



INTELLIGENT SYSTEMS ENGINEERING

INDIANA UNIVERSITY
School of Informatics and Computing

Alexander Gumennik, Ph.D.

Assistant Professor of Intelligent Systems Engineering

Director of Fibers & Additive Manufacturing Enabled Systems Laboratory at the Department of Intelligent System Engineering (ISE FAMES Lab)

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Research interests

Pervasive sensing for Internet of Things, nano-to-macro integration by additive manufacturing, fiber devices for bio-synthetic interfacing and biomimetic fibers, fiber-embedded nano-photonics and nano-devices, fabrics with active functionalities.

Positions

Assistant Professor	Indiana University, Bloomington	08/2016 – Present
Lead Engineer	Formlabs Inc., Somerville, MA	02/2015 – 07/2016
Research Affiliate	Massachusetts Institute of Technology	02/2015 – 08/2016
Postdoctoral Associate	Massachusetts Institute of Technology	02/2011 – 02/2015
Graduate Researcher	Hebrew University of Jerusalem, Israel	10/2002 – 12/2010
Assistant Lecturer	Hebrew University of Jerusalem, Israel	10/2004 – 04/2010
Fulbright Visiting Scholar	University of California, San Diego	01/2007 – 04/2007
Engineering Intern	Intel, FAB8, Jerusalem, Israel	08/2003 – 11/2004

Education

- **Ph.D., Applied Physics, Hebrew University of Jerusalem.** **12/2004 – 12/2010**

Thesis: “Refractive Index Engineering of Photonic Devices in Electro-Optic Substrates by Implantation of Light Energetic Ions”.

Advisor: Prof. Aharon J. Agranat (HUJI). Co-advisors: Profs. Mordechai Segev (Technion) and Michael Hass (Weizmann Institute).



- **M.Sc., Applied Physics, Hebrew University of Jerusalem. 10/2002 – 12/2004**
Thesis: "Construction of Waveguiding Structures within Electrooptic Crystals by Implantation of Light Ions".
Advisor: Prof. Aharon J. Agranat (HUJI).
- **B.Sc., Physics and Mathematics, Hebrew University of Jerusalem. 10/1995 – 08/1998**
Graduated at the age of 19.

Awards, Honors, and Fellowships

- Rothschild post-doctoral fellowship of Yad Hanadiv **2010-2011**
- Eshkol scholarship of the Israel Ministry of Science **2007-2010**
- Intel award for outstanding Ph.D. students **2007-2008**
- Wolf foundation doctoral excellence scholarship **2006-2007**
- Fulbright doctoral dissertation fellowship **2006-2007**

Journal Publications

- [1] T. Khudiyev, J. Clayton, E. Levy, N. Chocat, **A. Gumennik**, A. M. Stolyarov, J. Joannopoulos, and Y. Fink, "Electrostrictive all-fiber microelectromechanical systems", **submitted (2017)**.
- [2] **A. Gumennik** *, E. C. Levy *, B. Grena *, C. Hou, M. Rein, A. Abouraddy, J. D. Joannopoulos, Y. Fink, "Confined in-fiber solidification and structural control of silicon and silicon-germanium microparticles", **Early Edition, doi:10.1073/pnas.1707778114 PNAS (2017)**,.
- [3] L. Wei, C. Hou, E. Levy, G. Lestoquoy, **A. Gumennik**, A. F. Abouraddy, J. D. Joannopoulos, and Y. Fink, "Optoelectronic Fibers via Selective Amplification of In-Fiber Capillary Instabilities", **Adv. Mater. 29, 1603033 (2017)**.
- [4] M. Rein, E. Levy, **A. Gumennik**, A. F. Abouraddy, J. Joannopoulos, and Y. Fink, "Self-assembled fibre optoelectronics with discrete translational symmetry", **Nat. Commun. 7, 12807 (2016)**.
- [5] S. Frishman, **A. Gumennik**, H. Ilan, Aharon J. Agranat, "A Bragg grating embedded in a slab waveguide fabricated by the implantation of high-energy light ions in KLTN substrate", **Appl. Phys. B 115, 143 (2014)**.
- [6] **A. Gumennik** *, L. Wei *, G. Lestoquoy *, A. M. Stolyarov, X. Jia, P. H. Rekemeyer, M. J. Smith, X. Liang, B. J.-B. Grena, S. G. Johnson, S. Gradečak, A. F. Abouraddy, J. D.



- Joannopoulos, Y. Fink, "Silicon-in-Silica spheres via axial thermal gradient in-fibre capillary instabilities", **Nat. Commun.** **4**, 2216 (2013).
- [7] **A. Gumennik** *, A. M. Stolyarov *, B. R. Schell *, C. Hou, G. Lestoquoy, F. Sorin, W. McDaniel, A. Rose, J. D. Joannopoulos, and Y. Fink, "All-in-fiber chemical sensing", **Adv. Mater.** **24**, 6005 (2012).
- [8] A. M. Stolyarov *, **A. Gumennik** *, W. McDaniel, O. Shapira, B. Schell, F. Sorin, K. Kuriki, G. Benoit, A. Rose, J. D. Joannopoulos, and Y. Fink, "Enhanced chemiluminescent detection scheme for trace vapor sensing in pneumatically-tuned hollow core photonic bandgap fibers", **Opt. Express** **20**, 12407 (2012).
- [9] **A. Gumennik**, Y. Kurzweil-Segev, A. J. Agranat, "Electrooptical effects in glass forming liquids of dipolar nano-clusters embedded in a paraelectric environment", **Opt. Mater. Express** **1**, 332 (2011).
- [10] H. Siman Tov, **A. Gumennik**, H. Ilan, and A. J. Agranat, "Construction of conducting and photoconducting 3D structures with submicron resolution in electrooptical substrates", **Appl. Phys. A** **102**, 45 (2011).
- [11] **A. Gumennik**, G. Perepelitsa, A. Israel, and A. J. Agranat, "A tunable channel waveguide array fabricated by the implantations of He⁺ ions in an electrooptical KLTN substrate", **Optics Express** **17**, 6166 (2009).
- [12] H. Ilan, **A. Gumennik**, G. Perepelitsa, A. Israel, and A. J. Agranat, "Construction of an optical wire imprinted in potassium lithium tantalate niobate by He⁺ implantation", **Appl. Phys. Lett.** **92**, 191101 (2008).
- [13] **A. Gumennik**, H. Ilan, R. Fathei, A. Israel, A. J. Agranat, I. Shachar, and M. Hass, "Design methodology of refractive index engineering by implantation of high-energy particles in electro-optic materials", **Appl. Opt.** **46**, 4132 (2007).
- [14] H. Ilan, **A. Gumennik**, R. Fathei, A. J. Agranat, I. Shachar, and M. Hass, "Submerged waveguide constructed by the implantation of ¹²C ions in electrooptic crystals", **Appl. Phys. Lett.** **89**, 241130 (2006).
- [15] **A. Gumennik**, A. J. Agranat, I. Shachar, and M. Hass, "Thermal stability of a slab waveguide implemented by α particles implantation in potassium lithium tantalate niobate", **Appl. Phys. Lett.** **87**, 251917 (2005).

Asterisk () denotes equally contributing authors.*



Patent Applications

- [1] **A. Gumennik** and A. Eltony, “Techniques of Additive Fabrication Using an Aspheric Lens and Related Systems and Methods”, Patent Application by Formlabs Inc. **US20170036398 (2017)**.
- [2] Y. Fink, A. F. Abouraddy, S. Gradecak, B. Grena, **A. Gumennik**, X. Jia, J. D. Joannopoulos, S. G. Johnson, G. R. Lestoquoy, X. Liang, P. H. Rekemeyer, M. J. Smith, A. M. Stolyarov, L. Wei,” Dynamic In-Fiber Particle Production With Precise Dimensional Control”, Patent Application by MIT **US20140272411, US20150044463, WO2014160504A1 (2015)**.
- [3] **A. Gumennik**, Y. Fink, B. J.-B. Grena, J. D. Joannopoulos, “High-Pressure In-Fiber Particle Production With Precise Dimensional Control”. Patent Application by MIT **US20140272411 (2014)**.
- [4] **A. Gumennik**, A. M. Stolyarov, B. R. Schell, C. Hou, G. R. Lestoquoy, F. Sorin, W. R. McDaniel, Y. Fink, A. Rose, J. D. Joannopoulos “Fiber Sensor”. Patent Application by MIT **WO2014047660 A1, US20140212084 (2013)**.

Grants

- [1] L. A. Baker (PI), **A. Gumennik (Co-PI)**, S. C. Jacobson (Co-PI), S. Setayeshgar (Co-PI), A. Zlotnick (Co-PI), National Science Foundation, Submitted (**January 2017**). Requested amount - **\$458,600**.

Invited Talks

- [1] **A. Gumennik**, “From Macro to Nano ...and Back: Functional fiber devices and systems for bio-synthetic interfacing and Internet of Things”, 3D Bioprinting Core Users Group Meeting, IU School of Medicine, IUPUI, IN, United States, Academic, Local (**December 12, 2016**).
- [2] **A. Gumennik**, “From Macro to Nano ...and Back: Functional fiber devices and systems for Internet of Things”, Mech E Seminar Series, Department of Mechanical Engineering, IUPUI, IN, United States, Local (**January 17, 2017**).

Conference Abstracts and Proceeding Papers

- [1] **A. Gumennik**, E. Levy, B. Grena, C. Hou, M. Rein, A. Abouraddy, J. Joannopoulos, Y. Fink, “Si-Ge Micro-Spheres of Prescribed Morphology from In-Fiber Capillary Breakup and Controlled Crystallization”, oral presentation SM2.4.02 at 2017 MRS Spring Meeting & Exhibit (Material Research Society, **2017**).



- [2] **A. Gumennik**, L. Wei, G. Lestoquoy, A. M. Stolyarov, X. Jia, B. Grena, S. G. Johnson, A. F. Abouraddy, J. D. Joannopoulos, Y. Fink, “In-fiber capillary breakup as a generic method for silicon processing and device fabrication”, oral presentation A10.02 at 2015 MRS Spring Meeting & Exhibit (Material Research Society, **2015**).
- [3] **A. Gumennik**, **B. Grena**, E. Levy, L. Wei, C. Hou, T. Sarathi, A. Abouraddy, J. D. Joannopoulos, Y. Fink, “Extraordinary stress in silicon spheres via anomalous in-fiber expansion”, oral presentation A10.05 at 2015 MRS Spring Meeting & Exhibit (Material Research Society, **2015**).
- [4] **M. Rein**, **A. Gumennik**, E. Levy, C. Hou, Y. Fink, “Self-Assembled Fiber Optoelectronic Devices through Selective In-Fiber Fluid Instabilities”, oral presentation V6.07 at 2015 MRS Spring Meeting & Exhibit (Material Research Society, **2015**).
- [5] L. Wei, A. M. Stolyarov, **A. Gumennik**, C. Hou, G. Lestoquoy, X. Jia, B. Grena, **A. F. Abouraddy**, J. D. Joannopoulos, and Y. Fink, “Recent progress in multimaterial fibers: From nanofabrication to novel device architectures,” (PIERS 2014, Guangzhou, China, 25-28 Aug., **2014**), Session 3P9a.
- [6] **Y. Fink**, A. F. Abouraddy, B. Grena, **A. Gumennik**, C. Hou, X. Jia, J. Joannopoulos, J. J. Kaufman, G. Lestoquoy, and L. Wei, "Opportunities in Multimaterial Fibers," in Workshop on Specialty Optical Fibers and their Applications, (Optical Society of America, **2013**), paper F1.1.
- [7] **A. M. Stolyarov**, L. Wei, **A. Gumennik**, O. Shapira, G. Lestoquoy, F. Sorin, B. R. Schell, C. Hou, W. McDaniel, A. Rose, J. Joannopoulos, and Y. Fink, "Multimaterial functional fibers," in Optical Fiber Communication Conference/National Fiber Optic Engineers Conference 2013, OSA Technical Digest (online) (Optical Society of America, **2013**), paper OTh1J.6.
- [8] **A. J. Agranat**, **A. Gumennik** and H. Ilan, “Refractive index engineering by fast ion implantations: a generic method for constructing multi-components electro-optical circuits”, in Proc. SPIE 7604, (**2010**), 76040Y DOI:10.1117/12.841287.
- [9] **A. Gumennik**, G. Perepelitsa, A. Israel and A. J. Agranat, “Refractive Index Engineering of a Tunable Channel Waveguide Array by the He⁺ implantation in an Electrooptic KLTN Substrate”, in The Conference on Lasers and Electro-Optics (CLEO)/The International Quantum Electronics Conference (IQEC) (Optical Society of America, Washington, DC, **2009**), CTuEE4.
- [10] H. Ilan, **A. Gumennik**, G. Perepelitsa, A. Israel and A. J. Agranat, “Channel Waveguide Formed by “One Shot” Implantation of He⁺ Ions”, in Conference on Lasers and Electro-Optics/Quantum Electronics and Laser Science Conference and Photonic Applications Systems Technologies 2008 Technical Digest (Optical Society of America, Washington, DC, **2008**), CTuS3.



- [11] H. Ilan, A. Gumennik, R. Fathei, A. J. Agranat, "Submerged waveguide constructed by the implantation of 12C ions in electrooptic crystals", in Conference on Lasers and Electro Optics/Quantum Electronics and Laser Science Conference and Photonic Applications Systems Technologies 2007 Technical Digest (Optical Society of America, Washington, DC, 2007), CMGG3.

Speakers are underlined.

Highlights

- Director of Fibers and Additive Manufacturing Enabled Systems Laboratory at the Department of Intelligent System Engineering (ISE FAMES Lab).
- Extensive experience in 3D printing, electrooptic materials, semiconductor device physics, integrated photonic circuits, and functional fibers, leading to seven first-author, six co-authored publications and four patent applications.
- Invented and tested novel fabrication techniques, including generic methodologies for fabrication of: photonic integrated circuitry in electrooptic substrates, fiber-embedded arrays of Si nano-spheres, fiber-embedded Si-Ge hetero-structures, and fiber-embedded highly stressed semiconductors.
- Designed and assembled measurement and processing setups such as: 3D printing setups, multi-axial prism couplers for characterization of waveguide-embedded photonic structures, birefringence-measurement setups for characterization of magneto- and electrooptical properties of ferroelectrics, and high-throughput high-temperature tapering and breakup setups for silica-based fiber processing.
- Developed and investigated novel prototype devices such as electrooptically-tunable phonic structures, photo detecting fibers, and fiber-based chemical sensors.

Research Experience

Director of Fibers & Additive Manufacturing Enabled Systems Laboratory at the Department of Intelligent System Engineering (ISE FAMES Lab) **08/2016 – Present**

- The vision of the ISE FAMES Lab is to provide an efficient interface, linking the cyberspace with the physical world. This is done by an engineering of fibers and fabrics, embedding ensembles of nano-transducers and sensors, that would listen, watch, smell, and palp their surroundings and communicate there sensations to a computer.

Lead Photonics Process Engineer, Formlabs Inc., Somerville, MA **02/2015 – 07/2016**

Consulting Scientist, Formlabs Inc., Somerville, MA **11/2014 – 02/2015**

- Designing, constructing and characterizing the laser-optics portion of 3D printing setups. (*Patent Application*)



Research Affiliate, Massachusetts Institute of Technology 02/2015 – 08/2016

Postdoctoral Associate, Massachusetts Institute of Technology 02/2011 – 02/2015

Research Laboratory of Electronics, Fibers @ MIT group

- Invented and implemented a fiber-based remote and distributed chemical detector, including project planning and effort coordination **with FLIR Systems, Inc.** (*Optics Express 2012, Advanced Material 2012 (cover story) + Patent Application*)
- Invented, designed and implemented an in-fiber process for Si nano-spheres fabrication for photonic, electronic and pharmaceutical applications. (*Nature Communications 2013 + Patent Application*)
- Designed and assembled 2 tapering setups for semiconductor/metal-core silica fibers scaling and break-up.
- Discovered and developed a method for ultra-high pressure generation and fabrication of hetero-structured Si-Ge particles in Janus and core-shell configuration by a capillary breakup of semiconductor-core silica fibers with subsequent gradual solidification of fiber-confined semiconducting droplets. (*Manuscript in Preparation + Patent Application*)
- Developed a fabrication of doped silicon microspheres with ultra-smooth surfaces for phonon-polaron near-field thermal transfer for photovoltaic and nano-scale thermal management applications. (*Manuscript in Preparation*)
- Developed and investigated self-assembly approach for fiber optoelectronics by means of selective amplification of capillary instabilities in chalcogenide core polymeric fibers. (*Nature Communications 2016*)
- Co-invented a method for self-assembly of in-fiber optoelectronics by means of selective amplification of capillary instabilities in germanium-core silica fibers. (*Advanced Materials 2017*)
- Co-wrote and co-PI'ed multiple research proposals for NSF, DARPA, and ARL.

Graduate Researcher, Hebrew University of Jerusalem 10/2002 – 12/2010

Department of Applied Physics, Optoelectronic Computing Group

- Developed and implemented a generic methodology for design and fabrication of building blocks for integrated photonic circuitry in electrooptic substrates by light energetic ions implantation. This project was conducted in collaboration with **Department of Particle Physics, Weizmann Institute, Rehovot, Israel**, and included multiple steps:
 - Design, fabrication and characterization of optical properties and thermal stability of He-implanted surface slab waveguide in potassium lithium tantalate niobate (KLTN). (*Applied Physics Letters 2005*)
 - Design, fabrication and characterization of C-implanted buried slab waveguide in KLTN. (*Applied Physics Letters 2006*)



- Development of semi-empirical calculation strategy allowing obtaining the implantation-induced refractive index change in KLTN knowing the ion species and the implantation dose. (*Applied Optics 2007*)
- Design, fabrication and characterization of He-implanted optical wire in KLTN. (*Applied Physics Letters 2008*)
- Design, fabrication and characterization of He-implanted electrooptically tunable coupled waveguide array in KLTN. (*Optics Express 2009*)
- Development of high-aspect ratio implantation-assisted etching technique in closely-packed perovskites. (*Proceedings of SPIE 2010*)
- Design, fabrication and characterization of He- and H-implanted photonic filtering/multiplexing grating in KLTN. (*Applied Physics B 2014*)
- Discovered and characterized electrically induced optical depolarization in glass forming liquids of ferroelectric nano-clusters in paraelectric Cu, Mo, Li – doped and pristine potassium tantalate niobate in the vicinity of phase transition. (*Optical Materials Express 2012*)
- Led technological and scientific investigation of conducting and photoconducting properties of submicron proton-implanted structures in KLTN. (*Applied Physics A 2011*)
- Assembled a measurement setup and investigated magneto-optic properties of KLTN with Mn-Ti, Mo, W doping.
- Inspired and planned a research strategy for investigation of applicability of KLTN to THz operation.
- Inspired and planned a strategy for fabrication of wide-beam large-angle stacked electrooptical deflector in KLTN.
- Co-wrote multiple research proposals.

Fulbright Visiting Scholar, University of California, San Diego **01/2007 – 04/2007**
Jacobs School of Engineering, Ultrafast & Nanoscale Optics Group

- Initiated and led a joint project for characterization of photonic gratings in electrooptic crystals fabricated in the Hebrew University by means of Time-Resolving Heterodyne Near-Field Scanning Optical Microscopy (NSOM) invented in UCSD.

Process Engineering Intern, Intel, FAB8, Jerusalem, Israel **08/2003 – 11/2004**
Diffusion-CVD Group

- Improved statistical performance characterization and contamination control over chemical vapor deposition (CVD) processes.
- Participated in implementation of 2DPM (2 defects-per-million) standards.

Research Assistant, Hebrew University of Jerusalem **06/2002 – 08/2003**
Department of Applied Physics, Optoelectronic Computing Group



- Optimized the growth of ferroelectric crystals by Czochralski method. Maintained and troubleshot the high-temperature crystal growth towers.

Education Activities

New IUB Engineering Program Curriculum Developer, IUB, ISE **09/2016-Present**

- Developing MSc curriculum for ISE Nanoengineering track
- Developing BSc curriculum for ISE Nanoengineering track

Lecturer, IUB, SoIC **01/2017-Present**

- Developing and/or lecturing
 - ENGR-E 599 Introduction to Intelligent Systems Engineering (beginning Fall 2016)
 - ENGR-E 687 Graduate independent studies (beginning Fall 2016)
 - ENGR-E 599 Rapid Prototyping (beginning Spring 2017)
 - PHYS-P 408/508 Current Research in Physics (beginning Spring 2017)
 - ENGR-E 507 Introduction to and Overview of Nanoengineering (beginning Spring 2018)

Research Mentor, IUB, ISE FAMES Lab **08/2016-Present**

- Mentoring Graduate and Undergraduate students independent studies

Research Mentor, MIT, Research Laboratory of Electronics **02/2011-08/2016**

- Co-Mentored two M.Sc. students, one Ph.D. candidates and two post-docs. This resulted in co-design and co-assembly experimental setups and paper co-authorships by the students.
- Provided ongoing training and guidance to new students and post-docs.

Assistant Lecturer, HUJI, The School of Computer Science and Engineering **10/2004-04/2010**

- Co-composed and co-lectured courses "Physics of Guided Waves" and "Introduction to Optonics"(B.Sc./M.Sc. level).

Research Mentor HUJI, The School of Computer Science and Engineering **10/2004-04/2010**

- Mentored seven M.Sc. students and two Ph.D. candidates. Up to date this led to four first-name authorships and six co-authorships by students on peer-reviewed papers, one conference presentation by student and four students' co-authorships on conference abstracts. Five of the students continued to Ph.D. studies.
- Composed tutorials, assembled setups and mentored students in engineering-students' physics lab (B.Sc. level).
- Supervised graduation projects by engineering students (B.Sc. level).



Professional Activities

Session Chair at MRS Spring Meeting, Phoenix AZ **04/2017**

- SM2.2: Energy Storage and Harvesting in Fibers and Textiles
- SM2.9: Nanofibers and Nanoscale Phenomena in Fibers and Textiles
- SM2.10: Advances in Fibers and Textiles III

Ad-Hoc Reviewer **05/2007 – Present**

- Reviewed multiple articles for Scientific Reports, Advanced Optical Materials, Applied Optics, Optical Materials Express, Applied Physics B, Materials Chemistry and Physics, Journal of Lightwave Technology as primary reviewer. Co-reviewed multiple articles with concurrent PIs for Nature Communications, Optics Letters, Applied Optics, and Applied Physics B: Lasers and Optics.
- Reviewed research proposals for Israel Science Foundation (ISF).

Member of Optical Society of America **11/2006 – Present**

Member of Materials Research Society **04/2015 – Present**

Project Leader, MIT & FLIR Systems, Inc. **02/2010 – 06/2014**

- Directed and advised projects in collaboration with FLIR Systems to model, fabricate, and test fiber-based remote chemical vapor sensors for detection of TNT and peroxide-based explosives.

Graduate Researcher, HUJI & Weizmann Institute, Rehovot, Israel **12/2004 – 12/2010**

- Developed and executed the Van-de-Graaff and Tandem accelerators adjustment for implantation of light ions into ferroelectric electrooptic crystals. Coordinated and led research efforts in collaboration with Prof. Michael Hass at the Department of Particle Physics at Weizmann Institute.

Computational, Analytical and Processing Skills

- Proficient with Zemax, Matlab and Solidworks parametric modeling. Proficient with RSoft, Mathcad and Origin modeling and data analysis. Familiar with COSMOL and LabVIEW functionality.
- Proficient with characterization and processing techniques such as: AFM-NSOM, SEM, TEM, FIB, FTIR, Prism Coupling. Familiar with Raman, Ellipsometry, and Reflectometry.
- Experienced with mechanical design, machine / fabrication shop, circuit design and laboratory test equipment.



- Experienced with cleanroom equipment: electroplating, CVD, thermal diffusion and e-beam deposition systems, photo and e-beam lithography, sputtering.
- Skilled in lab management, equipment maintenance, process troubleshooting and failure analysis.

Languages

- Russian, Hebrew, English.