures," *J. Vac. Sci & Technol.*, B27(6), pp.2580-2584, November/December 2009.
33. C. Guo, S.-Y. Lee, S. H. Lee, B.-G. Kim and H.-K. Cho, "Application of Neural Network to E-beam Dose Control for 3-D Proximity Effect Correction," *J. Vac. Sci & Technol.*, B27(06), pp.2572-2579, November/December 2009.
34. J. Kim, D. Joy and S.-Y. Lee, "Controlling Resist Thickness and Etech Depth for Fabrication of 3-D Structure in Electron-Beam Lithography," *Microelectronic Engineering*, 84/12, pp.2859-2864, 2007.
35. S.-Y. Lee and Kasi Anbumony, "Accurate Control of Remaining Resist Depth for Nanoscale 3-D Structures in E-beam Grayscale Lithography," *J. Vac. Sci & Technol.*, B25(6), pp.2008-2012, November/December 2007.
36. J. Kim, K. Jalhadi, S.-Y. Lee and D. Joy, "Fabrication of a Fresnel Zone Plate through E-beam Lithographic Process and its Application to Measuring of CD-SEM Performance," *J. Vac. Sci & Technol.*, B25(6), pp.1771-1775, November/December 2007.
37. K. Anbumony and S.-Y. Lee, "True Three-Dimensional Proximity Effect Correction in Electron-Beam Lithography," *J. Vac. Sci. Technol.*, B24 (6), 3115-3120, November/December 2006.
38. S.-Y. Lee and K. Anbumony, "Analysis of Three-Dimensional Proximity Effect in Electron-Beam Lithography," *Microelectronic Engineering*, 83, pp336-344, 2006.

39. S.-Y. Lee, F. Hu, and J. Ji, "Representation of Non-Rectangular Features for Exposure Estimation and Proximity Effect Correction in Electron-beam Lithography," *J. Vac. Sci. Technol.*, B 22(6), pp2929-2935, November/December 2004.
40. F. Hu and S.-Y. Lee, "Dose control for fabrication of grayscale structures using a single step electron-beam lithographic process", *J. Vac. Sci. Technol.*, B 21(6), pp2672-2679, November/December 2003.
41. S.-Y. Lee and D. He, "Simultaneous dose modification for balanced e-beam proximity correction minimizing CD error", *Microelectronic Engineering*, 69, pp47-56, August 2003.
42. S.-Y. Lee and J. Laddha, "Automatic Determination of Spatial Dose Distribution for Improved Accuracy in E-beam Proximity Effect Correction," *Microelectronic Engineering*, 57-58, pp303-309, 2001.
43. S.-Y. Lee and J. Laddha, "A Hierarchical Circuit Pattern Representation Format for Efficient E-beam Proximity Effect Correction," *Microelectronic Engineering*, 57-58, pp311-319, 2001.
44. S.-Y. Lee, "PYRAMID - A Hierarchical Approach to Proximity Effect Correction: Review and Update," (*invited paper*) *Recent Research and Development in Vacuum Science and Technology*, Transworld Research Network, 2, pp289-296, 2000.
45. S.-Y. Lee and J. Laddha, "Application of a Backpropagation Neural Network to Enhancing Accuracy of E-beam Proximity Effect Correction," *Microelectronic Engineering*, pp303-306, vol. 53, June 2000.
46. S.-Y. Lee, and J. Laddha, "Adaptive Selection of Control Points for Improving Accuracy and Speed of Proximity Effect Correction", *J. of Vac. Sci. and Technol.*, B 16(6), pp3269-3274, November/December 1998.
47. S.-Y. Lee and B.D. Cook, "PYRAMID-A Hierarchical Rule-based Approach to Proximity Effect Correction in E-Beam Lithography: Part I - Exposure Estimation" *IEEE Transactions on Semiconductor Manufacturing*, vol. 11, no. 1, pp108-116, February 1998.
48. B.D. Cook and S.-Y. Lee, "PYRAMID-A Hierarchical Rule-based Approach to Proximity Effect Correction in E-Beam Lithography: Part II - Correction" *IEEE Transactions on Semiconductor Manufacturing*, vol. 11, no. 1, pp117-128, February 1998.
49. S.-Y. Lee, B. Liu and B.D. Cook, "Reducing Recursive Effects for Fast Proximity Correction", *Microelectronic Engineering*, (35), pp491-494, 1997.
50. B.D. Cook and S.-Y. Lee, "Shape, Dose and Hybrid Modifications for PYRAMID in Electron Beam Proximity Effect Correction", *J. Vac. Sci. Technol.*, B 15(6), pp2303-2308, November/December 1997.
51. S.-Y. Lee and B. Liu, "Region-Wise Proximity Effect Correction for Heterogeneous Substrates in E-Beam Lithography: Shape Modification", *J. Vac. Sci. Technol.*, B 14(6), pp3874-3879, November/December 1996.
52. B.D. Cook and S.-Y. Lee, "Performance Analysis and Parameter Selection for PYRAMID", *Microelectronic Engineering*, (30), pp61-64, 1996.
53. S.-Y. Lee and B.D. Cook, "Interior Area Removal Method for PYRAMID", *J. Vac. Sci. Technol.*, B12(6), pp3449-3454, November/December 1994.

54. B.D. Cook and S.-Y. Lee, "Fast Proximity Effect Correction: An Extension of PYRAMID for Thicker Resists", *J. Vac. Sci. Technol.*, B11(6), pp2762-2767, Nov/Dec 1993.
55. J.C. Jacob, S.-Y. Lee, J.A. Mcmillan and N.C. MacDonald, "Fast Proximity Effect Correction: An Extension of PYRAMID for Circuit Patterns of Arbitrary Size", *J. Vac. Sci. Technol.*, B10(6), pp3077-3082, November/December 1992.
56. S.-Y. Lee, J.C. Jacob, C.M. Chen, J.A. Mcmillan, and N.C. MacDonald, "Proximity Effect Correction in Electron-beam Lithography: A Hierarchical Rule-based Scheme - PYRAMID", *J. Vac. Sci. Technol.*, B9(6), pp3048-3053, November/December 1991.