COVER SHEET FOR GRANT PROPOSALS

State Board of Education

SBOE PROPOSAL NUMBER: (to be assigned by SBOE)	AMOUNT REQUESTED: $50,000

TITLE OF PROPOSED PROJECT: Research on Films with Columnar Structure to Improve Memristor Speed, Reliability and Lifespan

SPECIFIC PROJECT FOCUS:

The proposed research—which Boise State is in the process of patenting—seeks to vastly improve the speed, reliability, and life span of redox nonvolatile conductive bridge memory (CBM) memristors. These memristors are a new emerging technology poised to replace the existing FLASH memory which has reached the limits of scaling. The potential market for this kind of memory is huge, driven in large part by the urgent need for such memory among the mobile platforms whose production and application grows every day. Non-volatile CBMs are two-terminal devices built up by two metal electrodes, one made from an electrochemically active metal (for example, silver or copper) and the other from an electrochemically inert metal (for example, platinum, tungsten, or nickel). Between the two electrodes there is an "active film," usually chalcogenide glass, or oxide. The performance of these memristors is based upon formation and dissolution through an electrochemical process of a metal filament embedded in the active film which contributes to the digital function of the devices – high resistive condition (off) and low restive condition (on) when the metal filament bridges the two electrodes.

Problem Causes and the Opportunity. A core reason for performance failure has to do with how silver ions distribute between electrodes on each side of the memristor, as they bridge from one side to another. Their distribution can be jagged and irregular, forming branches which do not contribute to the device performance and over time, begin to change shape and length, effectively scattering the bridge until it loses continuity and the device fails. The memristor under development in this project is unlike any known. At a successful prior demonstration in some germanium-containing chalcogenide glass films, we showed that we can instead direct the silver distribution to bridge on an *unvarying path*, never losing integrity. As a result, the memristor becomes more reliable, and maintains a longer life span in keeping with no additional cost to produce it. What's more, we believe this new design will also offer an increase in speed, while consuming less power than today's non-volatile CBM memristors. We anticipate these outcomes because by avoiding the branching and spanning directly between the two electrodes, the bridge will be of a shorter length.

Goal. The goal of the proposed project is to build on prior research by developing a mathematical model for creating a columnar structure in the active film. We will use this model to confine the bridge structure formation, and then to demonstrate intended results in the primary nonvolatile CBM materials that manufacturers are currently using in the R&D —chalcogenides and oxides. Our intent is through this project to identify the films that best optimize reliable bridging. The outcome of this project will be a proof of concept commercial product that Boise State can offer for licensing. Our prior patents, licensing and industry consulting and relationships in this arena will help to facilitate technology transfer.

PROJECT START DATE: 7/1/13	PROJECT END DATE: 6/30/14
NAME OF INSTITUTION: Boise State University	DEPARTMENT: Office of Sponsored Programs

ADDRESS: 1910 University Dr., Boise, ID 83725

E-MAIL ADDRESS: osp@boisestate.edu		PHONE NUMBER: (208) 426-4420	
	NAME:	TITLE:	SIGNATURE:
PROJECT DIRECTOR/PRINCIPAL INVESTIGATOR	Dr. Maria Mitkova	Associate Professor	Not required
CO-PRINCIPAL INVESTIGATOR			

NAME OF PARTNERING COMPANY:	COMPANY REPRESENTATIVE NAME:

	NAME:	SIGNATURE:
Authorized Organizational Representative		
	~~Karen Henry~~ Lisa Jordan, CRA	[signature]

SUMMARY PROPOSAL BUDGET

Name of Institution: Boise State University

Name of Project Director: Dr. Maria Mitkova

A. PERSONNEL COST (Faculty, Staff, Visiting Professors, Post-Doctoral Associates, Graduate/Undergraduate Students, Other)

Name/ Title	Salary/Rate of Pay	Fringe	Dollar Amount Requested
Dr. Maria Mitkova, Associate Professor	.5 months $90,251/year	31% of salary	$6,568
Graduate Research Assistant (1); to be hired	12 months $24,000/year	7% of salary	$25,680

% OF TOTAL BUDGET:	65%	SUBTOTAL:	$32,248

B. EQUIPMENT: (List each item with a cost in excess of $1000.00.)

Item/Description	Dollar Amount Requested
SUBTOTAL:	$0

G. TRAVEL:

Dates of Travel (from/to)	No. of Persons	Total Days	Transportation	Lodging	Per Diem	Dollar Amount Requested
To be determined Professional Conference or Collaborative Meetings with Arizona State University	1	5	$500/airfare $50/ local transport	$1,000	$350/per diem $600/ conference registration fee (if needed)	$2,500
					SUBTOTAL:	$2,500

H. Participant Support Costs:	Dollar Amount Requested
1. Stipends	
4. Other	
SUBTOTAL:	$0

I. Other Direct Costs:	Dollar Amount Requested
1. Materials and Supplies	
2. Publication Costs/Page Charges	
3. Consultant Services (Include Travel Expenses)	
4. Computer Services	
5. Subcontracts	
6. Other (specify nature & breakdown if over $1000) Graduate Student Fee Remission estimate for academic year 2013-2014 Laboratory Fees for the Boise State Center for Materials Characterization (approximately 150 hours@average of $38/hr	$9,552 $5,700
SUBTOTAL:	$15,252

J. Total Costs: (Add subtotals, sections A through I) **TOTAL:**	$50,000
K. Amount Requested: **TOTAL:**	$50,000

Project Director's Signature: Not required	Date:

INSTITUTIONAL AND OTHER SECTOR SUPPORT
(add additional pages as necessary)

A. INSTITUTIONAL / OTHER SECTOR DOLLARS

Source / Description	Amount

B. FACULTY / STAFF POSITIONS

Description

C. CAPITAL EQUIPMENT

Description

D. FACILITIES & INSTRUMENTATION (Description)

Processing

Most of the processing equipment is located in a common-use Idaho Microfabrication Laboratory at Boise state University (BSU) as well as the laboratories of the PI. In addition to acid and solvent wet benches and photoresist processing tools (spinners, ovens, etc.), the equipment relevant to this project includes:

- **Cressington 308R Modular Coater** – a highly versatile thin film deposition system with two resistively heated evaporation sources, a dc magnetron sputter head, and a glow discharge substrate cleaning head, capable of taking substrates up to 8 inch diameter on its rotating sample holder.
- **Woollam WVASE32 Ellipsometer** - a variable angle (60–90 degrees) spectroscopic ellipsometer. Measurements are performed in the wavelength range 420nm – 780 nm. This tool is used to determine thin film thickness and optical constants. (BSU)
- **Rudolph AutoEL II Ellipsometer -** a single wavelength ellipsometer using the 632.8 nm line of a He:Ne laser for measuring thickness and refractive index of thin dielectric films.
- **Dektak IIA Profilometer** - a surface profilometer that can measure topography with a scan length of 1 – 5 mm and about 10 nm vertical resolution. The maximum step height is 30 microns.
- **Karl Suss MJB3 Contact Aligner** - a highly versatile tool which can handle small pieces, wafers up to 3-inches, and masks up to 4 inches square. The tool can be operated in proximity and hard contact modes. Typical line resolution is 2 microns with I-line (365 nm) exposure.
- **LEO 1430 VP** scanning electron microscope with an Oxford Instruments EDS light element detector, electron beam lithography capabilities, and an electron backscatter diffraction (EBSD) detector.
- **Veeco NT1100** Optical Profiling System, a Gaertner Scientific ellipsometer, and a number of semiconductor-device processing capabilities including photolithography, dry etching, and chemical mechanical planarization.

Electrical Characterization Cascade Summit 11560 Probe Station equipped with an Auto-guard chamber for making ultra-low noise (< 50 fA) and low capacitance (10 aF resolution) measurements is available for device characterization. Three additional probe stations with multiple micromanipulators and heating/cooling capability are maintained in a test facility and are connected to a variety of test instruments, including an Agilent 1455C Semiconductor Parameter Analyzer, Tektronix TDS540B.

Materials Characterization A Hitachi S4700 field emission scanning electron microscope with a resolution of 1.5 nm and both secondary electron and back-scattered electron imaging modes is available for materials characterization. It is equipped with an energy dispersive x-ray analyzer (EDXA Phoenix) for elemental analysis. The FESEM can accept a variety of sample sizes from small pieces to 6” wafers, x-ray photoelectron spectroscopy (XPS), as well as transmission electron microscopy (TEM). X-ray diffraction (XRD) and modulated differential scanning calorimetry (MDSC) are also available.

In addition to the characterization tools described above, the PI has electrical measurement and characterization tools in her laboratory as well as access to a number of other instruments including: a Zeiss Axiovert 200 inverted optical microscope, nuclear magnetic resonance (NMR), micro-Raman spectroscopy.

Proposal to the Idaho Incubation Fund Program for FY 2014

1. Boise State University

2.Faculty Member and Institution	Maria I. Mitkova, with the Department of Electrical & Computer Engineering at Boise State University would direct the proposed project.
3.Past Incubation Fund Awards	This technology has never been proposed or granted an Incubation Fund award.

4.Executive Summary

The proposed research – which Boise State is in the process of patenting - seeks to vastly improve the speed, reliability, and life span of redox conductive bridge nonvolatile memristors forming the so called RRAM. The potential market for this kind of memory is huge and there is an urgent need for such memory, driven by the mobile platforms whose production and application grows every day. The non-volatile RRAM memristors are two-terminal devices build up by two metal electrodes, one of which is comprised by electrochemically active metal (for example silver or copper) and the other one is from an electrochemically inert material (for example platinum, tungsten, nickel, etc.) and a film - usually chalcogenide glass, or oxide between them which we call in this project "active film". The performance of these memristors is based upon formation and dissolution of a metal film embedded in the active film which contributes to the digital performance of the devices – high resistive condition (off) and low restive condition (on) when the metal film bridges the two electrodes.

Problem Causes and the Opportunity. A core reason for performance failure has to do with how silver ions distribute between electrodes on each side of the memristor, as they bridge from one side to another. Their distribution can be jagged and irregular, forming branches which do not contribute to the device performance and over time, begin to change shape and length, effectively scattering the bridge until it loses continuity and the device fails. The memristor under development in this project is unlike any one known so far. At a successful prior demonstration in some Germanium-containing chalcogenide glass films, we showed that we can instead direct the silver distribution to bridge on an unvarying path, never losing integrity. As a result, the memristor becomes more reliable, and maintains a longer life span in keeping with the additional cost to produce it. What's more, we believe this new design will also offer increase in speed, while consuming less power than today's non-volatile RRAM memristors, because of the shorter length of the bridge spanning directly between the two electrodes, avoiding the branching.

Goal. The goal of the proposed project is to build on prior research by developing a mathematical model for creation of a columnar structure in the active film, which to confine the bridge structure formation, and then to demonstrate intended results in the primary nonvolatile RRAM memristor materials that manufacturers are currently using—chalcogenides and oxides. Our intent is through this project to identify the films that best optimize reliable bridging. The outcome of this project will be formation of a fully completed commercialization product which Boise State can offer for licensing. In addition, our prior patents, licensing and industry consulting and relationships in this arena will help to facilitate technology transfer.

5. "GAP" PROJECT OBJECTIVE AND TOTAL AMOUNT REQUESTED

The objective of this project is to study the conditions at which a specific columned structure forming channels with a specific size could be formed in the films connecting the two electrodes of the memristor. This includes theoretical development of these conditions and experimental work dealing with oxides and chalcogenide films. We are very familiar with the later and succeeded in formation of a specific columnar structure in them, however, our initial experiments do not include all members of the germanium- containing chalcogenides, and oxides which could be of interest for the industry. Our research will be aimed towards creation of a technology enabling the formation of such channeled structure which could be directly applied by the industry.

6. Resource Commitments Reflection Over the Priorities of Boise State University:

Boise State University aspires to be a research university known for the finest undergraduate education in the region, and outstanding research and graduate programs. The university is a vital part of the community, and its commitment to the community extends beyond the educational programs, research, and creative activity.

The proposed project will play a role in three of the priorities for Boise State - (i) it will involve a graduate student to work on the project. This graduate student will gain experience in a very advanced field of the microelectronic and the new non-volatile memory solutions. The work on the project will require many creative solutions which will help the student to understand the value and the importance of the higher education he/she is getting at Boise State. (ii) The pioneering work and results in development and improvement of the non-volatile memory, which will be carried out during the implementation of the project will be achieved with the methods of STEM disciplines which Boise State pointed as one serious priority and the University is motivated to contribute a lot to the growth of their importance and the number of students graduating in the STEM fields. (iii) The product of this project is of interest for the Idaho private sector industry which in return will have an impact on the people working in it. This is in harmony with the community engagement of Boise State which is working with the community to create a rich mix of culture, learning experiences, and entertainment that educates and enriches the lives of our citizens. Boise State's campus culture and climate promote civility, inclusivity and collegiality.

7. Potential Impact to Idaho Economy

There are plenty of semiconductor companies in Idaho—Micron Technology Inc., American Semiconductors, Applied Materials, to name a few. Among them Micron Technology Inc. is the biggest one and indeed the biggest employer in Idaho. Micron Technology has licensed from Axon Technology Inc. the non-volatile RRAM memristors. There is a very high interest in developing new non-volatile memory solutions at Micron and the company offers NAND Flash and NOR Flash for computers and mobile devices. There is a high demand for non-volatile memory for all newly developing mobile electronics, which, there is no doubt, Micron will address and for which the non-volatile RRAM memristors will find tremendous application. So, this project, which will contribute to the increased speed performance of these devices and will improve their reliability and lifespan, will be of highest importance for Micron Technology Inc. as well as for many other semiconductor industry enterprises in Idaho and will help them win best market position.

8. The Market Opportunity:

a. The project will address the requirements for very fast switching of RRAM memristors and will increase their reliability. Those are among the major problems related to this type of memory in quest of solution. So the proposed project will help in resolving industrial challenge of a very high significance.

b. One industry overview prepared by Boise State's Group for Economic Development shows that advanced solid state non-volatile memory chips for which the RRAM memristors are the main building block, are expected to see tremendous growth in the next several years. The global market for *emerging non-volatile random access memory* products has reached $115 million in 2010. This market is expected to increase to 1.6 billion by 2015 at an average annual growth (AAGR) of 69% through the forecast period, which includes emerging technologies. [http://www.marketresearch.com/corporate/aboutus/press.asp?view=3&article=2223]

Next generation memories are the emerging non-volatile memory technologies, which are expected to replace existing memories. Next generation memories majorly targets the non-volatile memories such as NAND and NOR Flash with $22.9bill market in 2012 [http://www.electroiq.com/articles/sst/2012/04/nand-flash-memory-sees-steady-growth-thanks-to-ultrabooks-tablets-smartphones.html].

The major drivers for the next generation memory market are faster switching time, high endurance and power efficiency. In addition, the huge application base of traditional memories will also become the driver for this market. Since these memories are not completely established, there are still flaws in processes which causes drawbacks like instability and low write endurance rate in some of the memories. As mentioned, these memories are the replacement for flash memories in near future. The flash market has already tapped the huge market and hence it makes the way for next generation new memory solutions to be developed. [http://www.electroiq.com/articles/sst/2013/03/non-volatile-memory-market-report--drivers-and-challenges-of-eme.html].

c. The technology is aimed to improve the performance of the non-volatile RRAM memristors. They represent a small fraction of the price of the chip but because of the multiplication of the effect due to the volume of the market for such type of memory, its value will be really high. A warranty for the value of this technology for the market comes by the fact that it targets the two most important requirements which need solid and effective solution –

the high switching speed and reliability of this type of memristors. The market, with all new mobile platform solutions, requiring non-volatile memory, is practically endless.

9. The technology and the path to commercialization:

a. The project is related to research, for which already a solution has been disclosed at the Boise State Patent Committee, which will result in formation of a specific columnar structure in the active film of the non-volatile memory RRAM memristors. This structure results in formation of channels in the films which size can be controlled by the technological process, in which the metal ions of the conductive bridge will travel between the two electrodes. Thus, the so completed channel structure will contribute to the faster diffusion of the metal ions and faster formation of the conductive bridge because there will be an established direct pathway for the ions to traverse. So the bridge will grow one dimensionally within the channel *avoiding* formation of branches and other futile side structures which on one hand would retard the bridge formation and on the other hand would reduce the reliability of the device since the growing bridge will not follow the same pattern at each switching process. Currently amorphous films are used between the two electrodes. Because of the disordered structure of these films, the conductive bridge forms plenty of branches and takes a way dictated by the disordered structure of the films, which increases the time for the bridge formation. In addition, because of the disordered structure of the applied films, there are many options for the conductive bridge to form within the amorphous medium which decreases the reliability of the devices.

b. The technology will bring improvement in the two major requirements related to the performance of the non-volatile RRAM memristors – their switching speed and reliability which inevitably will speed up their introduction to the market place. The technology has been disclosed at Boise State and decision to file a patent has been made.

c. The technology has been developed by Dr. Maria Mitkova with the experiments carried out by one of her students – Muhammad Rizwan Latif without specific funding for the research. Boise State has paid the standard salary of M. Mitkova who is Assoc. Professor and the scholarship and tuition for M. R. Latif who is a PhD student.

d. Once protected by patent law and developed in full, this technology will be offered for licensing, which could initiate a revolution in the computer and mobile platforms industry influencing the memory architecture and leading to very limited power consumption. M. Mitkova has contacts to potential licensees and she will be assisted in forging a license by the Boise State's University and Industry Ventures to the Division of Research and Economic Development.

10. Commercialization partners:

The first commercialization partner which comes to mind is Micron Technology Inc. because of the location of the head quarter of the company in Idaho, its high interest in non-volatile memory for mobile devices, and because of the close relationship between it and Boise State. There is collaboration agreement between the Boise State and Micron Technology Inc. which works very effectively in many aspects and contributes to increasing the quality of education offered at Boise State and in return delivery of better professionals for Micron. Because of the close interaction between them, there are many open avenues which could be explored for licensing. If necessary, this could include meetings with the leaders of the Emerging memory technology team in Micron. Such meetings can result in understanding the specific needs of

Micron, so that the research on project to be oriented directly to deliver a solution for them. Upon successful completion of this project, future activities could be related for example to development of new technologies for memristive arrays fabrication, etc.

Besides licensing and collaboration with Micron Technology Inc. which is of crucial importance for the economy of Idaho, the project offers endless opportunities for licensing by other semiconductor companies which are developing the nonvolatile RRAM memristors. One of them is for example Adesto Technology Inc. located in Sunnyvale CA, which has been created in order to develop integrated circuit solutions in which nonvolatile RRAM memristors are embedded. Dr. M. Mitkova has been consulting in this company, which will alleviate the contact with them. Other companies which announced their interest in development of nonvolatile RRAM memristors are Seagate Technology Inc., Samsung, Sony, NEC, etc.

11.Specific Project Plan and Detailed Use of Funds

The tasks to be undertaken in fulfillment of the project are divided in five major groups:

Theory - Theoretical considerations about formation of a columnar structure in thin films obtained by physical deposition methods – influence of the deposition rate and other deposition parameters over the films' structure; mathematical description of the formation of column structure for chalcogenide and oxide films.

Experiments with Chalcogenide Glasses - Experiments related to formation of films with columnar structure based on chalcogenide glasses – study of the effect of the film composition for the size of the channels in the formed films, discussion of the role of the films' structure and composition over the characteristics of the columnar structure.

Experiments with Oxides - Experiments related to formation of films with columnar structure based on oxides – study of the effect of the film composition for the size of the channels in the formed films, discussion of the role of the films' structure and composition over the characteristics of the columnar structure.

Study of Silver Diffusion - Silver diffusion will be studied through performing Energy Dispersion Spectroscopy (EDS) and Neutron Reflectometry for establishing of the diffusion profile and measurement of the in situ diffusion dynamics.

Devices Testing – This step will verify the outcome of the project

Here are details about milestones and performance metrics, including:

- Preliminary theoretical treatment of the problem for columnar structure formation – the metrics will be mathematical presentation of the structural model of the films
- Full characterization of the columnar structure formation in germanium-containing chalcogenide glasses – the metrics is fabrication of the films and their characterization with scanning electron microscope
- Full characterization of the columnar structure formation in oxide films – the metrics is fabrication of the films and their characterization with scanning electron microscope
- Study of the Ag diffusion in the formed films – the metrics is delivery of compositional results - EDS, XRD, as well as data from in situ Ag diffusion.
- Devices preparation and testing with Agilent 4155B Semiconductors Parameter Analyzer – the metrics are fabricated devices and I-V characteristics as well as retention characteristics.

Team and Roles - The team working on the project will be completed by Dr. Maria Mitkova, associate professor, and Mr. Muhammad Rizwan Latif – PhD student at Boise State.

Dr. M. Mitkova will be responsible for the scientific leadership of the project. She will give the guidelines as how the research will be conducted, as well as will control the development of the research. She is committing 0.5 month summer effort ($5,014). This request is based on her annual salary of $90,251. Benefits are 31% of salary, so the total amount salary + fringe benefits for her included in the projects' budget is $6,568.

Mr. Muhammad Rizwan Latif is a PhD student who will be responsible for conducting the experimental work related to the project. He is committing one year for this work which includes $24,000 for his scholarship with $1,680 fringe benefits and also $9,719 for his tuition compensation.

The budget foresees $5,533 for payments for usage of the Idaho Microfabrication Laboratory and the Boise State Center for Materials Characterization as well as $2,500 for participation at the Material Research Society meeting for presentation of the results of the project or alternatively visit to Arizona State University for carrying out of Rutherford Backscattering analysis of the produced films which is the best for their characterization and such equipment is not available at BSU.

12. Institutional and Other Sector of Support

Boise State with its infrastructure will support the work on the project. It posses well developed facilities presented in details in the Appendix which will be used for the project. Boise State will also support through the Office for Economic Development the licensing of the results of the project through aggressive search for companies who would be interested from the results of this project as well as will negotiate the licensing conditions.

FACILITIES AND EQUIPMENT

Processing

Most of the processing equipment is located in a common-use Idaho Microfabrication Laboratory at Boise state University (BSU) as well as the laboratories of the PI. In addition to acid and solvent wet benches and photoresist processing tools (spinners, ovens, etc.), the equipment relevant to this project includes:

- **Cressington 308R Modular Coater –** a highly versatile thin film deposition system with two resistively heated evaporation sources, a dc magnetron sputter head, and a glow discharge substrate cleaning head, capable of taking substrates up to 8 inch diameter on its rotating sample holder.
- **Woollam WVASE32 Ellipsometer** - a variable angle (60–90 degrees) spectroscopic ellipsometer. Measurements are performed in the wavelength range 420nm – 780 nm. This tool is used to determine thin film thickness and optical constants. (BSU)
- **Rudolph AutoEL II Ellipsometer -** a single wavelength ellipsometer using the 632.8 nm line of a He:Ne laser for measuring thickness and refractive index of thin dielectric films.
- **Dektak IIA Profilometer** - a surface profilometer that can measure topography with a scan length of 1 – 5 mm and about 10 nm vertical resolution. The maximum step height is 30 microns.
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- **LEO 1430 VP** scanning electron microscope with an Oxford Instruments EDS light element detector, electron beam lithography capabilities, and an electron backscatter diffraction (EBSD) detector.

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Electrical Characterization

Cascade Summit 11560 Probe Station equipped with an Auto-guard chamber for making ultra-low noise (< 50 fA) and low capacitance (10 aF resolution) measurements is available for device characterization. Three additional probe stations with multiple micromanipulators and heating/cooling capability are maintained in a test facility and are connected to a variety of test instruments, including an Agilent 1455C Semiconductor Parameter Analyzer, Tektronix TDS540B.

Materials Characterization

A Hitachi S4700 field emission scanning electron microscope with a resolution of 1.5 nm and both secondary electron and back-scattered electron imaging modes is available for materials characterization. It is equipped with an energy dispersive x-ray analyzer (EDXA Phoenix) for elemental analysis. The FESEM can accept a variety of sample sizes from small pieces to 6" wafers, x-ray photoelectron spectroscopy (XPS), as well as transmission electron microscopy (TEM). X-ray diffraction (XRD) and modulated differential scanning calorimetry (MDSC) are also available.

In addition to the characterization tools described above, the PI has electrical measurement and characterization tools in her laboratory as well as access to a number of other instruments including: a Zeiss Axiovert 200 inverted optical microscope, nuclear magnetic resonance (NMR), micro-Raman spectroscopy.

MARIA I. MITKOVA

Associate Professor,

Department of Electrical & Computer Engineering (Phone) 208.426.1319
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1910 University Dr. Boise, ID 83725-2075 (E-mail) mariamitkova@boisestate.edu

Web site: http://coen.boisestate.edu/mariamitkova/

PROFESSIONAL PREPARATION

Diploma (MS) in Microelectronic Technologies (*magna cum laude)* Technological University, Sofia, Bulgaria,

Ph.D. in Technical Sciences, Technological University, Sofia, Bulgaria.

APPOINTMENTS

Assoc. Professor Dept. of Electrical & Computer Engineering Boise State University Nov. 2006 – current.

Res. Assoc. Prof. Dept. of Electrical Engineering/CSSER, Arizona State University, AZ 00 – 06.

Research Associate in Dept. of Chemistry, Arizona State University, AZ 1999–2000.

Research Associate in Dept. Electrical and Computer Engineering and Computer Science, University of Cincinnati, OH 1997–1999.

Professor and Department head in Institute of Electrochemistry and Energy Systems, Bulgarian Academy of Sciences 1994–2002.

Assoc. Professor in the Institute of Optical Materials and Technologies, Bulgarian Academy of Sciences 1985–1994.

Ass. Professor Dept. Microelectronic Technologies, Technological University Sofia, Bulgaria 1979–1985.

Post Doc. Technical University Vienna, Austria 1978-1979.

RELATED PUBLICATIONS

1. S. Wald, J. Baker, M. Mitkova and N. Rafla – **A non-volatile memory array based on nano-ionic Conductive Bridge Memristors** – *2011 IEEE Workshop on Microelectronics and Electron Devices (WMED)* (2011).
2. M. Mitkova, Y. Sakaguchi, D. Tenne, S. Bhagat, T. L. Alford – **Structural Details of Ge-Rich and Silver-doped Chalcogenide Glasses for Nanoionic Nonvolatile Memory** - *Phys. Status Solidi* (a) 207, (2010) 621.
3. S. P. Thermadan, S. K. Bhagat, T. L. Alford, Y. Sakaguchi, M.N. Kozicki, M. Mitkova – **Influence of Cu diffusion conditions on the switching of Cu-SiO_2 based resistive memory devices** – *Thin Solid Films* 518, (2010) 3293.
4. A. Kovalskiy, H. Jain, M. Mitkova – **Electronic evidences for the mechanism of photo-induced silver diffusion into chalcogenide glass films** - *J. Non-Cryst. Sol.* 355 (2009) 1924.
5. Y. Sakaguchi, D. A. Tenne, M. Mitkova – **Structural Development in Ge-rich Ge-S glasses** – *J. non-Cryst. Sol.* 355 (2009) 1792.

OTHER SIGNIFICANT PUBLICATIONS

1. M. Mitkova, D. Butt, Radiation Sensor Based on Chalcogenide Glasses, US Patent Application Number: 13/249106

2. De Nyago Tafen, D.A. Drabold, M. Mitkova - **Silver transport in GexSe1−x:Ag materials: *ab initio* simulation of a solid electrolyte** *J. of Phys.: Cond. Mat.* B 72 (2005) 054201.
3. De Nyago Tafen, D. A. Drabold**,** M. Mitkova - **Direct *ab initio* simulation of silver ion dynamics in chalcogenide glasses -** *phys. stat. sol*. (b) **242**, No. 7, (2005) R55.
4. Y. Sakaguchi, A. Kovalskiy, A. Miller, H. Jain, M. Mitkova, **In Situ Measurement of x-Ray - Induced Silver Diffusion into $Ge_{30}Se_{70}$ Thin Film** — J. Am. Ceram. Soc. 91 (2008) 760.
5. M. Mitkova, P. Chen, M. Ailavajhala, D. Butt, D. Tenne, H. Barnaby, and I. Esqueda, "**Gamma ray induced structural effects in bare and Ag doped Ge–S thin films**," *Journal of Non-Crystalline Solids,* 360 (2013) 352.

SYNERGISTIC ACTIVITIES

1. Teaching Awards:

- Nomination for Outstanding mentor, Arizona State University – 2002.
- Nomination to give the last lesson before graduation, Arizona State University – 2003.

2. Memberships and Awards:

- Fellow Selenium-Tellurium Development Association, Belgium
- Member, IEEE, USA
- Member, The Materials Research Society, USA
- Member, American Society for Engineering Education, USA
- Charter for Excellent young inventor at the International Exhibition Expo 81
- DAAD scholarship—1991
- Nominations for the Stanford Ovshinsky award—2008 and 2009
- Alumni International of Rupprecht Karls University Heidelberg, Germany
- Member and chair of the Faculty Research Committee at Boise State University—2010 –
- Invited speaker at 28 conferences, most recently: The 3rd International Conference on Optical, Optioelectronic and Photonic Materials and Applications (ICOOPMA2010), The 9th International Conference on Excitonic and Photonic Processes in Condensed and Nano Materials, (EXCON'2010),

3. Technical referee for: Nature, Philosophical Magazine, Physical Review B, Applied Physics Letters, J. of Applied Physics, J. of Physics and Chemistry of Solids, Physica Status Solidi, Advanced Materials, Physica B: Condensed Matter, Journal of the American Ceramic Society,

RECENT COLLABORATORS

C. A. Angell (ASU), P. Boolchand (University of Cincinnati), D. Drabold (Ohio University), P. J. Ewen (University of Edinburgh), S. O. Kasap (University of Saskatchewan), M. N. Kozicki (Arizona State), V. Lyubin (Ber Sheva University), M. Micoulaut (University Paris), H. Oyanagi (University of Kyoto), K. Schwartz (Schwehr Ionen Forschungszentrum, Darmstadt), K. Shimakawa (Gifu University),

RECENT THESIS ADVISEES AND POSTDOCTORAL SCHOLARS

J. Aberouette (M.S. advisee) Motorola, M. Balakrishnan (M.S. /PhD advisee) Micron, M. Obi (M.S. advisee), Intel, C. Ratnakumar (M.S. advisee) Cypress, C. Gopalan (PhD advisee) Adesto Technology Inc., P. Maroufkhani (PhD advise) Intel, M. Park (PhD advisee) Spansion, Y. Sakaguchi (postdoctoral scholar), Tokyo University, Ping Chen (postdoctoral scholar).

GRADUATE ADVISORS

Prof. Zorka Boncheva-Mladenova—Technological University, Sofia, Bulgaria
Prof. Hans-Joachim Seifert—University of Kassel, Germany

POSTGRADUATE SPONSOR: Prof. Wolfgang Fallmann, Technical University Vienna, Austria

CURRICULUM VITAE

Maria I. Mitkova, Ph.D.

Associate Professor
Dept. of Electrical & Computer Engineering
Boise State University
Boise, ID 83725-2075
Tel. (208) 426 1319; Fax (208) 426 2470;
E-mail: mariamitkova@boisestate.edu
http://coen.boisestate.edu/mariamitkova/

RESEARCH FIELDS

- Amorphous semiconductors; Semiconductor device processing; Phase change non-volatile memristors; Optoelectronics and neural networks; Solid state science; Redoxy conductive bridge memristors and Radiation sensing

EDUCATION

- **Ph.D.** Dissertation topic: "Glass Formation and Creation of Phase-change Memory Devices Based on Glasses from the Ge-Se-Ga and Ge-Se-In Systems", Technological University, Sofia, Bulgaria. Advisor Dr. Zorka Boncheva-Mladenova; Co-advisor Dr. Hans-Joachim Seifert - University of Kassel, Germany
- **Diploma in engineering –** equivalent to master's degree; master's thesis "Investigation of Chemical Transport of Silver Telluride with Bromine for Growth of Semiconducting Single Crystals of β Silver Telluride", Technological University, Sofia, Bulgaria *(magna cum laude).*

EMPLOYMENT

11/2006 – current

- Associate Professor Boise State University, Dept. of Electrical & Computer Engineering

11/2003 – 10/2006

- Associate Research Professor – Dept. of Electrical Engineering, Arizona State University, Tempe, Arizona

5/2000 – 10/2006

- Director for Materials Research and Development - Axon Technology Corp., Scottsdale, Arizona

3/2000 – 11/2003

- Research Scientist – Center of Solid State Electronics Research and Dept. of Electrical Engineering, Arizona State University, Tempe Arizona

9/1999 – 6/2000

- Faculty Research Associate – Dept. Chemistry and Biochemistry Arizona State University (ASU), Tempe, Arizona

3/1997 – 9/1999

- Visiting Faculty and Faculty Research Associate, Dept. of Electrical and Computer Engineering and Computer Science, University of Cincinnati (UC), Cincinnati Ohio

11/1994 – 10/2002

- Professor, Institute of Electrochemistry and Energy Systems, Bulgarian Academy of Sciences; Department Head of Division for Amorphous Solid-State Electrolytes and Optical Recording Media.

9/1985 - 11/1994

- Associate Professor, Central Laboratory of Optical Storage & Processing of Information, Bulgarian Academy of Sciences.

10/1979 – 9/1985

- Assistant Professor in Dept. of Semiconductor Technology at the Technological University, Sofia, Bulgaria

10/1978 – 10/1979

- Post doc at the Institute for Sensor- and Actuator Systems, Department of Electronics, Technical University Vienna, Austria; under Prof. Wolfgang Fallmann

PUBLICATIONS (PRESENTED ON ADDITIONAL SHEETS) **AND CITATIONS**

- Over 120 scientific publications
- Co-author or editor of 3 books
- 5 invited chapters in books
- H-index - 19 including citations in books and patents
- 6 US patents and 9 pending US patent applications

HONORS AND AFFILIATIONS

- OAD scholarship for research – 1978, Austria
- DAAD scholarship for research – 1991, Germany
- Charter for Excellent Young Inventor at the International Exhibition Expo 81
- Nomination as Outstanding Mentor, Arizona State University – 2002.
- Nomination to give the Last Lesson before graduation, Arizona State University – 2003.
- Nomination for the Stanford Ovshinsky Award for Excellence in Research of Non-crystalline Chalcogenides 2008.
- Alumni International of Rupprecht Karls University Heidelberg, Germany – 1997
- Elected Member of the New Yourk Academy of Sciences 1996
- Fellow of the Selenium Tellurium Developing Association
- Member of the American Physical Society
- Member of the Material Research Society
- Member of IEEE
- Member of the American Society for Engineering Education
- Member of the World Federation of Scientists

CONSULTANT

- Hoechst AG, Frankfurt/Main, Germany – 1994-1997
- European Media Laboratory GmbH, Heidelberg, Germany 1995-1996
- Infineon Technologies AG, Munich, Germany 2004-2005
- Nanochip Inc. Fremont/California, USA 2005-2006
- Tower Semiconductors LTD. Tel Aviv, Israel 2006
- Adesto Inc. Sunnyvale/California, USA 2007-2009
- Micron Technology Inc., Boise/Idaho, USA 2010 - current
- pSiFlow Technology Inc., Boise/Idaho, USA 2011 - current

TEACHING

I have taught 6 individual courses since I became associate professor at BSU. These were lectures and laboratory courses on various fields of semiconductor processing and electrical properties of materials and devices where my main expertise is. Those are the following courses:

ECE 440/540	Introduction to Integrated Circuits and MEMS Processing (combined undergrad. and graduate course)
ECE 440L/540L	Introduction to Integrated Circuits and MEMS Processing Laboratory (combined undergraduate and graduate course)
ECE 441/541	Advanced Silicon Processing (combined undergraduate and graduate course)
ECE 697-003	Advanced Photolithography (graduate course)

I also taught ECE340/MSE310 Electronic Properties of Materials and Devices and ECE 597-01/002 Chalcogenide Glasses.

RESEARCH

Research on glass formation of semiconducting glasses - prediction of the glass formation in new chalcogenide and chalco-halide systems based on the Constraint Counting Theory and chemical bonding in the glasses. (publications 31, 34, 36, 38, 45, 48 on my list).

Research on phase-change nonvolatile memory devices – new technology has been developed for building of phase-change nonvolatile memory devices based on thin Ge-Se and Ge-S films doped with Ga or In. The introduction of metals contributes towards faster and more stable switching due to decrease of the crystallization enthalpy; dc as well ac and pulse operation of these devices is demonstrated showing very competitive performance compared to existing devices. (publications 68-70)

Formation of microstructures on thin films, using the intrinsic photosensitivity of the chalcogenide glasses and photodiffusion of silver in them. The diffusion kinetics is optimized by application of bi-layered structures or chemically modified silver containing glasses.(publications 21, 22, 26, 27, 35)

Real time optical recording on thin chalcogenide films. The research is focused into two areas: obtaining of an image due to phase change (photo-crystallization of the films) or by modification of the polymer network leading to change in the optical properties of the films and hence to formation of an image. In this way optical elements for the IR optics as well as holographic gratings for *Optoelectronic Neural Networks* have been produced on thin films. (publications 41-43)

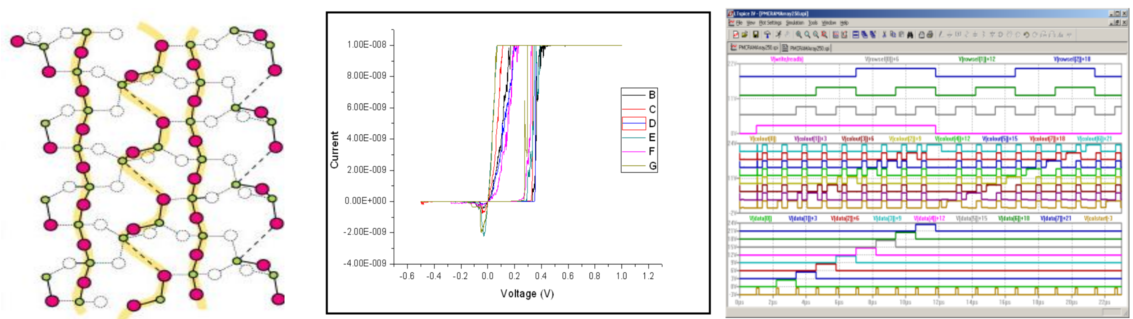
Redoxy conductive bridge memristors (programmable metallization cell (PMC) devices). These devices are built by an electrochemically inert electrode, solid electrolyte based on Chalcogenide Glass doped with electrochemically active metal (i.e. Ag or Cu) and an Ag or Cu electrode. Their performance relies on the formation and dissolution of a metal bridge growing in a solid electrolyte between the two electrodes. This resistive switching of the material is used for binary information storage (1 and 0), and defines the main aspects of this innovative improvement in the nonvolatile memory technology. The PMC process is characterized by *fast switching, information being stored not as a charge but as nanoscopic amounts of metal in the electrolyte, high scalability and reliability. The storage medium can be placed in the interconnect layers above the silicon circuitry in a back-end-of-line (BEOL) sequence, making the technology compatible with CMOS logic processes.* One of the best characteristics of these devices is that the threshold voltage for the switching to occur is within 0.2-0.5 volts. The PMC devices are recognized as a significant emerging technology – please, see the most recent ITRS link for the year 2011 for new emerging devices. http://www.itrs.net/Links/2011ITRS/2011Chapters/2011ERD.pdf where on p. 70 also works co-authored by me are referred under ## 332 and 345. My contributions are related to materials research for achieving threshold voltage for specific applications of these devices and improvement of their reliability. (publications 6, 19, 20, 23, 25)

Resonant frequency alteration - We have demonstrated a tunable MEMS resonator using our PMC electrolyte-electrodeposit system. The resonator test bed is a set of 1 μm thick suspended polycrystalline silicon beams, ranging from 50 to 200 μm in length, with an 80 nm thick film of Ag-Ge-Se (sub-saturated) electrolyte on their top surface. A silver electrode is formed at one end and both ends have aluminum pads added to facilitate bonding/packaging for electrical characterization. The electrodeposit grown on the beam changes both its vibrating mass and stiffness. My research contributed to improvement in the deposit growth kinetics. (publication 17)

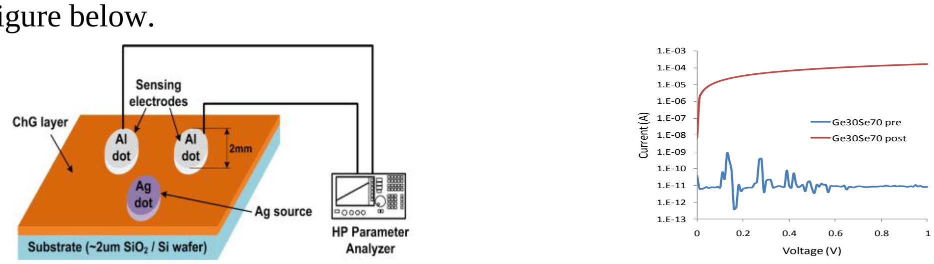
Formation of elements for bio-lab on a chip – developing of materials for valves in microchannel systems and cantilevers for bio-labs on a chip based on chalcogenide glasses with electrochemically grown and dissolved silver pathways. This enables reversible valving without mechanical parts. The material is optimized through structural and kinetic studies. (publication 24)

Alteration of reflectance for formation of optical displays - Surface electrodeposition can be used to alter the reflectance of a surface as the optical properties of the metal are obviously radically different from those of the electrolyte film. To demonstrate this, I created solid electrolyte patterns on silicon wafers, with wide electrodes at either end (Ag and Ni). Before the application of a bias, the light is able to pass through the thin film to be reflected by the substrate with little impediment. After application of a bias the pixel becomes occluded and the light is absorbed in it. Application of an opposite bias returns the optical device in its initial condition. I optimized the material for fast switching of these displays. (publication 29, 30)

Studies and application of chalcogenide glasses in memristive memory devices (their materials, structure, technology, testing, array formation) and radiation sensing. I have contributions to the understanding of the Cu diffusion in SiO_2 as material for memristors based on this material combination, developed structure model of Ge very rich chalcogenide glasses for application in memristive memory, showed the role of oxidation for the photoinduced phenomena in chalcogenide glasses. As a result I showed how the materials could be optimally used for non-volatile memristive memory. Examples of the structure of Ge very rich devices which enable easy Ag diffusion, an IV characteristic of nanoionic memristive devices and example of 8x8 memristive device array simulation produced by my students are shown on the figure below.



Radiation sensing: The radiation sensitivity of chalcogenide glasses, combined with the radiation induced Ag diffusion in them are used for formation of radiation sensors in which these two effects result in medium with much higher conductivity than the initial material. A preliminary proof of concept for these devices was the in situ study of x-ray induced Ag diffusion in chalcogenide glasses, which I conducted at BSU. It showed that using these processes low cost high performance adaptive microelectronic devices that react to γ radiation to produce an easily measured change in electrical resistance can be produced. My research is related to study of the effects, modeling them and study of the dependence – material's structure/device's function. Example for the structure of the radiation sensor and it IV characteristic are shown in the figure below.



Studies of sorption properties of chalcogenide glass films for application in gas sensing - since the chalcogenide glasses by the nature of their disordering have a big free volume and their reaction ability is very low, I expect that they would have a good gas absorption capacity and my first experiments proved these expectations. With my publications in this aspect I showed the importance of the preliminary studies of the free volume of the material, comparison between it and the molar volume and chemical activity of the gaseous molecules in order to make this usually very practically oriented field of publications a real science.

I have generated $1,837,584 funding for research ($1,228,558 as a PI and $609,026 as a co-PI). Currently I have three ongoing projects with DOD (DTRA) , and pSiFLow Technology Inc. My research has also been supported by NSF through the International Materials Institute New Functionality of Glass. NATO and NASA-ICSG funded my work related to studies of radiation effects in chalcogenide glasses.

NATIONAL AND INTERNATIONAL RECOGNITION

A. International conferences committees member and sessions chair:

1. Member of the International Program Committee Tenth International Conference of Solid State Chemistry (SSC 10 – Pardubice, Czech Republic) 2012.
2. Member of the International Program Committee of the International Conference of Optical and Optoelectronic Processes and Materials Application (ICOOPMA 2012 – Nara Japan) 2012.
3. Member of the International Advisory Committee International Conference Amorphous and Nanocrystalline Chalcogenides (ANC 3,ANC 4 and ANC 5 – 2007, 2009, 2011).
4. Session chair, 5th International Conference on Optical, Optioelectronic and Photonic Materials and Applications (ICOOPMA12 – Nara, Japan) 2012.
5. Session Chair 3rd, 4th and 5th International Conferences Amorphous and Nanocrystaline Chalcogenides (ANC3 Brasov, ANC4 Constanta, and ANC5 Bucharest Romania) 2007, 2009 and 2011.
6. Session Chair, Fourth International Conference on Optical, Optoelectronic and Photonic Materials and Applications (ICOOPMA 10 - Budapest, Hungary) 2010.
7. Session Chair, The 9th International Conference on Excitonic and Photonic Processes in Condensed and Nano Materials, (EXCON'10 - Brisbane, Australia) 2010.
8. Panelist and Session Chair 1st International Workshop on Conductive Bridge Memory (CBRAM – Stanford University) 2010.
9. Session Chair, 23rd International Conference on Amorphous and Nanocrystalline Semiconductors (ICANS 23) 2009.

10. Session Chair, 3rd International Conference on Optical, Optioelectronic and Photonic Materials and Applications (ICOOPMA08 – Edmonton, Alberta, Canada) 2008.

B. Invited Talks at International Conferences:

1. ***Invited Plenary*** Fifth International Conference on Amorphous and Nanostructured Chalcogenides - Fundamentals and Applications 26 June-1 July 2011 Bucharest Romania – **“**New concept for expanding the chalcogenide glasses application for radiation sensing".
2. ***Invited and Panelist*** First International Workshop on Conductive-Bridge Memory (CBRAM), April 23-24, 2010 Stanford University, CA **–** **“**Materials Solutions for CBRAM Device Formation – the Good, the Bad and the Ugly”;ember of the panel and moderator for the discussion related to the application of materials for CBRAM fabrication
3. ***Invited*** Fourth International Conference on Optical, Optoelectronic and Photonic Materials and Applications August 15-20, 2010 Budapest, Hungary – **“**Optically Induced Processes in Chalcogenide Glasses - from Visible Light to x-Rays”.
4. ***Invited*** 9th International Conference on Excitonic and Photonic Processes in Condensed and Nano Materials, EXCON'10, - July 11-16 2010, Brisbane, Australia - “Photo-induced Phase Transitions - New Results on the Formation of new Phases after Photooxidation and Photoinduced Ag Diffusion in Chalcogenide Glasses”.
5. ***Invited plenary*** Fourth International Conference on Amorphous and Nanostructured Chalcogenides/ Fundamentals and Applications - June 29 - July 3 2009, Constanta, Romania, "Photooxidation in Chalcogenide Glasses - is it Similar to Photosynthesis in Plants and what the Products of the Process are?"
6. ***Invited*** 23rd International Conference on Amorphous and Nanocrystalline Semiconductors, August 23-28, 2009 Utrecht, the Netherlands, “Structural Details on Silver Doped Chalcogenide Glasses and their Application for Non-volatile Memory”
7. ***Invited and panelist*** International Workshop : Solar Energy Workshop November 16-18, 2008, Pittsburgh, PA, USA “Glass for Harvesting, Storage & Efficient Usage of Solar Energy”; Member of the panel and moderator of the discussions related to new solar energy materials.
8. ***Invited*** Third International Conference on Optical, Optoelectronic and Photonic Materials and Application 2008, 20-25 July 2008, Edmonton Canada, “Photoinduced Diffusion in Tetrahedrally coordinated Chalcogenide Glasses”
9. ***Invited plenary*** Third International Conference on Amorphous and Nanostructured Chalcogenides/ Nexus: Modeling of Amorphous Materials, 2-6 July 2007 Brasov - Romania – **“**Programmable Metallization Cell Non-volatile memory – Materials and Devices Engineering”.

C. Invited Seminar talks:

1. Structural Details of Silver-doped Chalcogenide Glasses and their Application for Nanoionic Nonvolatile Memory and Radiation Sensing Devices – talk given at a seminar at the Japanese Atom Energy Agency on 06. 01. 2012.
2. Series of Lectures Related to the Structure, Properties and Application of Diverse Materials for Redoxy Conductive Bridge Memristive Non-volatile Memory – talks given at Micron Technology Inc. September – October 2011
3. From floppy to stressed rigid – structural specifics of sputtered chalcogenide glasses – seminar talk given at the Department of Physics at Ohio University on 05. 14. 2010.
4. Non-volatile Nano-ionic Memory Storage – Science and Materials Engineering - talk given at Micron Technology Inc. on 11.13. 2009.
5. Nanoionic Non-volatile Electrochemical Memory Storage – Design and Threshold Voltage Control - talk given at the seminar of the Department of Electrical Engineering at University of Idaho on 10. 29. 2009.
6. Non-volatile Electrochemical Memory Storage – Science, Technology and Multi-level Cell Integrated Circuit Design - talk given at JPL NASA on 05.15.2009.
7. ReRAM – Where is the technology now? (review) talk given at Adesto Technology Inc. on 03. 20. 2009.
8. Nano-ionic Conductive Bridge Non-volatile Memory – are the Conventional CMOS Materials good for it? –talk given at the COEN seminar at Boise State University on 03. 20. 2008.
9. Nano-ionic Conductive Bridge Non-volatile Memory – Materials Science and Engineering talk given at the seminar in the Center for Solid State Electronics Research , Arizona State University on 03. 15. 2008.
10. Ag Doped Chalcogenide Glasses – Science, Engineering and Application for Non-Volatile Memory - talk given at the MSE department seminar at BSU on 09. 21. 2007
11. Programmable Metallization Cell Technologies - Materials Research and Engineering – talk given at Adesto Technology Inc. on 05.03. 2007.

BSU SERVICE:

- Chair of the BSU Faculty Research Committee
- Member : Safety Committee at COEN
- Member: Idaho Microfabrication Laboratory Committee at COEN
- Adviser of over 80 undergraduate students at BSU
- Facilitated a donation to BSU of all issues of Journal of Optoelectronic and Advanced Materials since its inception till 2006. Currently these journals are available to all faculty and students in room MEC 202 J.
- Financially contribute monthly for the establishment of a Research Award Endowed Fund in the ECE department for students' scholarship.

- Facilitated the tour for the Engr. 120 class in the ECE Department and Idaho Microelectronic Laboratory with material which increased the interest of the students towards the Electrical Engineering profession.
- Contributed to the campaign of interviewing candidates for the ECE Department chair position by performing telephone interviews.
- Participated as a member of the search committee in the interviewing process of faculty candidates in the ECE department.
- Initiated conversations with the Department of Electrical Engineering at the University of Edinburgh UK for an international collaboration in the field of EE teaching and research.
- Always open to cover the classes of my colleagues at BSU teaching in the field of devices when they need me to.
- Helped with a financial donation to the Mechanical Engineering Club – Mini-Baja Project.
- Member of the undergrad recruiting committee at the ECE department and participation in events and contribution to recruiting of undergraduate students for the ECE department.

PROFESSIONAL SERVICE:

- Co-Director with Michael F. Thorpe from Arizona State University/ Oxford University UK of NATO Advanced Study Institute “Amorphous Insulators and Semiconductors” 1996
- Referee for J. of Non-Crystalline Solids; Vacuum; IEEE Electronic devices; IEEE Nanotechnology; Surface Science; Electrochemical and Solid State Letters; Philosophical Magazine; Nature; Solid State Ionics; etc. referring in average two scientific articles/month.
- Referee for NSERC (Canada)
- Invited speaker to 9 (since I am associate professor at BSU) scientific conferences in the field of my research work.
- Member of the International Advising or Program Committees of 5 international conferences
- Member of the editorial board of the Journal Optoelectronic Advanced Materials Symposia

SERVICE TO THE SOCIETY

- Make monthly contributions to the United Way to help to those in need in our society to achieve their goals through monthly deductions from my paychecks.
- Support with monetary contributions the Paralyzed Veterans of America.
- Sent money and expressed my wish to visit St. Joseph’s Indian School to help improve education.
- Helped with money the Memorial Sloan-Kettering Cancer Center.
- Lend a hand with a financial support to the American Heart Association
- Helped with financial contributions to Boys town

- Offered financial support to Easter Seals

LIST OF PUBLICATIONS

Books:

1. M. F. Thorpe, **M. I. Mitkova** (editors) NATO ASI Series 3. High Technology - Vol. 2 "Amorphous Insulators and Semiconductors", Kluwer Academic Publishers, Dordrecht/Boston/London 1997.
2. **M. Mitkova**, A. Nikolova, G. Peev, T. Racheva, V. Shanov, A. Shurbanova English-Bulgarian Terminological Dictionary for Chemical Technology and Materials for Microelectronics and Electronic Devices, Publishing House of the Technological University, Sofia, 1984
3. Z. Boncheva-Mladenova, V. Vassilev, **M. Mitkova** - Textbook for Seminars and Laboratory Work in Chemistry and Physical Chemistry of Semiconductors, Publishing House of the Technological University, Sofia, 1981

Book Chapters:

1. **Maria Mitkova,** Yoshifumi Sakaguchi -**Nano-ionic nonvolatile memory devices – basic ideas and structural model of rigid Ge-S glasses as medium for them** - Chapter 14 in *Rigidity and Intermediate Phases in Nanomaterials*, edited by Matthieu Micoulaut and Mihai Popescu, Publishing Company INOE Publ. House, Bucharest, 2009, 357.
2. M. N. Kozicki, **M. Mitkova – Devices based on mass transport in solid electrolytes** – Chapter 16 in the book *Nanotechnology*, Volume 3: Information Technology I, editor Rainer Waser, Wiley-VCH Verlag GmBH&Co.KGaA Weinheim 2008, p. 485.
3. **M Mitkova**, M. N. Kozicki – **Fourfold Coordinated Silver-containing Chalcogenide Glasses - Basic Science and Applications in Optical Programmable Metallization Cell (PMC) Technologies** Chapter 8 in *Optoelectronic Amorphous Materials and Devices*, Volume 1, Non-Crystalline materials for Optoelectronics, G. Lucovsky and M. Popescu editors, INOE Publ. House, Bucharest, 2004, p. 211.
4. **M. Mitkova** - **Real Time Optical Recording in Semiconducting Thin Films** Chapter 12C in *Amorphous Semiconductors and Insulators* editor Punit Boolchand, World Scientific Press LTD, Singapore, New Jersey, London, Hong Kong, 2000, p. 813.
5. **M. Mitkova** – **Synthesis, Structure and Some Modes of Application of New Chalcogenide and Chalco-halide Glasses with Silver** - *NATO ASI Series, 3. High Technology* - vol.23, M.F. Thorpe and M.I. Mitkova editors, Kluwer Academic Publishers, Dordrecht/Boston/London 1997, p. 71.

Articles in Peer Reviewed Journals

1. **M. Mitkova,** P. Chen, M. Ailavajhala,(grad. student) D. Butt, D. Tenne, I. Esqueda, H. Barnaby, **Structural Details of Ge-S Chalcogenide Glasses Modified by Silver Radiation Induced Diffusion in Them**,*J. Non-Cryst. Sol.*, 360 (2013 352.
2. **M. Mitkova**, P. Chen, M. Ailavajhala, D. Butt, D. Tenne, H. Barnaby, and I. Esqueda, "**Gamma ray induced structural effects in bare and Ag doped Ge–S thin films**," *Journal of Non-Crystalline Solids*, 2013
3. Y. Gonzalez-Velo, H. J. Barnaby, A. Chandran, D. R. Oleksy, P. Dandamudi, M. N. Kozicki, K. E. Holbert, **M. Mitkova**, M. Ailavajhala, and P. Chen. **"Effects of Cobalt-60 Gamma-Rays on Ge-Se Chalcogenide Glasses and Ag/Ge-Se Test Structures.**" *Nuclear Science, IEEE Transactions on* 59, no. 6 (2012): 3093-3100.
4. Mahesh Ailavajhala, **Maria Mitkova**, and Darryl P. Butt. "**Simulation and process flow of radiation sensors based on chalcogenide glasses for in situ measurement capability.**" *physica status solidi (c)* (2012).
5. Ping Chen, **Maria Mitkova**, Dmitri A. Tenne, Kasandra Wolf, Velichka Georgieva, and Lazar Vergov. "**Study of the Sorption Properties of Ge20Se80 Thin Films for NO2 Gas Sensing**" *Thin Solid Films* 525 (2012) 141–147.
6. Velichka Georgieva, **Maria Mitkova**, Ping Chen, Dmitri Tenne, Kasandra Wolf, and Victoria Gadjanova. " **NO2 gas sorption studies of Ge33Se67 films using quartz crystal microbalance.**"*Materials Chemistry and Physics* (2012).
7. —Nesheva, D., Ailavajhala, M., Chen, P., Tenne, D. A., Barnaby, H., **Mitkova, M.**, "**Studies of Gamma Radiation Induced effects in Ge-Rich Chalcogenide Thin Films**" Proceedings of the RAD 2012. pp. 19-22
8. S. Wald, J. Baker, **M. Mitkova** and N. Rafla – **A non-volatile memory array based on nano-ionic Conductive Bridge Memristors** – *2011 IEEE Workshop on Microelectronics and Electron Devices (WMED)* (2011).
9. P. Chen, M. Ailavajhala, **M. Mitkova**, D. Tenne, I. S. Esqueda, H. Barnaby – **Structural study of Ag-Ge-S solid electrolyte glass system for resistive radiation sensing** – *2011 IEEE Workshop on Microelectronics and Electron Devices (WMED)* (2011).
10. **M. Mitkova**, Y. Sakaguchi, D. Tenne, S. Bhagat, T. L. Alford – **Structural Details of Ge-Rich and Silver-doped Chalcogenide Glasses for Nanoionic Nonvolatile Memory** - *Phys. Status Solidi* (a) 207, (2010) 621.
11. S. C. P. Thermadan (grad. student), S. K. Bhagat (grad. student), T. L. Alford, Y. Sakaguchi, M.N. Kozicki, **M. Mitkova** -**Influence of Cu diffusion conditions on the switching of Cu-SiO_2- based resistive memory devices** - *Thin Solid Films* 518 (2010) 3293.
12. **M. Mitkova**, Y. Sakaguchi, D. Tenne, S. Bhagat (grad. student), T. L. Alford - **Structural Details of Ge-Rich and Silver-doped Chalcogenide Glasses for Nanoionic Nonvolatile Memory** - *Phys. Status Solidi* A, v. 207, (2010) 621.

13. A. Kovalskiy, H. Jain, **M. Mitkova** - **Electronic evidences for the mechanism of photo-induced silver diffusion into chalcogenide glass films** - *J. Non-Cryst. Sol.* 355 (2009) 1924.
14. Y. Sakaguchi, D. A. Tenne, **M. Mitkova** – **Evolutoion of chemical structure during silver photodiffusion into chalcogenide glass thin films** - *J. non-Cryst. Sol.* 355 (2009) 1792.
15. Y. Sakaguchi, D. Tenne, **M. Mitkova**, **Oxygen-assisted photoinduced structural transformation in amorphous Ge-S films** - *Phys. Status Solidi* B 246, (2009) 1813.
16. **M. Mitkova**, A. Kovalskiy, H. Jain, Y. Sakaguchi -**Effect of photo-oxidation on the photodiffusion of silver in germanium chalcogenide glasses** - *J. Optoel. and Adv. Mat.*11(2009) 1899.
17. M. Jin (grad. student), Punit Boolchand, Maria Mitkova: **Heterogeneity of molecular structure of Ag photo-diffused $Ge_{30}Se_{70}$ thin films**, Journal of Non-Crystalline Solids 354 (2008) 2719.
18. A. Kovalskiy, A. Miller, H. Jain, and **M. Mitkova:** **In Situ Measurement of x-Ray -Induced Silver Diffusion into $Ge_{30}Se_{70}$ Thin Film** J. Am. Ceram. Soc., 91 (2008) 760.
19. Murali Balakrishnan (grad. student), Michael N. Kozicki, Christian D. Poweleit, Shekhar Bhagat (grad. student), Terry L. Alford and **Maria Mitkova** **Structural Study of Cu photodoped Ge-S glasses,** J. Optoelct. and Adv. Mat., v. 9 (2007) 3241.
20. Murali Balakrishnan (grad. student), Michael N. Kozicki, Christian D. Poweleit, Shekhar Bhagat (grad. student), Terry L. Alford and **Maria Mitkova** **Crystallization Effects In Annealed Thin GeS_2 Films Photodiffused with Ag** J. of Non-Cryst. Sol.353 (2007) 1454.
21. M. Mitkova, M. N. Kozicki, **Ag-Photodoping in Ge-Chalcogenide Amorphous Thin Films - Reaction Characterization -** J. of Phys. & Chem. of Sol. 68 (2007) 866.
22. C. Gopalan Grad. student), M. N. Kozicki, S. Bhagat (grad. student), C. Powelait, T. Alford, **M. Mitkova**, **Cu doped WO_3 Formation and Characterization**, J. Non-Cryst. Sol 353 (2007) 1844.
23. Stefan Enderling, Charles L. Brown III (grad. student), Stewart Smith, Martin H. Dicks, J. Tom M. Stevenson, **Maria Mitkova**, Michael N. Kozicki, Anthony J. Walton, **Sheet Resistance Measurement of Non-Standard Cleanroom Materials using Suspended Greek Cross Test Structures,** *IEEE Transactions on Semiconductor Manufacturing*, 16, (2006) 2.
24. **M. Mitkova**, M.N. Kozicki, H. C. Kim (grad. student), T. L. Alford - **Crystallization Effects in Annealed Thin Ge-Se Films Photodiffused with Ag,** *J. Non-Cryst. Sol.* 352 (2006) 1986.
25. M.N. Kozicki, **M. Mitkova** - **Mass Transport in Sold Electrolyte Films – Materials and Applications,** *J. Non-Cryst. Sol.*352 (2006) 567.
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