

**NSF ERC
for
EUV
Science
and
Technology**



news from the EUV ERC

Volume 6 Issue 1

June, 2014

Extreme Ultraviolet Engineering Research Center 10 Years and Counting

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EUV

An NSF Engineering Research Center

The Extreme Ultraviolet Engineering Research Center is graduating from the NSF program that founded the Center and helped it grow over the last 10 years. Center research has expanded the boundaries of extreme ultraviolet technologies creating new knowledge and commercial impact. Numerous graduates of the Center have moved on to industry or to other research institutions where they are making significant contributions to the development of new products and new knowledge. During that time, the Center has also established and expanded labs and equipment. The labs have expanded into new buildings. Now the Center continues to push those boundaries into the next generation of industrial technologies with new funding from NSF and other federal agencies. This summer the Center is running very active programs that provide Research Experiences for Undergraduates and Research Experiences for Teachers.

As the Center moves into its second decade, it has received new funding from NSF in the form of an Advancing Innovative Research (AIR) grant, and a new 3-year RET grant to establish research experiences for teachers. Center groups at all three institutions have also received grants from different federal agencies to continue the research. The Colorado Universities have also committed funding to support the Center during the next five years. The future of EUV research, education, and its impact on industry remains extremely bright. Current and future collaborations with industry provide partnerships in which industry guidance and Center expertise combine to train the high tech workforce of the future while advancing capabilities that highly benefit our industry partners. We at the EUV ERC are extremely grateful for the relationships and collaborations we have with industry. We are looking forward to not only strengthening those relationships but also establishing new relationships with new industry partners.

Please join with us in celebrating the first 10 years and in continuing our industrial collaborations in the next ten years ... and beyond.



Beyond Graduation

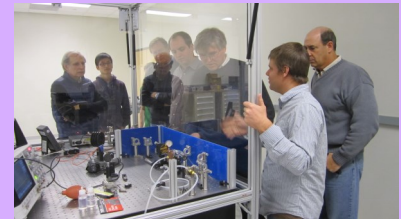
New Funding Continued Impact

The EUV ERC and IAB Member Cymer Collaborate to win NSF AIR Grant

The NSF *Accelerating Innovation Research* (AIR) program is part of the *Partnerships for Innovation* initiative that has the goals of accelerating the translation of technologically-promising NSF-funded research discoveries toward commercial reality and engaging students and faculty in entrepreneurial/innovative thinking. Competition for this award is open only to companies partnering with current or graduated NSF Engineering Research Centers.

Our NSF grant is focused on leveraging existing EUVL technology from the NSF EUV ERC and semiconductor equipment companies to help speed the significant development of future generation EUVL lithography. Project is designed to create an innovation ecosystem to address the critical challenges surrounding printing future generation computer chips, and educating a uniquely trained workforce necessary to transfer and commercialize this new technology.

NSF AIR grants provide funding with matching industry investments of cash and in-kind support, for a period of up to 18 months. See NSF publication 14-569 for details of the most recent solicitation.



Cymer team members David Brandt, Igor Formenkov, Michael Purvis, and Joe Bendik visiting a Center Laboratory at CSU.

EUV ERC Named Research Experience for Teachers Site (2014-2017)

The EUV ERC, recently received another award from the National Science Foundation to serve as a Research Experience for Teachers (RET) site. The grant is a joint collaboration between Colorado State, CU-Boulder, and UC-Berkeley. Building on the successes of the previous RET grant, EUV Center Education Director Kaarin Goncz and faculty from the Center will work in concert with Dr. Michael de Miranda, professor of engineering education and electrical and computer engineering, to reach out to high school teachers in the STEM (science, technology, engineering, and math) disciplines. The team will focus primarily on teachers in districts that support underrepresented minority groups. The teachers spend 6 weeks of their summer at the Center. The main focus of the program is to provide the teachers with an authentic, research experience along with workshops in lasers and optics, and other professional development opportunities that will allow them to modify and build new classroom curriculum. The EUV ERC has previously hosted 24 teachers. This summer, we are excited to welcome 8 new teachers! Few places in the world offer this unique research focus area in the EUV sciences, and the grant represents a big step forward in efforts to train the next generation of STEM teacher and students.



Caption: As part of the summer experience, teachers take a tour of KM Labs to see first-hand applications of their research projects. Industry tours also help make teachers aware of job opportunities so that they can communicate this information to their students.

CLEO 2014 June 9 - 12, 2014

Monday June 9th, 2014

SM1F. Solid State Laser Systems for Secondary Source Generation

8:00 AM - 10:00 AM; Executive Ballroom 210F (Convention Center)

9:00 AM - 9:30 AM

SM1F.4. 1 Joule, 100 Hz Repetition Rate, Picosecond CPA Laser for Driving High Average Power Soft X-Ray Lasers

Brendan A. Reagan; Cory Baumgarten; Keith Wernsing; Herman Bravo; Mark Woolston; Alden Curtis; Federico J. Furch; Brad Luther; Dinesh Patel; Carmen Menoni; Jorge J. Rocca

Tuesday June 10th, 2014

FTu2D. Novel XUV/X-Ray Sources

Presider(s): Oliver Muecke (Deutsches Elektronen Synchrotron)

2:00 PM - 4:00 PM; Executive Ballroom 210D (Convention Center)

3:15 PM - 3:30 PM

FTu2D.5. Ultra-High Energy Density Relativistic Plasmas and X-ray Generation by Ultrafast Laser Irradiation of Nanowire Arrays, Michael Purvis; Jorge Rocca; Reed Hollinger; Clayton Bargsten; Vyacheslav Shlyaptsev; Brad Luther; Alexander Pukhov; Carmen S. Menoni; Yong Wang; Liang Yin; Amy Prieto; Amanda Townsend; David Keiss

FTu3B. Advances in High-Harmonic Generation

Presider(s): François Légaré (INRS-Energie Mat & Tele Site Varennes)

4:30 PM - 6:30 PM; Executive Ballroom 210B (Convention Center)

4:30 PM - 4:45 PM

FTu3B.1. Magnetic Circular Dichroism Probed with Bright High-order Harmonics

Ofer Kfir; Patrik Grychtol; Emrah Turgut; Ronny Knut; Dmitriy Zusin; Dimitar Popmintchev; Tenio Popmintchev; Hans Nembach; Justin M. Shaw; Avner Fleischer; Henry Kapteyn; Margaret Murnane; Oren Cohen

4:45 PM - 5:00 PM

FTu3B.2. High flux coherent supercontinuum soft X-ray source driven by a single-stage 10 mJ, kHz, Ti:sapphire laser amplifier

Chengyuan Ding; Wei Xiong; Tingting Fan; Daniel Hickstein; Tenio Popmintchev; Xiaoshi Zhang; Mike Walls; Margaret Murnane; Henry Kapteyn

5:30 PM - 5:45 PM

FTu3B.5. Generation of Bright Isolated Attosecond Soft X-Ray Pulses Driven by Multi-Cycle Mid-Infrared Lasers

Christopher A. Mancuso; Ming-Chang Chen; Carlos Hernandez-Garcia; Franklin Dollar; Benjamin Galloway; Dimitar Popmintchev; Benjamin Langdon; Amelie Auger; P. C. Huang; Barry C. Walker; Luis Plaja; Agnieszka Jaron-Becker; Andreas Becker; Margaret Murnane; Henry Kapteyn; Tenio Popmintchev

6:00 PM - 6:15 PM

FTu3B.7. Theory of time-gated phase-matching for isolated attosecond soft x-ray pulse generation using mid-infrared lasers. Carlos Hernandez-Garcia; Ming-Chang Chen; Christopher Mancuso; Franklin Dollar; Benjamin Galloway; Dimitar Popmintchev; Pei-Chi Huang; Barry C. Walker; Tenio Popmintchev; Margaret Murnane; Henry Kapteyn; Luis Plaja; Agnieszka Jaron-Becker; Andreas Becker

CLEO 2014 June 9 - 12, 2014

(continued)

Thursday June 12th, 2014

FTh1D. Solitons and Temporal Effects

Presider(s): Marco Peccianti (University of Sussex)

2:00 PM - 4:00 PM; Meeting Room 212 A/C (Convention Center)

2:45 PM - 3:00 PM

JTh3J.3. Enhanced Laser Damage Behavior of Laser Mirror by Modification of the Top Layer Design

Drew Schiltz; Peter Langston; Dinesh Patel; Luke Emmert; Leandro Acquaroli; Cory Baumgarten; Brendan A. Reagan; Wolfgang Rudolph; Ashot Markosyan; R. Route; Martin M. Fejer; Jorge Rocca; Carmen S. Menoni

STh4H. Plasmonics, Raman and Resonance Sensing

Presider(s): Ralph Jimenez (University of Colorado at Boulder)

4:30 PM - 6:30 PM; Executive Ballroom 210H (Convention Center)

5:00 PM - 5:15 PM

STh4H.3. 3D plasmonic hollow nanoantennas as tools for neuroscience applications

Michele Dipalo; Mario Malerba; Gabriele C. Messina; Rosanna La Rocca; Ermanno Miele; Hayder Amin; Alessandro Maccione; Luca Berdondini; Francesco De Angelis

STh3O. Timing and Imaging

Presider(s): Franklyn Quinlan (National Inst of Standards & Technology)

2:00 PM - 4:00 PM; Salon V & VI (Marriott)

2:00 PM - 2:15 PM

STh3O.1. High fidelity, general reflection-mode coherent diffractive imaging with a tabletop EUV source

daniel adams; Bosheng Zhang; Matthew Seaberg; Dennis Gardner; Elisabeth Shanblatt; Margaret Murnane; Henry Kapteyn

STh4E. OPO, OPA and Regenerative Amplifiers

Presider(s): Takao Fuji (National Institutes of Natural Sciences)

4:30 PM - 6:30 PM; Executive Ballroom 210E (Convention Center)

6:15 PM - 6:30 PM

STh4E.8. High Repetition Rate, mJ-Level, mid-IR OPCPA System

Michael Gerrity; Susannah Brown; Tenio Popmintchev; Margaret Murnane; Henry Kapteyn; Sterling Backus

Industrial Advisory Board Meeting February 27, 2014 San Jose, California

Members of the Center's Industrial Advisory Board joined Center Principal Investigators and staff for a meeting held at the end of the SPIE Advanced Lithography conference in San Jose, California. PIs Margaret Murnane, Patrick Naulleau and Jorge Rocca provided updates on Center research. The industrial Liaison Officer, Bob Bower, provided attendees with an overview of industry program activities. Much of the latter part of the meeting focused on Center graduates who have gone on to positions in industry. This part of the meeting wrapped up with a detailed discussion of the Center's sustainability plans including sources of funding already in place as well as future funding opportunities.

The Center also rolled out a new addition to the industry portion of the website. Student resumes are now posted at <http://projects-web.engr.colostate.edu/euvec/industry/resumes.shtml>. In addition to the resumes, the webpage provides, for each student, a recent photo, contact information, a brief summary of goals, expected graduation date and a listing of the research group affiliation.



This year's meeting included presentations from the Center's Deputy Director, Margaret Murnane, University of Colorado, Boulder, Patrick Naulleau, Director, CXRO at Berkeley, and the Center Director, Jorge Rocca, Colorado State University.

Research Updates

Progress in the Development of High Harmonic Lasers and Applications

Margaret Murnane

Progress in the Development of EUV Lasers and Applications

Jorge Rocca

Progress in EUV Metrology Systems and Applications

Patrick Naulleau



- Adrian N. Pfeiffer, M. Justine Bell, Annelise R. Beck, Hiroki Mashiko, Daniel M. Neumark, and Stephen R. Leone, "Alternating absorption features during attosecond-pulse propagation in a laser-controlled gaseous medium", *Phys. Rev. A* 88, 051402(R) (2013)
- Kelly ST, Nigge P, Prakash S, Laskin A, Wang B, Tyliczszak T, Leone SR, Gilles MK., "An environmental sample chamber for reliable scanning transmission x-ray microscopy measurements under water vapor", *Rev. Sci. Instrum.* 84, 073708 (2013)
- Ranitovic P, Hogle CW, Rivière P, Palacios A, Tong XM, Toshima N, González-Castrillo A, Martin L, Martín F, Murnane MM, Kapteyn H., "Attosecond vacuum UV coherent control of molecular dynamics", *Proceedings of the National Academy of Sciences* 111, 3, 912 (2014)
- M. Marconi, "Breakthroughs in Photonics: Nano-structuring and nano-fabrication", *IEEE Photonics Journal*, 5, 2 (2013)
- Adrian N. Pfeiffer, Scott G. Sayresa & Stephen R. Leone, "Calculation of valence electron motion induced by sequential strong-field ionisation", *Molecular Physics*, 111, 14-15 (2013)
- Zhi-Heng Loh and Stephen R. Leone, "Capturing Ultrafast Quantum Dynamics with Femtosecond and Attosecond X-ray Core-Level Absorption Spectroscopy", *J. Phys. Chem. Lett.*, 4 (2) (2013)
- Erik R. Hosler and Stephen R. Leone, "Characterization of vibrational wave packets by core-level high-harmonic transient absorption spectroscopy", *PhysRevA* 88, 023420 (2013)
- Piotr Matyba, Adra V. Carr, Cong Chen, David L. Miller, Guowen Peng, Stefan Mathias, Manos Mavrikakis, Daniel S. Dessau, Mark W. Keller, Henry C. Kapteyn, and Margaret Murnane, "Controlling the electronic structure of graphene using surface-adsorbate interactions", *BAPS*, 59, 1 (2014)
- Wei Li, Victor Martinez Esquiros, Lukasz Urbanski, Dinesh Patel, Carmen S. Menoni, and Mario C. Marconia, "Defect-free periodic structures using extreme ultraviolet Talbot lithography in a table-top system", *J. Vac. Sci. Technol. B* 31, 06F604 (2013)
- MG Capeluto, MC Marconi, CC Lemmi., "Design of a phase-shifting interferometer in the extreme ultraviolet for high-precision metrology", *Appl Opt.*, 53(7) (2014)
- Josh Vura-Weis, Chang-Ming Jiang, Chong Liu, Hanwei Gao, J. Matthew Lucas, Frank M. F. de Groot, Peidong Yang, A. Paul Alivisatos, and Stephen R. Leone, "Femtosecond $M_{2,3}$ -Edge Spectroscopy of Transition-Metal Oxides: Photoinduced Oxidation State Change in $\alpha\text{-Fe}_2\text{O}_3$ ", *J. Phys. Chem. Lett.*, 4 (21) (2013)
- Bosheng Zhang, Matthew D. Seaberg, Daniel E. Adams, Dennis F. Gardner, Elisabeth R. Shanblatt, Justin M. Shaw, Weilun Chao, Eric M. Gullikson, Farhad Salmassi, Henry C. Kapteyn, and Margaret M. Murnane, "Full field tabletop EUV coherent diffractive imaging in a transmission geometry", *Optics Express*, 21, 19 (2013)
- Ofer Kfir, Patrik Grychtol, Emrah Turgut, Ronny Knut, Dmitriy Zusin, Dimitar Popmintchev, Tenio Popmintchev, Hans Nembach, Justin M. Shaw, Avner Fleischer, Henry Kapteyn, Margaret Murnane and Oren Cohen, "Generation of bright circularly-polarized extreme ultraviolet high harmonics for magnetic circular dichroism spectroscopy", Submitted (2014)
- M.-C. Chen, C. Hernández-García, C. Mancuso, F. Dollar, B. Galloway, D. Popmintchev, P.-C. Huang, B. Walker, L. Plaja, A. Jaron-Becker, A. Becker, T. Popmintchev, M. M. Murnane, H. C. Kapteyn, "Generation of Bright Isolated Attosecond Soft X-Ray Pulses Driven by Multi-Cycle Mid-Infrared Lasers", Submitted (2014)

- Chengyuan Ding, Wei Xiong, Tingting Fan, Daniel D. Hickstein, Tenio Popmintchev, Xiaoshi Zhang, Mike Walls, Margaret M. Murnane, Henry C. Kapteyn, "High flux coherent supercontinuum soft X-ray source driven by a single-stage 10 mJ, kHz, Ti:sapphire laser amplifier", under Optics Express peer review (2014)
- CJ Stolz, JE Wolfe, JJ Adams, MG Menor, NE Teslich, PB Mirkarimi, JA Folta, R Soufli, CS Menoni, D Patel., "High laser-resistant multilayer mirrors by nodular defect planarization [invited].", Appl Opt. 53(4) (2014)
- Nils Lundt, Stephen T. Kelly, Tobias Rödel, Benjamin Remez, Adam M. Schwartzberg, Alejandro Ceballos, Chloé Baldasseroni, Peter A. F. Anastasi, Malcolm Cox, Frances Hellman, Stephen R. Leone, and Mary K. Gilles, "High spatial resolution Raman thermometry analysis of TiO₂ microparticles", Rev Sci Instrum., 84(10) (2013)
- Birgitta Bernhardt, Annelise R. Beck, Xuan Li, Erika R. Warrick, M. Justine Bell, Daniel J. Haxton, C. William McCurdy, Daniel M. Neumark, and Stephen R. Leone, "High-spectral-resolution attosecond absorption spectroscopy of autoionization in xenon", Phys. Rev. A 89, 023408 (2014)
- Brendan A. Reagan, Wei Li, Lukasz Urbanski, Keith A. Wernsing, Chase Salsbury, Cory Baumgarten, Mario C. Marconi, Carmen. S. Menoni, and Jorge J. Rocca, "Hour-long continuous operation of a tabletop soft x-ray laser at 50-100 Hz repetition rate", Optics Express, 21, 23 (2013)
- M. Justine Bell, Annelise R. Beca, Hiroki Mashika, Daniel M. Neumarka and Stephen R. Leone, "Intensity dependence of light-induced states in transient absorption of laser-dressed helium measured with isolated attosecond pulses", Journal of Modern Optics, 60, 17 (2013)
- MF Lin, DM Neumark, O Gessner, SR Leone., "Ionization and dissociation dynamics of vinyl bromide probed by femtosecond extreme ultraviolet transient absorption spectroscopy.", J Chem Phys. 140(6), 2014
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- Wei Xiong, Daniel D. Hickstein, Kyle J. Schnitzenbaumer, Jennifer L. Ellis, Brett B. Palm, K. Ellen Keister, Chengyuan Ding, Luis Miaja-Avila, Gordana Dukovic, Jose L. Jimenez, Margaret M. Murnane, and Henry C. Kapteyn, "Photoelectron Spectroscopy of CdSe Nanocrystals in the Gas Phase: A Direct Measure of the Evanescent Electron Wave Function of Quantum Dots", Nano Lett., 13 (6) (2013)
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- Michael A. Purvis, Vyacheslav N. Shlyaptev, Reed Hollinger, Clayton Bargsten, Alexander Pukhov, Amy Prieto, Yong Wang, Bradley M. Luther, Liang Yin, Shoujun Wang & Jorge J. Rocca, "Relativistic plasma nanophotonics for ultrahigh energy density physics", Nature Photonics 7 (2013)

- Emrah Turgut, Patrik Grychtol, Chan La-O-Vorakiat, Daniel E. Adams, Henry C. Kapteyn, Margaret M. Murnane, Stefan Mathias, Martin Aeschlimann, Claus M. Schneider, Justin M. Shaw, Hans T. Nembach, and Thomas J. Silva, "Reply to Comment on Ultrafast Demagnetization Measurements Using Extreme Ultraviolet Light- Comparison of Electronic and Magnetic Contributions", *Phys. Rev. X* 3, 038002 (2013)
- Y Wang, L Yin, S Wang, MC Marconi, J Dunn, E Gullikson, JJ Rocca, "Single-shot soft x-ray laser linewidth measurement using a grating interferometer", *Opt Lett.* 38(23) (2013)
- Brendan A. Reagan, Mark Berrill, Keith A. Wernsing, Cory Baumgarten, Mark Woolston, and Jorge J. Rocca, "High average power 100 Hz repetition rate table-top soft x-ray lasers at sub-15 nm wavelengths", *Physical Review A*, (recently accepted for publication) (2014)
- Matthew D. Seaberg, Bosheng Zhang, Dennis F. Gardner, Elisabeth R. Shanblatt, Margaret M. Murnane, Henry C. Kapteyn, Daniel E. Adams, "Tabletop Nanometer Extreme Ultraviolet Imaging in an Extended Reflection Mode using Coherent Fresnel Ptychography", submitted, arXiv:1312.2049, (2014)
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- Lu Li, Yong Wang, Shoujun Wang, Eduardo Oliva, Liang Yin, T. T. Thuy Le, Sameh Daboussi, David Ros, Gilles Maynard, Stephane Sebban, Bitao Hu, Jorge J. Rocca, and Philippe Zeitoun, "Wavefront improvement in an injection-seeded soft x-ray laser based on a solid-target plasma amplifier", *Optics Letters*, 38, 20 (2013)
- Y. Wang, S. Wang, E. Oliva, L. Li, M. Berrill, L. Yin, J. Nejd, B. M. Luther, C. Proux, T. T. T. Le, J. Dunn, D. Ros, Ph. Zeitoun and J. J. Rocca, "Gain dynamics in a soft-X-ray laser amplifier perturbed by a strong injected X-ray field", *Nature Photonics* 8 (2013)
- Michael A. Purvis, Vyacheslav N. Shlyaptsev, Reed Hollinger, Clayton Bargsten, Alexander Pukhov, Amy Prieto, Yong Wang, Bradley M. Luther, Liang Yin, Shoujun Wang & Jorge J. Rocca, "Relativistic plasma nanophotonics for ultrahigh energy density physics", *Nature Photonics* 7 (2013)



The 14th International Conference on X-Ray Lasers 2014

The 14th International Conference on X-Ray Lasers was held at Colorado State University, Fort Collins, Colorado, USA, from May 26th– 30th, 2014. The conference included an excursion to Rocky Mountain National Park including a stop at the Alpine Visitor's Center at 12,000+ feet and a reception at the historic Stanley Hotel in Estes Park, Colorado. Thursday night's banquet was held at the Canyon Chop House in Fort Collins. The 14th International Conference had a total of 64 talks and a poster session with 25 Posters. Attendees came from numerous locations in Europe, Asia, South America, Russia and Australia as well as the United States.



The presentations were organized within 12 sessions including X-Ray Lasers, X-Ray Imaging, FEL-based X-Ray sources, Lithography, Optics, Characterization, Relativistic Phenomena and X-Ray Laser Material Interaction. A highlight of the conference was a celebration of the life of Jim Dunn who, although he passed away in March, was very much a part of the conference in both the content of the presentations and in spirit. In addition to a retrospective slide show, Jim was remembered by several speakers.



The following were presented by EUV ERC participants in the International Conference on X-Ray Lasers and will be published in the *Proceedings of the 14th International Conference on X-Ray Laser* to be released in the Fall of 2014.



- Brendan A. Reagan, Cory Baumgarten, Keith A. Wernsing, Mark Berrill, Mark Woolston, Lukasz Urbanski, Wei Li, Mario C. Marconi, Carmen S. Menoni, and Jorge J. Rocca, "Advances in High Average Power, 100 Hz Repetition Rate Table-top Soft X-ray Laser".
- Ph. Zeitoun, S. Daboussi, H. Dacassa, T. T. T. Le, L. Li, B. Mahieu, E. Oliva, D. Ros, S. Sebban, Y. Wang, S. Wang, L. Yin, B. Hu, and J. J. Rocca, "Laboratoire d'Optique Appliquée (LOA), Campus Polytechnique, Chemin de la Hunière 91761 Palaiseau, France".
- V. N. Shlyaptsev, G. Avaria, M. Grisham, J. Li, F.G. Tomasel, M. Busquet, M. Woolston, J.J. Rocca, "Capillary Discharge X-ray Lasers: The Quest for the sub-10nm Lasing".
- D. Popmintchev, C. Hernández-García, J. A. Pérez-Hernández, M.-C. Chen, F. Dollar, C. Manusco, X.-M. Tong, D. Romanov, R. Levis, B. Shim, A. Gaeta, A. Jaron-Becker, A. Becker, L. Plaja, M. M. Murnane, and H. C. Kapteyn, T. Popmintchev, "Bright Isolated Attosecond Pulses in the X-ray Regime and Applications".
- P. Grychtol, O. Kfir, R. Knut, E. Turgut, D. Zusin, D. Popmintchev, T. Popmintchev, H. Nembach, J. Shaw, A. Fleicher, H. Kapteyn, M. Murnane and O. Cohen, "Generation of high harmonics with circular polarization and their use for magnetic materials studies".
- I. Kuznetsov, J. Filevich, M. Woolston G.L. Gasper, D. Carlton, W. Chao, E.H. Anderson, E.R. Bernstein, D.C. Crick, J.J. Rocca and C.S. Menoni, "Volumetric composition imaging at the nanoscale by soft x-ray laser ablation mass spectrometry".
- D.F. Gardner, B. Zhang, D.E. Adams, M.D. Seaberg, E.R. Shanblatt, M. Murnane, H. Kapteyn, "Reflection mode imaging with extreme-ultraviolet light from a high harmonic source".
- M.C. Marconi, N. Monserud, E. Malm, P. Wachulak, W. Chao, "Time resolved holography in a table top with a table top Soft X-ray Laser".
- V. Kimberg, C. Weninger, T. Kierspel, T. Mullins, B. Erk, A. Sanchez-Gonzalez, M. Purvis, D. Ryan, R. Coffee, J. D. Bozek, C. Bostedt, S. Carron Montero, A. Lindahl, M. Ilchen, A. Lutman, J. Krzywinski, T. Maxwell, M. Agaker, C. Sathe, R. Squibb, M. Mucke, V. Zhaunerchyk, R. Feifel, D. Rolles, R. London, O. Mücke, J. Nordgren, J. J. Rocca, J. Küpper, J.E. Rubensson, N. Rohringer, "Stimulated X-Ray Raman Scattering with Free-Electron Laser Sources".
- Patrick P. Naulleau, Christopher N. Anderson, Weilun Chao, Peter Fischer, Kenneth A. Goldberg, Eric M. Gullikson, Ryan Miyakawa, "EUV research at Berkeley Lab: enabling technologies and applications".
- Wei Li, D. Patel, W. Chao, C.S. Menoni, M.C. Marconi, "Defect-free fabrication of periodic structures using Talbot lithography and a table top Soft X-ray Laser".
- Ryan Miyakawa, Patrick Naulleau, "Applications for coherent narrow-band EUV sources in semiconductor high volume manufacturing".
- Michael A. Purvis, Vyacheslav N. Shlyaptsev, Reed Hollinger, Clayton Bargsten, Alexander Pukhov, David Keiss, Amanda Townsend, Yong Wang, Shoujun Wang, Liang Yin, Amy Prieto, Mark Berrill, Bradley Luther, Jorge J. Rocca, "X-ray Generation in Ultra-High Energy Density Relativistic Plasmas by Ultrafast Laser Irradiation of Nanowire Arrays".
- Elisabeth Shanblatt, Matthew Seaberg, Bosheng Zhang, Dennis Gardner, Margaret Murnane, Henry Kapteyn, Daniel Adams, "Keyhole reflection-mode coherent diffractive imaging of nano-patterned surfaces using a tabletop EUV source".
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- L. Yin, Y. Wang, S. Wang, M. Berrill, M.C. Marconi, O. Martinez, J. Dunn, J.J. Rocca, "Single-shot Soft-x-ray Laser Linewidth Measurements with a Grating".
- Ludek Vysin, Libor Juha, Marie Davidkova, Jorge J. Rocca, "XUV capillary-discharge laser-induced damage to biomolecular systems: from DNA plasmids to biomembranes and cell surfaces".
- G. Avaria, M. Grisham, J. Li, F.G. Tomasel, V. N. Shlyaptsev, M. Busquet, M. Woolston, J.J. Rocca, "Ionization of Xenon to the Nickel-like stage and beyond in micro-capillary plasma columns heated by ultrafast current pulses".
- J. Nejd, I.D. Howlett, J. J. Rocca, D. Carlton, and C.s. Menoni, "Soft x-ray digital holographic microscopy".
- S. Leone, "Isolated X-ray Attosecond Pulses and The Science of Attosecond Measurements"

Awards and Honors

IEEE Professor Carmen Menoni Named University Distinguished Professor

Carmen Menoni, a professor of Electrical and Computer engineering, Chemistry and the School of Biomedical Engineering, is an internationally recognized researcher in optics and a role model for women in engineering and science.

She has established strong research programs in semiconductor physics, optical materials science and engineering, and nano-scale imaging and spectroscopy using bright beams of extreme ultraviolet laser light.

In 2012, Menoni received CSU's Scholarship Impact Award, the university's highest recognition for accomplishments in research. It is awarded to faculty whose scholarship has had national and international impact.

Her innovative research has received national and international recognition, including an R&D 100 Award, widely recognized as the "Oscars of Innovation," for leading the development of a compact extreme ultraviolet light-based microscope. She also has received two technology transfer awards from the state of Colorado for her contributions to industry.

Menoni is Fellow of the Institute of Electrical & Electronics Engineers, the Optical Society of America, the American Physical Society, and the International Society for Optics and Photonics. Menoni is founding editor and present editor in chief of IEEE Photonics Journal.

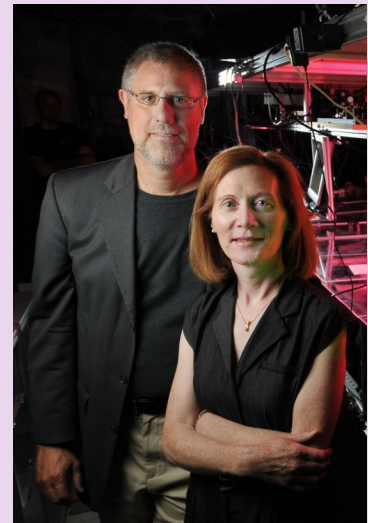


Henry Kapteyn and Margaret Murnane 2014 CU Boulder Inventors of the Year

Boulder Physics professors Henry Kapteyn and Margaret Murnane were honored by the University of Colorado's Technology Transfer Office for their work improving the development of nanotechnology.

The professors were recognized at an awards dinner on April 24. The TTO presented awards to four CU Boulder professors and researchers who pioneer scientific and technological innovation. Inventions by researchers from the university's four locations have led to the creation of 132 new companies in the past 20 years, according to a release. Nearly 90 of those companies operate in Colorado and seven of them are publicly traded.

Kapteyn and Murnane were named the inventors of the year. The two use with ultrafast lasers and x-rays to provide a more detailed look into nano processes. The technology could lead to the production of nano devices. The duo founded KMLabs in 1994 to commercialize their research, making their work available to academia, industry researchers and companies that develop nanotechnology.



Students and Post Docs



2014 NSF Graduate Fellowship,
David Couch



2013 SPIE Fellowship,
Clayton Bargsten



2013 John Dawson Thesis
Prize, Franklin Dollar



2013 NSF Graduate Fellowship,
Drew Schiltz
2013 Directed Energy
Professional Society Fellowship,
Drew Schiltz

The Extreme Ultraviolet (EUV) Engineering Research Center is one of 20 centers established in the United States through the National Science Foundation and supplemented by industry funding. Colorado State University (CSU) is the host institution with partner sites at the University of Colorado (CU), UC Berkeley and Lawrence Berkeley National Laboratory. The Center's research mission is the development of compact coherent EUV sources and EUV-engineered systems that provide solutions to challenging scientific and industrial problems, including the development of new tools for nanotechnology and nanoscience. The Center has an important educational mission providing a unique environment for the training of students, young engineers and scientists. An Industry Advisory Board (IAB) with members, ranging from large- to small-capitalized companies, spanning instrumentation, semiconductor, lasers and optics, nanotechnology and the biological and chemical sciences actively participate in early access to technologies, joint research projects, directed research projects and the hiring of the some of the best students in the world in these areas.

EUV IAB Throughout the History of the Center



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