Wonseok Shin, Ph.D.

As of October 2013

Appointment

Postdoctoral Scholar in Prof. Shanhui Fan's group at Stanford University

Contact Information

Spilker Engineering and Applied Sciences, Box 249
348 Via Pueblo
Stanford, CA 94305-4088, USA

e-mail: wsshin@stanford.edu
website: http://www.stanford.edu/~wsshin

Education

Stanford University 2006–2013
Ph.D. in Electrical Engineering (advisor: Prof. Shanhui Fan)

Stanford University 2004–2007
M.S. in Electrical Engineering

Seoul National University 1997–2001
B.S. in Physics and Mathematics

Industry Experience

Park Systems, Suwon, Korea 2001–2004
Software Engineer
Developed algorithms and software for scanning probe microscope (SPM) operation and image processing, including

- non-contact mode SPM algorithm on DSP
- tip deconvolution algorithm

Honors and Awards

Samsung Scholarship	2006–2011
National Research Foundation of Korea Fellowship	2004–2006
Summa cum laude graduate, Seoul National University	2001
Merit-based scholarship, Seoul National University	1997–2001
Bronze prize, the 18th Korea National Mathematics Contest for College Students	1999
Silver medal, the 8th Korean Mathematical Olympiad (KMO)	1994

Research Description

Efficient solution of the frequency-domain Maxwell's equations in 3D
To improve the performance of iterative solvers of the frequency-domain Maxwell's equations in 3D, I develop various techniques such as

- correct formulation of a differential equation for plasmonics
- correct choice of the perfectly matched layer (PML) boundary condition
- engineering the eigenvalue distribution of the Maxwell operator using the continuity equation
- symmetrizing the Maxwell operator while preserving the condition number of the operator

Combining these techniques, I have achieved more than 300-fold speedup in frequency-domain Maxwell's equations solvers.

Design of novel nanophotonic components
Using the efficient Maxwell's equations solver, I design novel nanophotonic components such as

- perfect bends and splitters in plasmonic waveguides
- efficient couplers between plasmonic and dielectric waveguides
- deep-subwavelength antennas with unidirectional radiation patterns

Analysis of the nature of the energy loss in plasmonic and metamaterials systems
Plasmonic and metamaterial devices are subject to the energy loss in their metallic components. To understand the nature of the loss and hence to improve the performance of these devices, I examine

- analytic expression of the loss in metals
- electromagnetic eigenmodes of plasmonic and metamaterial systems
- upper and lower bound of the electromagnetic eigenmodes

Ph.D. Dissertation

W. Shin, "3D finite-difference frequency-domain method for plasmonics and nanophotonics," submitted to the Department of Electrical Engineering, Stanford University (2013).

Refereed Journal Publications

W. Shin, W. Cai, P. B. Catrysse, G. Veronis, M. L. Brongersma, and S. Fan, "Broadband sharp 90-degree bends and T-splitters in plasmonic coaxial waveguides," *Nano Letters*, vol. 13, pp. 4753–4758 (2013).

W. Shin and S. Fan, "Accelerated solution of the frequency-domain Maxwell's equations by engineering the eigenvalue distribution," *Optics Express*, vol. 21, pp. 22578–22595 (2013).

A. Raman, W. Shin, and S. Fan, "Upper Bound on the Modal Material Loss Rate in Plasmonic and Metamaterial Systems," *Physical Review Letters*, vol. 110, art. no. 183901 (2013).

W. Shin, A. Raman, and S. Fan, "Instantaneous electric energy and electric power dissipation in dispersive media," *Journal of Optical Society of America B*, vol. 29, pp. 1048–1054 (2012).

W. Shin and S. Fan, "Choice of the perfectly matched layer boundary condition for frequency-domain Maxwell's equations solvers," *Journal of Computational Physics*, vol. 231, pp. 3406–3431 (2012).

W. Cai, W. Shin, S. Fan, and M. L. Brongersma, "Elements for plasmonic nanocircuits with three-dimensional slot waveguides," *Advanced Materials*, vol. 22, pp. 5120–5124 (2010).

L. Verslegers, P. B. Catrysse, Z. Yu, W. Shin, Z. Ruan, and S. Fan,"Phase front design with metallic pillar arrays," *Optics Letters*, vol. 35, no. 6, pp. 844–846 (2010).

Conference Oral Presentations

W. Shin, W. Cai, P. B. Catrysse, G. Veronis, M. L. Brongersma, and S. Fan, "Plasmonic nano-coaxial waveguides for 90-degree bends and T-splitters," *CLEO*, San Jose, California, June 9–14, 2013.

W. Shin and S. Fan, "Choice of the perfectly matched layer boundary condition for iterative solvers of the frequency-domain Maxwell's equations," *the 28th Annual Review of Progress in Applied Computational Electromagnetics*, Columbus, Ohio, April 10–14, 2012.

W. Shin and S. Fan, "Accelerated solution of the frequency-domain Maxwell's equations by engineering the spectrum of the operator using the continuity equation," *the 12th Copper Mountain Conference on Iterative Methods*, Copper Mountain, Colorado, March 25–30, 2012.

W. Shin and S. Fan, "Choice of the Perfectly Matched Layer boundary condition for iterative solvers of the frequency-domain Maxwell's equations," *SPIE Photonics West*, San Francisco, California, January 21–26, 2012.

Seminar Presentations

W. Shin, "Brief introduction to the finite-difference frequency-domain (FDFD) method," a guest lecture in *EE256: Numerical Electromagnetics* at Stanford University, Stanford, California, May 24, 2013.

W. Shin, "3D finite-difference frequency-domain method for plasmonics and nanophotonics," a seminar at Korea University (host: Prof. Q-Han Park), Seoul, South Korea, April 4, 2013.

W. Shin, "3D finite-difference frequency-domain method for plasmonics and nanophotonics," *Exitonics Research Society Seminar* at KAIST (host: Prof. Doh Chang Lee), Daejun, South Korea, March 28, 2013.

W. Shin, "3D finite-difference frequency-domain method for plasmonics and nanophotonics," Global Research Laboratory Seminar at Seoul National University (host: Prof. Namkyoo Park), Seoul, South Korea, March 26, 2013.

W. Shin, "Modification of Maxwell's equations for iterative methods," *Linear Algebra and Optimization Seminar* at Stanford University, Stanford, California, February 21, 2013.

W. Shin, "3D finite-differenece frequency-domain method for plasmonics and nanophotonics," *Optics and Electronics Seminar* at Stanford University, Stanford, California, January 28, 2013.

W. Shin, "A large-scale FDFD solver of Maxwell's equations for nanophotonics," a seminar at KAIST (host: Prof. Yong-Hee Lee), Daejun, South Korea, August 19, 2009.

Poster Presentations

W. Shin, A. Raman, and S. Fan, "Upper bound on the modal material loss rate in plasmonic and metamaterial systems," *First Year Review of AFOSR MURI: Template-Directed Directionally Solidified Eutectic Metamaterials*, Dayton, Ohio, October 8–9, 2013.

W. Shin, A. Raman, and S. Fan, "Instantaneous electric energy density and power dissipation density in dispersive media," *IONS NA-3*, Stanford, California, October 13–15, 2011.

W. Shin and S. Fan, "Impact of the PMLs on the convergence of iterative methods of solving Maxwell's equations in the frequency domain," *Stanford University Photonics Retreat*, Marshall, California, April 8–10, 2011.

W. Shin and S. Fan, "A large-scale 3D finite-difference frequency-domain solver of Maxwell's equations for nanophotonics," *Stanford University Photonics Retreat*, Napa, California, April 9–11, 2010.

Software Development

FD3D (**F**requency-**D**omain solver of Maxwell's equations in **3D**)
FD3D is a parallelized computational kernel for solving the frequency-domain Maxwell's equations in 3D. It constructs a linear system from Maxwell's equations by the finite-difference method, and solves the linear system by a Krylov iterative method. FD3D is written in C using the PETSc library, and it runs on any LINUX clusters that support MPI communication.

Maxwell
Maxwell is a MATLAB user interface for FD3D. It produces input files for FD3D from problem specifications (such as electromagnetic properties and shapes of objects). It also reads solution files calculated by FD3D and visualizes them. In addition, Maxwell can solve the frequency-domain Maxwell's equations using MATLAB's built-in linear system solvers.