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Pre-Manufacturing Behavior Forecasting and Modeling of Silicon Photonics Dual-Mode Devices Using Computer Algebra

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Silicon-based light-emitting devices are extremely desirable for integrating optical signal processing with electronic data processing. These dual-mode devices are basic to develop a generation of ultrafast computers, based on combined electronic and optical signal processing on the one hand, and advanced generations of optoelectronic devices for optical communication systems on the other hand. As part of the efforts to address the need of developing such ultra-fast electro-optics dual-mode processing computers, there is a need to develop an entire family of new silicon-based nanoscale electro-optical components which may smoothly integrate into the existing microelectronics industry. Series of such electro-optics silicon-based devices (transistors, capacitors, photo-activated and thermo-activated modulators, sensors, waveguides…), which optimally couple electrical and optical properties have been developed [1]. Due to the fabrication high-cost of such complex devices, there is a strong need to accurately simulate and forecast their expected electro-optical behavior, using advanced simulations, to assure smooth functionality. Comsol Multi-Physics Package software [2] is employed and integrated with Matlab-Simulink [3]. The physical equations are discretized on a mesh using the Galerkin Finite Element Method (FEM) [4], and to a reduced extent the method of Finite Volumes (FVM). Equations can be implemented in a variety of forms such as directly as a PDE, or as variation integral, the so called weak form [5]. Boundary conditions may also be directly imposed or using variation constraint and reaction forces. Both choices have implication for convergence and physicality of the solution. The mesh is assembled from triangular or quadrilateral elements in two-dimensions, and hexahedral or prismatic elements in three dimensions, using a variety of algorithms, pending the needs. Solution is achieved using direct or iterative linear solvers and non-linear solvers. The former are based on conjugate gradients, the latter generally on Newton-Raphson iterations. The research presents next simulation challenges.

Keywords
Finite Element Method (FEM), Finite Volumes Method (FVM), Partial Differential Equation (PDE), Nanoscale Body Devices (NSB), Simulations, Nanotechnology

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