Multi-Source, Complex Beamline Modeling Development in MICHELLE eBEAM*

S.G. Ovtchinnikov, M.M. Mkrtchyan, R. Shtokhammer & J.J. Petillo
Science Applications Int'l Corporation, 700 Technology Park Dr., Billerica, MA 01821
ovtchinnikov@saic.com

S.J. Cooke, A.N. Vlasov & B. Levush
Naval Research Laboratory, 4555 Overlook Ave., SW, Washington, DC 20375

Simulations of modern, high current electron beam lithography devices may require modeling of optical components and multiple electron sources that are positioned both aligned with, and oblique to, the main device axis. Such devices may include counter streaming regions, where two beams are co-located in space while propagating in opposite directions. Modeling such complex multi-beam systems presents different computational challenges depending on the specific device and regime being modeled. Applications of interest require in some cases the modeling of both global and stochastic space charge, where inclusion of the latter requires direct evaluation of Coulomb interactions.

A mesh-less solution has been chosen in the MICHELLE-eBEAM code[1] we are reporting on, where the static electric and magnetic fields are represented semi-analytically[2] and the inter-particle effects are captured using a direct Coulomb field evaluation. In addition, simulating counter streaming beams requires a large particle count to resolve inter-beam dynamics, and an efficient algorithm coupled with the GPU hardware acceleration is employed to provide the necessary computational power. In general, depending on the beam densities and particle energies involved, the counter streaming inter-particle interaction time could range from the long-term time scale, where particles travel together in a parallel fashion, to the short-term time scale, where particles fly by one another. For our application in high current nanolithography the regime is constrained by the short fly-by interaction times. A model implemented in MICHELLE-eBEAM for simulating counter streaming beams reduces the fly-by interaction between each pair of counter streaming particles to a single scattering event taking place at the location along the main device axis where the particles cross one another.

We report on our progress in these areas as well as present example applications to modeling nanolithographic designs involving counter streaming beams in complex beamlines.

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[1] S.G. Ovtchinnikov, et al., "High accuracy electron beam model development in MICHELLE: eBEAM", J. Vac. Sci. Technol. B 28, C6J8 (2010).

[2] E. Munro, et al., "Simulation software for designing electron and ion beam equipment", Microelectronic Engineering 83 (2006) 994–1002.