

Engineering Sciences and Applied Mathematics

David Chopp

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**Research Area**

Scientific Computing with Applications to Microbiology and Materials

**Experience**

Department Chair, Engineering Sciences and Applied Mathematics Northwestern University	2014-present
Charles Deering McCormick Professor of Teaching Excellence Northwestern University	2008-2011
Professor, Engineering Sciences and Applied Mathematics Northwestern University	2009-present
Co-director, Computational Biology and Bioinformatics Program Northwestern University	2006-2008
Associate Professor, Engineering Sciences and Applied Mathematics Northwestern University	2003-2009
Assistant Professor, Engineering Sciences and Applied Mathematics Northwestern University	1996-2003
Software Developer, Math Group Rogue Wave Software, Corvallis, OR	1996
National Science Foundation Postdoctoral Fellow / Acting Assistant Professor University of Washington	1993-1995
National Science Foundation Postdoctoral Fellow University of California, Los Angeles	1992-1993
Research Assistant Professor in Pure and Applied Mathematics University of California, Los Angeles	1991-1992
Research Associate, Physics Division Lawrence Berkeley Laboratory	1989-1991
Teaching Assistant, Mathematics Dept. University of California, Berkeley	1985-1989

**Education**

University of California, Berkeley Ph.D. in Mathematics Thesis: Computation of Minimal Surfaces via Mean-Curvature Flow	May 1991
University of Washington B.S. in Mathematics, Summa cum laude with Distinction in Mathematics Major: Mathematics and Applied Mathematics in Numerical Analysis	June 1985

<b>Awards</b>	T. William Heyck Faculty Fellow Award, Northwestern University	2017
	Charles Deering McCormick Professor of Teaching Excellence, Northwestern University	2008
	National Science Foundation Postdoctoral Fellow	1992
	Bernard Friedman Prize in Applied Mathematics	1991
<b>Lectures</b>	<p>"The Locally Adaptive Time Stepping (LATS) Method: From Hodgkin-Huxley to Cahn-Hilliard," Oberwolfach workshop on geometric PDEs, 2015</p> <p>"The Locally Adaptive Time Stepping (LATS) Method: From Hodgkin-Huxley to Cahn-Hilliard," U. Washington, 2015</p> <p>"Review of Mathematical Modeling of Biofilms in Waste Water Treatment," U. Lund, Sweden, 2013</p> <p>"Modeling and Simulation of Microbial Fuel Cells," SES Meeting, 2011</p> <p>"Modeling and Simulation of Microbial Fuel Cells," ICIAM Meeting, 2011</p> <p>"Modeling and Simulation of Bacterial Biofilms," University of Iowa, 2010</p> <p>"The Mathematics of Knots, Puzzles, and Games," Northwestern University, 2010</p> <p>"Simulation and Validation of 3-Dimensional Fatigue Cracks," MAA Joint Meetings, 2010</p> <p>"A Multi-Species Model for Bacterial Biofilms used in Waste Water Treatment," U. of California, Berkeley, 2009</p> <p>"A Multi-Species Model for Bacterial Biofilms used in Waste Water Treatment," U. of Guelph, 2009</p> <p>"Simulating 3D Fatigue Crack Growth," MAA Joint Meetings, 2009</p> <p>"A Multi-Species Model for Bacterial Biofilms used in Waste Water Treatment," MAA Joint Meetings, 2009</p> <p>"Modeling and Simulation of Bacterial Biofilms," MBI, Ohio State University, 2008</p> <p>"Impact of Fluid Flow on Bacterial Biofilms," SIAM-Life Sciences Meeting, Montreal, Quebec, Canada, 2008</p> <p>"Velocity Extensions and the Level Set Method," SIAM Annual Meeting, San Diego, 2008</p> <p>"Fast Marching Methods: Time Advancement and Non-Graded Cartesian Grids," Northwestern U. 2008</p> <p>"Impact of Fluid Flow on Bacterial Biofilms," AMS Sectional Meeting, U. Indiana, 2008</p> <p>"Simulating Bacterial Biofilms," Ohio State University, 2008</p> <p>"Simulation of Bacterial Biofilms," Statistical and Applied Mathematical Sciences Institute, 2007</p> <p>"Influence of Fluid Flow on Bacterial Biofilms," American Society of Microbiology Meeting, 2007</p> <p>"Modeling Bacterial Biofilms," Howard Univ., 2007</p> <p>"Modeling Bacterial Biofilms," Michigan State Univ., 2007</p> <p>"Assorted Applications of Curvature Dependent Flow," Purdue Univ., 2007</p> <p>"Assorted Applications of Curvature Dependent Flow," MSRI, 2007</p> <p>"Modeling Quorum Sensing in Bacterial Biofilms," SIAM Annual Meeting, 2004</p> <p>"Applications of the Level Set Method in Materials Science," Invited speaker, American Vacuum Society Prairie Regional Meeting, U. Illinois, Urbana-Champaign, 2004</p> <p>"Modeling Quorum Sensing in Bacterial Biofilms," Biocomplexity VI, U. Indiana, 2004</p> <p>"Foliations of Hyperbolic Space and Minimal Surfaces with Voids," Geometric Flows: Theory and Computation, Institute for Pure and Applied Mathematics, UCLA, 2004</p> <p>"Modeling Quorum Sensing in Growing Bacterial Biofilms," Illinois Institute of Technology, 2003</p> <p>"Modeling Quorum Sensing in Growing Bacterial Biofilms," Vanderbilt U., 2003</p> <p>"The Fast Marching Method and Velocity Extensions Revisited," Northwestern Nonlinear PDE Conference, 2003</p> <p>"The Coupled eXtended-Finite Element Method and Level Set Method applied to Crack</p>	

Propagation," North Carolina State U., 2003

"Modeling Quorum Sensing in Growing Bacterial Biofilms," U. Wisconsin, Madison, 2003

"Modeling Quorum Sensing in Growing Bacterial Biofilms," Northwestern U., 2003

"Initializing the Fast Marching Method and a New Analysis of Velocity Extensions," SIAM Annual Meeting, 2002

"Recent Advances in the Level Set Method for Multiphase Flow," U. Iowa, 2002

"A Coupled Extended Finite Element/Level Set Method," SIAM Annual Meeting, 2001

"A Coupled Extended Finite Element/Level Set Method," Northwestern U., 2001

"A Coupled Extended Finite Element/Level Set Method for Multiple Crack Growth," US Nat. Cong. Comp. Mech., 2001

"Higher Order Fast Marching and Anisotropic Edge Diffusion," DARPA/NSF VIP Workshop on Thin-Film Deposition, 2000

"Modeling of Microstructural and Surface Morphological Evolution," SIAM Conference on Mathematical Aspects of Materials Science, 2000

"Fast Approximations of Surface Diffusion," U. Virginia, 2000

"Simulation of Annealing," DARPA/NSF VIP Workshop on Thin-Film Deposition, 1999

"Simulation of Annealing," Materials Research Society Workshop on Thin-Film Deposition, 1999

"Simulation of Thin-Film Deposition," U. Illinois Urbana-Champaign, 1999

"Modeling Surface Diffusion using the Level Set Method," Northwestern U., 1999

"Advances in Mathematical Models for Thin-Film Growth," U. Illinois Urbana-Champaign, 1998

"Level Set Methods Applied to Surface Self-Diffusion and Epitaxial Growth," Cal. Tech. U., 1998

"Level Set Methods Applied to Thin Film Deposition," Stanford U., 1997

"Smoothing and Roughening: Level Set Method Applications in Rock Tumbling, Sintering, and Epitaxial Growth," SIAM Meeting, 1997

"Advances in Level Set Methods," U. of Chicago, 1997

### Service

Co-chair, Minisymposium: Computational Mechanics of Sharp Fronts and Interfaces  
US National Congress on Computational Mechanics, 2011

Member, International Scientific Committee, 7<sup>th</sup> International Conference on Computational Modeling of Free and Moving Boundary Problems, 2003

Panelist, Joint NSF/NIH Symposium on Accelerating Mathematical-Biological Linkages, 2003  
US National Congress on Computational Mechanics, 2011

Chair, Minisymposium: Mathematical Modeling of Biofilms, SIAM Annual Meeting, 2003

### Student Advising

Magda Stolarska, Ph.D., December 2002

Anthony Tongen, Ph. D. December 2002

Michael Rempe, Ph. D. August 2006

Benjamin Vaughan, Ph. D. August 2007

Bryan Smith, Ph. D. July 2008

Brian Merkey, Ph. D. July 2008

Richard Kublick, Ph. D. December 2010

Jared Hicks, Ph. D. August 2017

Narut Sereewattanawoot, Ph.D. expected 2018

Noah Ford, Ph.D. expected 2019

Colton Bryant, Ph.D. expected 2020

Undergrads: Tom Barrett, Jared Kassebaum, Paul Park, Jeff Cohen, Hugh Le

### Committees

Faculty Fellow, Slivka Residential College, 2014-present

Faculty Fellow, Ayers Residential College, 2015-present

Associate Master, Slivka Residential College, 2010-2014  
 McCormick Promotion and Tenure Committee, At Large Representative, 2012-2014  
 McCormick Promotion and Tenure Committee ES/AM Representative, 2009-2011  
 Ad Hoc Tenure Committee WCAS, 2009  
 Virtual School of Computational Science and Engineering Operating Council Great Lakes Consortium for Petascale Computing, 2008-2010  
 ES/AM Faculty Search Committee ES/AM Dept., 2007-2008  
 ES/AM Faculty Search Committee (Chair) ES/AM Dept., 2006-2007  
 University Hearing and Appeals System (UHAS) Board NU, 2006-2014  
 Graduate Admissions Committee ES/AM Dept., 2004–present  
 McCormick Computer Resources Committee Sch. of Engineering, 2003–present  
 Safety Committee Sch. of Engineering, 2001–2006  
 Computing Committee ES/AM Dept., 1996–present  
 Cooperative Engineering Education Committee Sch. of Engineering, 2001–2006  
 Computational Science in Engineering Committee Sch. of Engineering, 1999–2003  
 Prelim Exam Committee ES/AM Dept., 1996–present  
 Dept. Vision Committee ES/AM Dept., 2005  
 Curriculum Committee Sch. of Engineering, 1998–2003  
 McCormick Identity Committee Sch. of Engineering, 2002

## Publications

- A. Caruso, F. Boano, L. Ridolfi, D. L. Chopp, A. Packman. Biofilm-Induced Bioclogging Produces Sharp Interfaces in Hyporheic Flow, Redox Conditions and Microbial Community Structure, *Geophysical Research Letters*, **44**:4917-4925, 2017.
- A. Sadeghirad, D. L. Chopp, X. Ren, E. Fang, J. Lua. A Novel Hybrid Approach for Level Set Characterization and Tracking of Non-Planar 3D Cracks in the Extended Finite Element Method, *Engineering Fracture Mechanics*, **160**:1-14, 2016.
- R. Kublik and D. L. Chopp. A Locally Adaptive Time-Stepping Algorithm for the Solution to Reaction-Diffusion Equations on Branched Structures, *Advances in Computational Mathematics*, **42**(3):621-649, 2016.
- X. Li, D.L. Chopp, W.A. Russin, P.T. Brannon, M. R. Parsek, A.I. Packman. In Situ Biomineralization and Particle Deposition Distinctively Mediate Biofilm Susceptibility to Chlorine, *Applied and Environmental Microbiology*, **82**(10):2886-2892, 2016.
- X. Li, D.L. Chopp, W.A. Russin, P.T. Brannon, M. R. Parsek, A.I. Packman. Spatial Patterns of Carbonate Biomineralization in Biofilms, *Applied and Environmental Microbiology*, **81**(21):7403-7410, Nov., 2015.
- X. Li, J.L. Song, A. Culotti, W. Zhang, D.L. Chopp, N. Lu, A.I. Packman. Methods for Characterizing the Co-Development of Biofilm and Habitat Heterogeneity, *Journal of Visualized Experiments*, **97**, March, 2015.
- B. V. Merkey and D. L. Chopp. Modeling the Impact of Interspecies Competition on Performance of a Microbial Fuel Cell, *Bull. Math. Biology*, **76**(6):1429-1453, 2014.
- B. S. Tseng, W. Zhang, J. J. Harrison, T. P. Quach, J. L. Song, J. Penterman, P. K. Singh, D. L. Chopp, A. I. Packman, and M. R. Parsek. The Extracellular Matrix Protects *Pseudomonas aeruginosa* Biofilms by Limiting the Penetration of Tobramycin, *Environmental Microbiology*, **15**(10):2865-2878, 2013.
- A. A. Davila, D. W. Buck, D. L. Chopp, C. M. Connor, S. Persing, V. Rawlani, and J. Y. S. Kim. A Novel Prospective Three-Dimensional Analysis of Nasolabial Fold Augmentation, *Aesthetic Surgery Journal*, **32**(4):488-494, 2012.
- B. V. Merkey and D. L. Chopp. The Performance of a Microbial Fuel Cell Depends Strongly on Anode Geometry: A Multidimensional Modeling Study, *Bull. Math. Biology*, **74**:834-857, 2012.
- D. L. Chopp, V. Rawlani, M. Ellis, S. A. Johnson, S. Khan, K. Bethke, N. Hansen, J. YS Kim. A

- Geometric Analysis of Mastectomy Incisions: Optimizing Intraoperative Breast Volume, *Canadian J. of Plastic Surgery*, **19**(2):45-50, 2011.
- R. Duddu, D. L. Chopp, and P. Voorhees. Diffusional Evolution of Precipitates in Elastic Media Using the Extended Finite Element and the Level Set Methods, *J. Computational Physics*, **230**(4):1249-1264, 2011.
- J. Shi, D. L. Chopp, J. Lua, N. Sukumar, and T. Belytschko. Abaqus Implementation of Extended Finite Element Method Using a Level Set Representation for Three-Dimensional Fatigue Crack Growth and Life Predictions, *Engg. Fract. Mech.*, **77**(14):2840-2863, 2010.
- B. L. Vaughan, B. G. Smith, D.L. Chopp. The Influence of Fluid Flow on Modeling Quorum Sensing in Bacterial Biofilms, *Bull. Math. Biology*, **72**(5):1143-1165, 2010.
- D. L. Chopp. Another look at velocity extensions in the level set method. *SIAM J. Sci. Comp.*, **31**(5):3255-3273, 2009.
- B. Merkey, B. E. Rittmann, and D.L. Chopp. Modeling How Soluble Microbial Products (SMP) Support Heterotrophs in Autotroph-Based Biofilms, *J. Theoretical Biology*, **259**:670-683, 2009.
- R. Duddu, D.L. Chopp, and B. Moran. A Two-Dimensional Continuum Model of Biofilm Growth Incorporating Fluid Flow and Shear Stress Based Detachment, *Biotechnology and Bioengineering*, **103**(1):92-104, 2009.
- N. Sukumar, D. L. Chopp, E. Béchet, N. Möes. Three-dimensional non-planar crack growth by a coupled extended finite element and fast marching method, *Int. J. Num. Meth. Eng.*, **76**(5):727-748, 2008.
- M. J. Rempe, N. Spruston, W. L. Kath, and D. L. Chopp. Compartmental neural simulations with spatial adaptivity. *J. Comp. Neuroscience*, **25**(3):465-480, 2008.
- R. Duddu, S. Bordas, D. L. Chopp, and B. Moran. A combined extended finite element and level set method for biofilm growth. *Int. J. Num. Meth. Eng.*, **74**(5):848-870, 2008.
- B. G. Smith, B. L. Vaughan, and D. L. Chopp. The extended finite element method for boundary layer problems in biofilm growth, *CAMCoS*, **2**(1):35-56, 2007.
- M. J. Kirisits, J. Margolis, B. L. Purevdorj-Gage, B. Vaughan, D. L. Chopp, P. Stoodley, and M. R. Parsek. The influence of the hydrodynamic environment on quorum sensing in *Pseudomonas aeruginosa* biofilms, *J. Bacteriology*, **189**(22):8357-8360, 2007.
- B. L. Vaughan, Jr., B. G. Smith, and D. L. Chopp. A comparison of the extended finite element method with the immersed interface method for elliptic equations with discontinuous coefficients and singular sources. *CAMCoS*, **1**(1):207-228, 2006.
- J. D. Shrout, D. L. Chopp, C. L. Just, M. Hentzer, M. Givskov, and M. R. Parsek. The impact of quorum sensing and swarming motility on *Pseudomonas aeruginosa* biofilm formation is nutritionally conditional. *Molecular Microbiology*, **62**(5):1264-1277, 2006.
- A. Tongen and D. L. Chopp. Simulation of multigrain thin film growth. *Interfaces and Free Boundaries*, **8**:1-19, 2006.
- M. J. Rempe and D. L. Chopp. A predictor-corrector algorithm for reaction-diffusion equations associated with neural activity on branched structures. *SIAM J Scientific Computing*, **28**(6):2139-2161, 2006.
- M. Torres, D. L. Chopp, and T. Walsh. Level set methods to compute minimal surfaces in a medium with exclusions (voids). *Interfaces and Free Boundaries*, **7**(2), 2005.
- S. Kodambaka, D. L. Chopp, I. Petrov, and J. E. Greene. Coalescence kinetics of two-dimensional TiN islands on atomically-smooth TiN(001) and TiN(111) terraces. *Surface Science*, **540**(2-3):L611-L616, 2003.
- M. Stolarska and D. L. Chopp. Modeling spiral cracking due to thermal cycling in integrated circuits. *Int. J. Num. Meth. Eng.*, **41**(20):2381-2410, 2003.
- D. L. Chopp, M. J. Kirisits, M. R. Parsek, and B. Moran. The dependence of quorum sensing on the depth of a growing biofilm. *Bull. Math. Biol.*, **65**(6):1053-1079, 2003.
- D. L. Chopp and J. A. Velling. Foliations of hyperbolic space by constant mean curvature surfaces sharing ideal boundary. *Exp. Math.*, **12**(3):339-350, 2003.
- D. L. Chopp and N. Sukumar. Fatigue crack propagation of multiple coplanar cracks with the coupled extended finite element/fast marching method. *Int. J. Eng. Sci.*, **41**(8):845-869, 2003.

N. Sukumar, D. L. Chopp, and B. Moran. Extended finite element for three-dimensional fatigue crack propagation, *Engineering Fracture Mechanics*, 70(1):29-48, 2003. **Named one of the most highly cited papers of 2002-2005.**

D. L. Chopp, M. J. Kirisits, M. R. Parsek, and B. Moran. A mathematical model of quorum sensing in a growing *P. aeruginosa* biofilm. *Journal of Industrial Microbiology and Biotechnology*, 29(6):339-346, 2002.

K. A. Smith, F. J. Solis, and D. L. Chopp. A projection method for motion of triple junctions by level sets. *Interfaces and Free Boundaries*, 4(3):263-276, 2002.

H. Ji, D. L. Chopp, and J. E. Dolbow. A hybrid extended finite element/level set method for modeling phase transformations. *International Journal for Numerical Methods in Engineering*, 54(8):1209-1233, 2001.

D. L. Chopp. Replacing iterative algorithms with single-pass algorithms. *Proceedings of the National Academy of Sciences*, 98(20):10992-10993, 2001.

D. L. Chopp. Some improvements of the fast marching method, *SIAM Journal of Scientific Computing*, 23(1):230-244, 2001.

M. Stolarska, D. L. Chopp, N. Möes, and T. Belytschko. Modelling crack growth by level sets in the extended finite element method, *International Journal for Numerical Methods in Engineering*, 51(8):943-960, 2001.

F. H. Baumann, D. L. Chopp, G. H. Gilmer, J. E. Greene, H. Huang, S. Kodambaka, P. O'Sullivan, and T. Diaz de la Rubia, "Multi-scale modelling of thin film deposition: Applications to Si device processing," *Materials Research Society Bulletin*, 26(3), March, 2001.

N. Sukumar, D. L. Chopp, N. Möes, and T. Belytschko. Modelling holes and inclusions by level sets in the extended finite element method. *Computer Methods in Applied Mechanics and Engineering*, 190(46-47):6183-6200, 2001.

D. L. Chopp. A level-set method for simulating island coarsening. *Journal of Computational Physics*, 162:104-122, 2000.

D. L. Chopp and J. A. Sethian, Motion by intrinsic Laplacian of curvature. *Interfaces and Free Boundaries*, 1(1):107-123, 1999.

D. L. Chopp, L. C. Evans, and H. Ishii, Waiting time effects for Gauss curvature flows. *Indiana U. Math Journal*, 48(1):311-334, 1999.

S. Angenent, T. Ilmanen, and D.L. Chopp, A computed example of nonuniqueness of mean curvature flow in  $\mathbb{R}^3$ . *Communications on Partial Differential Equations*, 20(11-12):1937-1958, 1995.

D. L. Chopp, Numerical computation of self-similar solutions for mean curvature flow. *Journal of Experimental Mathematics*, 3(1):1-15, 1994.

D. L. Chopp and J. A. Sethian, Flow under curvature: Singularity formation, minimal surfaces, and geodesics, *Journal of Experimental Mathematics*, 2(4):235-255, 1993.

D. L. Chopp, Computing minimal surfaces via level set curvature flow, *Journal of Computational Physics*, 106(1):77-91, May 1993.

## Conference Proceedings

M. Stolarska, D. L. Chopp, N. Moës, and T. Belytschko. Modelling crack growth by level sets. In the 14th European Conference on Fracture, 2002.

J. E. Dolbow, H. Ji, and D. L. Chopp. Advances in the hybrid finite element / level set method for phase transformations. In the 5th World Congress on Computational Mechanics, 2002.

J. A. Sethian and D. L. Chopp, "Physics and geometry of flow under curvature: Singularity formation, minimal surfaces, geodesics, and surface tension." In *DeGruyter Trento Conference on Mean Curvature Flow*, July 1994. ([pdf](#))

J. A. Sethian and D. L. Chopp, "Flow under mean curvature: Singularity formation and minimal surfaces." In *Computational Crystal Growers Workshop*, February, 1992. ([pdf](#))

## Book Chapters

D. L. Chopp. *Deformable Models: Biomedical and Clinical Applications*, chapter Simulating Bacterial Biofilms. Springer, 2007.

D. L. Chopp. *Handbook of Biomedical Image Analysis*, volume 1, chapter Recent Advances in

the Level Set Method. Kluwer Academic, 2005.

D. L. Chopp. *State of the Art PDE and Level Sets Algorithms, Approaches to Static and Motion Imagery Segmentation*, chapter Level Set Extensions, Flow and Crack Propagation. Kluwer Academic, 2002.

J. S. Suri, D. L. Chopp, and S. Laxminarayan. *State of the Art PDE and Level Sets Algorithms, Approaches to Static and Motion Imagery Segmentation*, chapter The Future of PDEs and Level Sets. Kluwer Academic, 2002.

### Technical Reports

D. L. Chopp. Numerical computation of self-similar solutions for mean curvature flow. Technical Report LBL-34559, Lawrence Berkeley Laboratory, 1993.

D. L. Chopp. Numerical computation of self-similar solutions for mean curvature flow. Technical Report CAM 93-17, UCLA, 1993.

D. L. Chopp. Flow under geodesic curvature. Technical Report CAM 92-23, UCLA, 1992

D. L. Chopp and J. A. Sethian. Flow under mean curvature: Singularity formation and minimal surfaces. Technical report CPAM-541, Center for Pure and Applied Mathematics, Univ. of Calif., Berkeley, 1991

D. L. Chopp. Computing minimal surfaces via level set curvature flow. Technical Report LBL-30685, Lawrence Berkeley Laboratory, 1991.