Applied Computational Electromagnetics Society

Around ACES

I was so pleased with the response to the response about the interview with Andy Drozd that I asked the same set of questions to two other ACESians I have known for quite some time: Bruce Archambeault and Liz Davenport. I am sure you will find their responses as interesting as I did.

Natialia Nikolova is another name that will be familiar to many ACES members. She has very kindly let us into her place of work: McMaster University.

Meet the ACESians

Bruce Archambeault

Where were you born and brought up, where do you live now and what circumstances brought you there?
I was born/raised in Manchester, NH (north-eastern USA). About 11 years ago, I moved to North Carolina to get away from the harsh winters and to have more sailing time throughout the year.

What did you read at university, which university(ies) and why this (these) subjects?
I did all of my university work as an adult with a family. I received my BSEE degree from the University of New Hampshire, then my MSEE at Northeaster Univ (Boston). I went back to University of New Hampshire for my PhD in Computational Electromagnetics. I find it hard to believe (after my initial experiences with EM as a BSEE and MSEE student) that I ended up specializing in EM! I think there must have been a fair amount of beer involved in that decision! Honestly, I was frustrated by the lack of understanding that most people seem to have concerning EMI/EMC, and wanted to learn CEM so I could make things more understandable and less magical.

What is your current job and what does it entail? What are you most proud of achieving?
I work for IBM in Research Triangle Park, NC. I was recently promoted to IBM Distinguished Engineer, which gives me a corporate wide mandate to 'improve the technology' where ever I can. I lead a number of other EMI/EMC people in EMI/EMC tool development as well as high speed (fullwave) Signal integrity (SI) tool development.

If you weren't doing this job what would your ideal occupation be? What are your abiding passions?
I like to teach. So if I was not doing this job, I might find a university where I could teach without the hassles associated with the need to get research funding and all the normal 'tenure track' things I hear about from others at universities.

One of my most abiding passions is to make sure users of CEM tools know the tool's limitations, and does the appropriate validation. It appals me how many people purchase expensive software, and then just blindly believe they get the correct answer. I am fond of saying that these tools will give a very accurate answer to whatever question the user asks. But did the user ask the questions they *thought* they were asking?

If you were abandoned in an underground laboratory with no immediate chance of release and with the opportunity of only using one numerical technique, which technique would you want to use and why? What 'big problem' would you want to spend your time trying to solve with your modelling?
I am a firm believer that as engineers we need to use a tool box approach, and use the right tool for the right job. So a variety of simulation techniques are required! But to stay within the constraint of your question, I would probably select FDTD. This technique is the most flexible (in my opinion) so it can be used for nearly anything.

As far as which big problem I would attempt to solve? I honestly do not have one….I work on many different problems, and I would expect that I would continue all these little problems and then bring them together.

If you had a 'one shot' time machine to bring someone from any period of history to keep you company in the underground laboratory, who would you choose and why?
someone with a big shovel to help me get out? I guess for pure conversation, I would select Michangelo (if we could communicate). I think he had more different ideas that were ahead of his time than anyone else I can think about.

Any interesting stories or anecdotes?
This is a true story that happened to me while getting near the end of my PhD studies … While taking the last advanced EM class that I needed for my degree, the professor decided to find the scattering off a circular metal disk. We started with Maxwell's equations, and planned to find the equivalent electric and magnetic currents on the disk, then the fields from those currents. I felt that I understood the math as well as the 'why' for a good part of the derivation. However, at one point, I realized I had lost track of why we were doing these steps. The step-by-step math made sense, but I could not see how this related to the problem we were trying to solve. However, I did not dare ask the professor, since *I* was supposed to know EM, at least, *if* I ever wanted to graduate!

After another class of simply copying the work he wrote on the board into my notebook without understanding, I was getting very nervous. On the third day, the professor was late so I asked the guy next to me for some help. He also did not have a clue what was going on. In fact, no one in the class knew what was going on!

Finally, when the professor appeared, I was brave enough to ask him about what we were doing and why (since it was not only me that did not understand!) He backed up to a point where we needed to integrate from "-a" to "+a" and the formula we were integrating had it's variable in the denominator. Since integration is simply moving along a path, and we would pass through zero on the way from "-a" to "+a", and since we can not have zero in the denominator, he had decided to go from "-a" to minus-infinity, then come back from plus-infinity to "+a"! (I did not know the minus-infinity and plus-infinity were connected!)

So all this work was simply to do an integration along the way to the final answer. So I put my pencil down, and told the professor that to let me know when he gets back to electromagnetics! And I would resume taking notes. He did not like that comment, of course. But if professors would simply tell the students that they need to go into "mathematical hell" for a while, I think EM would be much less scary!

Meet the ACESians

Liz Davenport

Where were you born and brought up, where do you live now and what circumstances brought you there?
I grew up in Croydon, Surrey – a boring place which at the time lacked the amenities of central London because it was too close, but was too far away to access them easily, especially if you're a teenager. Escaped to Bristol University, loved the city & stayed there.

What did you read at university, which university(ies) and why this (these) subjects?
Physics- I became interested at school, and never really thought seriously about doing anything else.

What is your current job and what does it entail? What are you most proud of achieving?
I'm a senior scientist in the mathematical modelling department at the BAE SYSTEMS Advanced Technology Centre, Filton. I work in the electromagnetics group where we're interested in modelling radar returns, installed antenna performance & EMC problems. The main part of my job involves development of software for predicting system EMC performance. I provide the technical input, validate and test the code, train & support new users, and try to prevent the software engineers from overspending.

Achievements? I saved the life of Sooty, my children's hamster, by rescuing her from the innards of the dishwasher.

If you weren't doing this job what would your ideal occupation be? What are your abiding passions?
I suppose my ideal job would be a university lecturer 30-40 years ago!

If you were abandoned in an underground laboratory with no immediate chance of release and with the opportunity of only using one numerical technique, which technique would you want to use and why? What 'big problem' would you want to spend your time trying to solve with your modelling?
The choice of modelling techniques is definitely like swings and roundabouts. Boundary elements are great for predicting scattering from structures, for both antennas and radar cross sections, so long as the scatterer is a good conductor. But if it's made from other materials, then the maths becomes more complex and things start to slow down… Finite difference has the advantages of speed and simplicity- indeed the fastest and simplest method, for both run time and meshing. However it does lack geometrical flexibility, which leads us to

finite elements. These are brilliant for conforming to the structure you're modelling, so long as you can afford to wait until next year for the results. And don't think that buying a bigger better computer will help, the next problem will always be too big for it and the current code will decline to compile. Maybe the best technique to use is the one you're most familiar with – you know where the heffalump traps are!

What 'big problem' would I want to solve? My professional interest, from the EMC viewpoint, is in internal fields in structures such as aircraft and ships, over a wide range of frequencies. The EMC specifications go up to 18GHz, and occasionally 40GHz, so the models are potentially electrically very large. I don't think that conventional CEM is the way to go for such problems, especially if you take into account all the variations in the possible configurations. Cables can follow slightly different routes, connectors and gaskets can change, particularly after use and maintenance, even dimensions and sub-units can vary between different equipments that are nominally the same. A CEM model only gives the right answer for the configuration you've chosen to model. I think the way ahead lies in statistical electromagnetics. So I might prefer to spend my time in the bunker developing ideas in this field, rather than number crunching.

If you had a 'one shot' time machine to bring someone from any period of history to keep you company in the underground laboratory, who would you choose and why?

This answer has nothing to do with work. I'd like to meet my great-grandfather, who was born in 1834, the seventh of ten children, and was working as a mill-hand in a Lancashire cotton factory in 1851. By 1860 he'd become a clergyman in the genteel spa town of Tunbridge Wells in Kent. I want to know how he achieved this. What educational opportunities were offered, and grasped, by him? How hard did he have to work, and who helped? All questions I'll never find the answers to!

Any interesting stories or anecdotes?

No – unless you want a detailed account of the rescue of Sooty from the dishwasher.

The Electromagnetics Research Team at McMaster University

RESEARCH FOCUS AND ACHIEVEMENTS

Our electromagnetics research team is part of the Department of Electrical and Computer Engineering at McMaster University, Canada. It comprises two laboratories: the Simulation Optimization Systems (SOS) Research Laboratory[1] and the Computational Electromagnetics (CEM) Research Laboratory.[2]

Our team is engaged in leading-edge research in electromagnetics-based computer-aided analysis and design of high-frequency structures as well as inverse imaging for the purposes of biomedical diagnostics and non-destructive testing.

The SOS Research Laboratory, headed by Prof. John W. Bandler and founded more than two decades ago, paved the way to the world's first statistical modeling/yield-driven design technology used within major CAD/CAE products. Collaborations, notably with Optimization Systems Associates Inc. (OSA), founded by Bandler, were vital. They made possible the creation of OSA's RoMPE™, HarPE™ and OSA90/hope™, featuring the world's most powerful harmonic balance optimization engines, as well as Empipe™, Empipe3D™, EmpipeExpress™, ***empath***™ and the breakthrough Space Mapping and Geometry Capture technologies. The Empipe family became the foundation of Agilent HFSS Designer and Momentum Optimization. The world's most advanced family of L_1, L_2, Huber, and *minimax* optimizers were implemented. Pioneering developments include design centering, optimal assignment of tolerances, postproduction tuning, and production yield enhancement.

Since 1993, the SOS Research Laboratory has focused on the Space Mapping technology, which it pioneered. This led to the development and exploitation of the user-friendly Matlab-based system called SMF (Space Mapping Framework). The Space Mapping technology, together with surrogate-based modeling and optimization, have grown to become a major research thrust in modern engineering optimization.

The SOS Research Laboratory is currently recognized as a world leader in the theory and applications of the optimization of complex engineering systems.

The CEM Research Laboratory was founded in 1999 and since then has built an international reputation for its leading-edge research in the areas of computer-aided electromagnetic analysis and design. Research is directed by professors Natalia K. Nikolova and Mohamed H. Bakr. On average, the group has 10 full-time graduate students and 2 postdoctoral fellows.

The CEM group works in collaboration with a number of research and industrial partners, notably, Research In Motion (RIM), Intratech Inline Inspection Services, DRDC (Defence Research and Development Canada), Royal Military College, University of Victoria, etc. Projects include microwave imaging for medical diagnostics, radiation hazard evaluation, magnetic flux leakage techniques for nondestructive testing, novel numerical approaches to high-frequency (microwave and photonic) structure analysis, sensitivity analysis for design optimization and inverse problem solutions. Our students are currently actively involved in the design and fabrication of ultra-wideband antennas for microwave imaging as well as a photogrammetry system for surface shape acquisition aiding inverse imaging. They master the theory and practice of electromagnetic simulation, optimization and image reconstruction.

The CEM Research Laboratory has pioneered the development of the first general sensitivity solvers, which work together with commercial and in-house electromagnetic simulators to produce response sensitivities with practically no computational overhead. The sensitivities are used in design optimization and image reconstruction driven by electromagnetic simulation leading to dramatic acceleration of these iterative procedures. With the aid of the computationally cheap sensitivities, yield and tolerances of complex structures are now estimated within seconds. Modeling based on electromagnetic simulation is also made faster and more reliable since the system behavior is described not only through its responses but also their gradients in the parameter space.

RESEARCH FACILITIES

Our research facilities are equipped with vector network analyzers (3.8 GHz, 50 GHz, 110 GHz, 4-port 20 GHz with a 16-port test-set), spectrum analyzers, high-speed oscilloscopes and high-speed arbitrary waveform generators. We have access to the anechoic chamber, the electromagnetic interference chamber and the specific absorption rate measurement facilities at RIM.

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[1] http://www.sos.mcmaster.ca/
[2] http://www.ece.mcmaster.ca/faculty/nikolova/cgi-bin/ceml.cgi

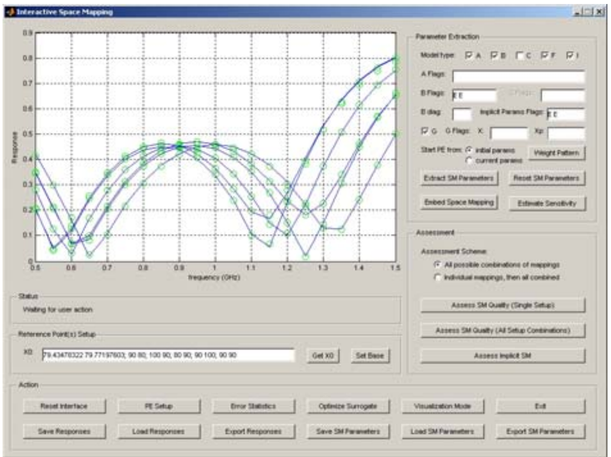


Fig. 1. Space mapping framework (SMF) user interface.

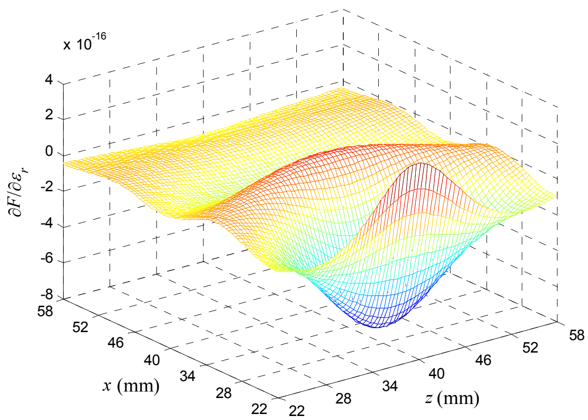


Fig. 2. Permittivity Jacobian map at 4 GHz in an x-z cross-section of a breast model derived from a time-domain field solution obtained with Quickwave-3D. The minimum indicates the presence of a small scatterer (tumor simulant).

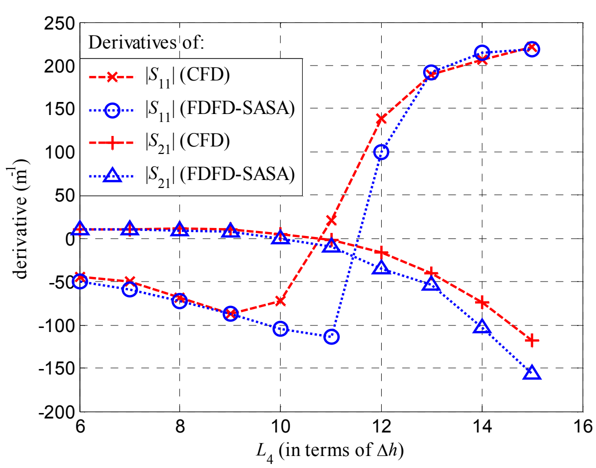


Fig. 3. Derivative curves for the S-parameter magnitudes of a waveguide filter calculated from field solutions obtained from a simulation with Ansoft HFSS. The plot validates our results (marked FDFD-SASA) with response-level central finite differences (marked CFD). Derivatives are with respect to a shape parameter L_4 for a sweep of L_4.

Commercial high-frequency CAD packages include: Ansoft HFSS and Maxwell, EMSS FEKO, Remcom XFDTD, Faustus Mefisto-3D Pro, Agilent ADS and Momentum, Sonnet ***em***; QWED Quickwave-3D, etc. We have a powerful computational 12-node Blade cluster. Each of the nodes can handle problems with memory requirements up to 32 GB of RAM.

PROJECTS

Some of the current research projects include:

- Matlab-based Space-Mapping Framework (Fig. 1)
- Sensitivity analysis of high-frequency structures (Figs. 2 and 3)
- Microwave imaging for breast cancer detection (Figs. 4, 5 and 6)
- Antenna design for the microwave imaging system for breast cancer detection (Fig. 7)
- Photogrammetry-based surface reconstruction for arbitrary 3-D objects aiding microwave imaging (Fig. 8)
- Antenna design for minimum specific absorption rate (SAR) of modern handset wireless devices
- SAR evaluation of handhelds (Fig. 9)
- Pipeline inspection based on magnetic flux leakage measurements (Fig. 10)
- Modeling and design of photonic structures (Fig. 11)
- Magnetic tracking system for biomedical applications
- Noise-based radar for concealed weapon detection

Our projects are funded by government research councils and industrial partners.

Fig. 4. S-parameter measurement of a breast phantom.

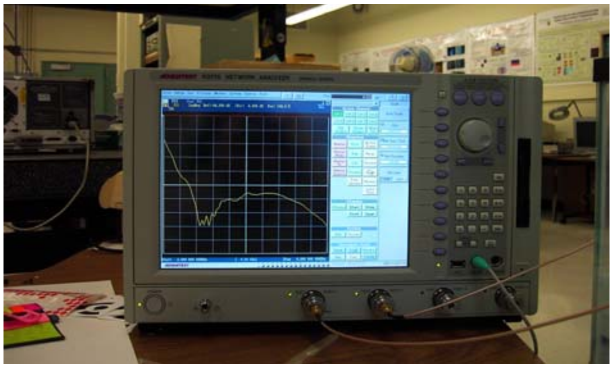


Fig. 5. The 4-port 20 GHz vector network analyzer (Advantest) used in the phantom measurements shown in Fig. 4.

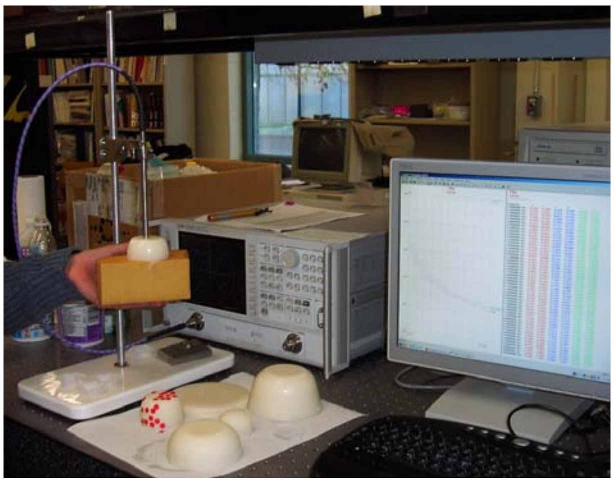


Fig. 6. Measuring the complex permittivity of breast phantoms with Agilent's Dielectric Probe 85070E.

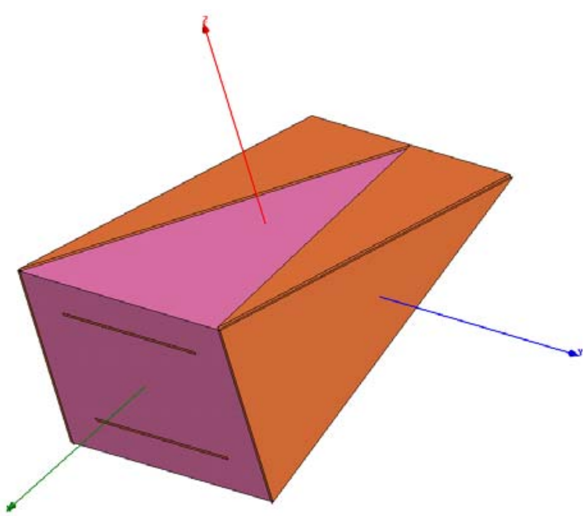


Fig. 7. A solid view of the CAD model of a novel ultra-wideband TEM-horn antenna for breast-imaging measurements.

OUR PROFESSORS

Prof. Bandler studied at Imperial College London and received the B.Sc.(Eng.), Ph.D., and D.Sc.(Eng.) degrees from the University of London, England, in 1963, 1967, and 1976, respectively. He joined McMaster University, Canada, in 1969. He is now Professor Emeritus. He was President of Optimization Systems Associates Inc. (OSA), which he founded in 1983, until November 20, 1997, the date of its acquisition by Hewlett-Packard. He is President of Bandler Corporation, which he founded in 1997. He is Fellow of several societies, including the IEEE, the Royal Society of Canada, and the Canadian Academy of Engineering. He received the Automatic Radio Frequency Techniques Group (ARFTG) Automated Measurements Career Award in 1994, and the IEEE MTT-S Microwave Application Award in 2004.

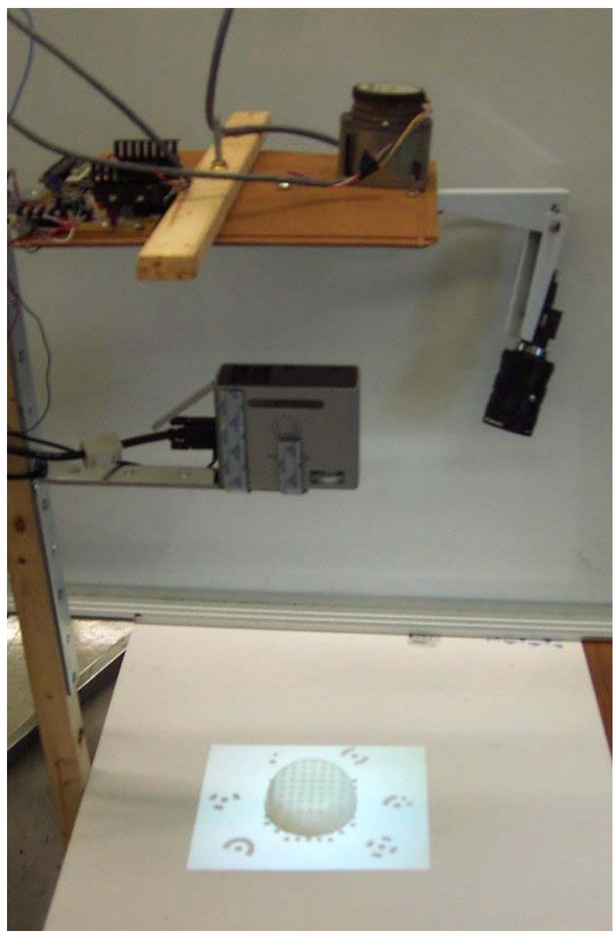


Fig. 8. Photogrammetry system for surface shape acquisition. The knowledge of the shape of the object whose interior is imaged through microwave *S*-parameter measurement enhances greatly the speed and the convergence of the reconstruction algorithm.

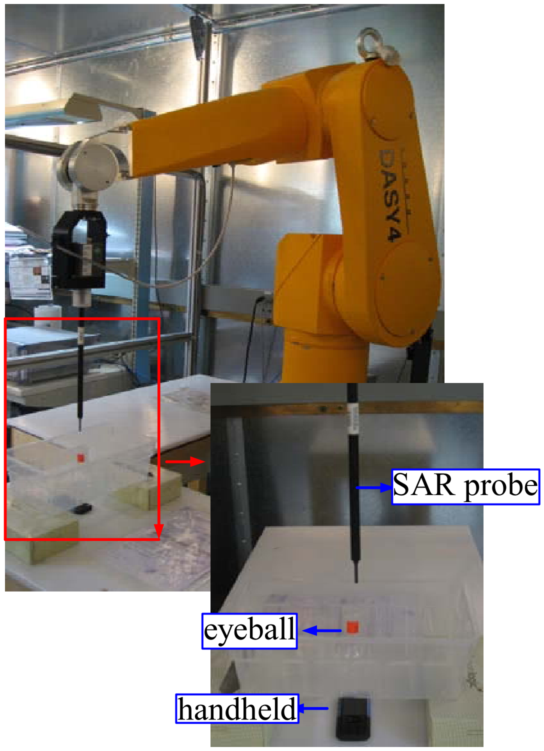


Fig. 9. SAR measurement robot with our human-eye phantom.

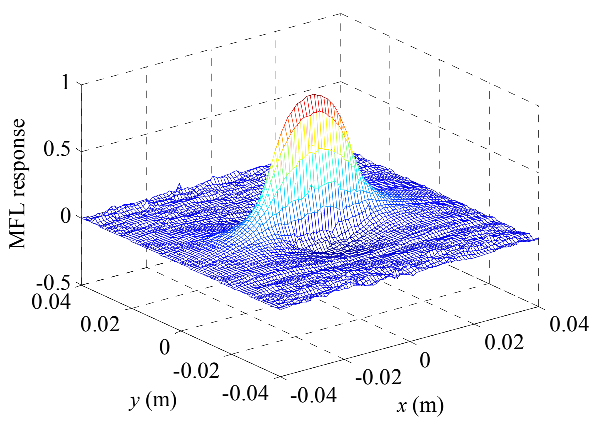


Fig. 10. The magnetic-flux-leakage (MFL) signal clearly indicates the presence of a crack in the wall of a steel gas-line pipe.

Prof. Bakr received the Ph.D. degree from McMaster University, Hamilton, ON, Canada, in 2000. In November 2000, he joined the Computational Electromagnetics Research Laboratory, University of Victoria, Victoria, Canada, as NSERC Post-Doctoral Fellow. He is currently an Associate Professor with the Department of Electrical and Computer Engineering, McMaster University. His research areas include computer-aided design and modeling of microwave circuits and photonic devices, neural-network applications, and bio-electromagnetism.

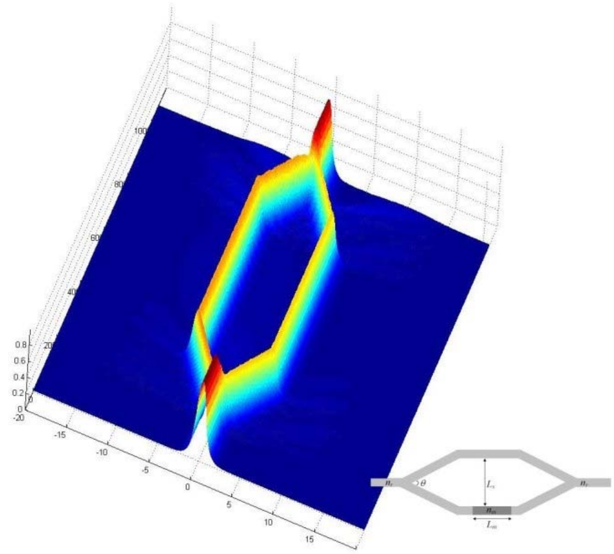
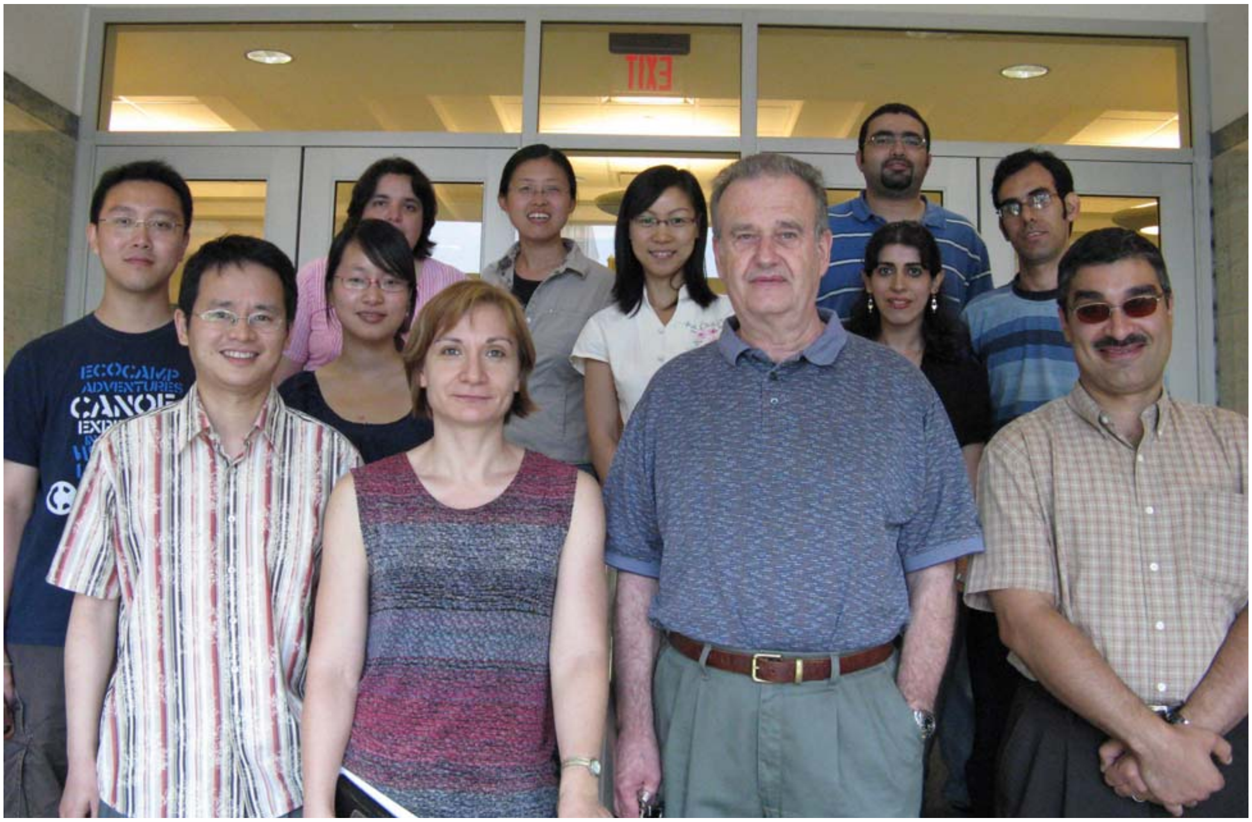


Fig. 11. Mach-Zehnder modulator ("On" state).

Professor Nikolova received the Ph.D. degree from the University of Electro-Communications, Tokyo, Japan, in 1997. From 1998 to 1999, she held a Postdoctoral Fellowship of the Natural Sciences and Engineering Research Council of Canada (NSERC), during which time she was initially with the Microwave and Electromagnetics Laboratory, DalTech, Dalhousie University, Halifax, Canada, and, later, for a year, with the Simulation Optimization Systems Research Laboratory, McMaster University, Hamilton, ON, Canada. In July 1999, she joined the Department of Electrical and Computer Engineering, McMaster University, where she is currently an Associate Professor. Her research interests include theoretical and computational electromagnetism, high-frequency analysis techniques, computer-aided design of high-frequency structures as well as inverse-problem solutions. Dr. Nikolova held a University Faculty Award of NSERC from 2000 to 2005. Since 2008, she is a Canada Research Chair in High-frequency Electromagnetics. She is a senior member of the IEEE, a correspondent of the International Union of Radio Science (URSI), a member of the Applied Computational Electromagnetics Society (ACES) and the ACES Board of Directors.



Members of the electromagnetics team at McMaster University in July 2008. From left to right: 1st row – Dr. Qingsha Cheng (research associate), Prof. Natalia Nikolova, Prof. John Bandler, Prof. Mohamed Bakr; 2nd row – Kai Wang (M.A.Sc. student), Xiaying Zhu (M.A.Sc. student), Li Liu (Ph.D. student), Maryam Ravan (post-doctoral fellow), Reza Amineh (Ph.D. student); 3rd row – Aastha Trehan (M.A.Sc. student), Jie Meng (M.A.Sc. student) and Mohammed Swillam (Ph.D. student).