

Space Nanotechnology Laboratory
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BIBLIOGRAPHY

| | |
|---|----|
| Publications..... | 2 |
| Presentations..... | 14 |
| Student Theses: | |
| Internship Reports..... | 37 |
| Bachelor's Thesis..... | 37 |
| Master's Thesis..... | 37 |
| Ph.D. Dissertations..... | 38 |
| Patents..... | 40 |
| Miscellaneous Reports and White Papers..... | 40 |
| Press Releases..... | 41 |

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- P71. "Why bother with x-ray lithography?," H.I. Smith and M.L. Schattenburg, presented at the *SPIE Conference on Electron-Beam, X-Ray and Ion-Beam Submicrometer Lithographies for Manufacturing II*, San Jose, California, Mar. 8-9, 1992 (*paper 1671-08*).
- P72. "The MIT high resolution x-ray spectroscopy instruments on AXAF," C.R. Canizares, D. Dewey, E.B. Galton, T.H. Markert, H.I. Smith, M.L. Schattenburg, B.E. Woodgate and S. Jordan, presented at the *American Institute of Aeronautics and Astronautics -- Space Programs and Technologies Conference*, Huntsville, Alabama, Mar. 24-27, 1992 (*paper AIAA-92-1469*).
- P73. "Spatially coherent, large-area, free-standing gratings of 200 and 100 nm period for atom interferometry produced using holographic lithography," J.M. Carter, D. Olster, M.L. Schattenburg, S.D. Hector and H.I. Smith, poster presented at the *36th International Symposium on Electron, Ion and Photon Beams (EIPB'92)*, Orlando, Florida, May 26-29, 1992 (*paper C57*).
- P74. "Observation of conductance quantization in a GaAs electron waveguide device fabricated by contact x-ray lithography," W. Chu, C.C. Eugster, A. Moel, E.E. Moon, J.A. del Alamo, H.I. Smith, M.L. Schattenburg, K.W. Rhee, M.C. Peckerar and M.R. Melloch, poster presented at the *36th International Symposium on Electron, Ion and Photon Beams (EIPB'92)*, Orlando, Florida, May 26-29, 1992 (*paper C58*).
- P75. "Fabrication of parallel quasi-one-dimensional wires using a novel conformable x-ray mask technology," R.A. Ghanbari, W. Chu, E. Moon, M. Burkhardt, K. Yee, D.A. Antoniadis, H.I. Smith, M.L. Schattenburg, K.W. Rhee, R. Bass, M.C. Peckerar and M.R. Melloch, poster presented at the *36th International Symposium on Electron, Ion and Photon Beams (EIPB'92)*, Orlando, Florida, May 26-29, 1992 (*paper C78*).
- P76. "Modeling and experimental verification of illumination and diffraction effects on process latitude in point source x-ray lithography," S.D. Hector, M.L. Schattenburg, E.H. Anderson, W. Chu, A. Yen and H.I. Smith,

presented at the *36th International Symposium on Electron, Ion and Photon Beams (EIPB'92)*, Orlando, Florida, May 26-29, 1992 (*paper S4*).

- P77. "Modeling and experimental verification of illumination and diffraction effects on image quality in x-ray lithography," S.D. Hector, M.L. Schattenburg, E.H. Anderson, W. Chu, V.V. Wong and H.I. Smith, presented at the *Microsystems Technology Laboratories & Industrial Liaison Program Microelectronics Research Review*, MIT, Cambridge, Massachusetts, Sept. 29-30, 1992.
- P78. "Observation of conductance quantization in a GaAs electron waveguide device fabricated by x-ray lithography," W. Chu, C.C. Eugster, A. Moel, R.A. Ghanbari, E.E. Moon, J.A. del Alamo, H.I. Smith, M.L. Schattenburg, K.W. Rhee, M.C. Peckerar and M.R. Melloch, presented at the *Microsystems Technology Laboratories & Industrial Liaison Program Microelectronics Research Review*, MIT, Cambridge, Massachusetts, Sept. 29-30, 1992.
- P79. "Large-area, free-standing gratings for atom interferometry produced using holographic lithography," J.C. Lew, J.M. Carter, M.L. Schattenburg and H.I. Smith, poster presented at the *Microsystems Technology Laboratories & Industrial Liaison Program Microelectronics Research Review*, MIT, Cambridge, Massachusetts, Sept. 29-30, 1992.
- P80. "Proximity x-ray nanolithography - current performance and theoretical limits," H.I. Smith and M.L. Schattenburg, presented at the *American Vacuum Society 39th National Symposium and Topical Conferences*, Chicago, Illinois, Nov. 9-13, 1992 (*invited paper J12-ThM6*).
- P81. "Fabrication of Si nanostructures," M.L. Schattenburg, H.I. Smith and K.Yee, presented at the *Seminar on "Light Emissive Silicon"*, MIT, Cambridge, Massachusetts, Dec. 4, 1992 (*invited*).

1993

- P82. "X-ray nanolithography: limits and application to sub-100 nm manufacturing," H.I. Smith and M.L. Schattenburg, presented at the *NATO Workshop on NANOLITHOGRAPHY: A Borderland between STM, EB, IB and X-ray Lithographies*, Rome, Italy, Apr. 6-8, 1993 (*invited*).
- P83. "Mask technology for x-ray nanolithography," H.I. Smith, M.L. Schattenburg, W. Chu, R. Ghanbari, M. Mondol and J. Carter, presented at the *1993 Materials Research Society Spring Meeting Symposium - Materials Aspects of X-ray Lithography*, San Francisco, California, Apr. 12-16, 1993 (*paper K2.1*).
- P84. "Simultaneous optimization of wavelength, spatial coherence, gap, feature bias and absorber thickness in synchrotron-based proximity x-ray lithography," S.D. Hector, H.I. Smith and M.L. Schattenburg, poster presented at the *37th International Symposium on Electron, Ion and Photon Beams (EIPB'93)*, San Diego, California, June 1-4, 1993 (*paper C92*).
- P85. "Fabrication of flip-bonded mesa masks for x-ray lithography," M.L. Schattenburg, N.A. Polce, H.I. Smith and R. Stein, presented at the *37th International Symposium on Electron, Ion and Photon Beams (EIPB'93)*, San Diego, California, June 1-4, 1993 (*paper L4*).
- P86. "Grating fabrication technology for the AXAF High Energy Transmission Grating Spectrometer (HETG)," M.L. Schattenburg, *Harvard-Smithsonian Astrophysical Observatory - Instrumentation Seminar*, Cambridge, Massachusetts, Sept. 10, 1993 (*invited*).
- P87. "Microlithography for the AXAF-I High Energy Transmission Grating Spectrometer," M. McGuirk, R.J. Aucoin, M.L. Schattenburg, R.C. Fleming and H.I. Smith, presented at the *American Institute of Aeronautics and Astronautics Space Programs and Technologies Conference*, Huntsville, Alabama, Sept. 21-23, 1993 (*paper AIAA-93-4203*).
- P88. "Optimizing synchrotron-based x-ray lithography for 0.1 μm lithography," S.D. Hector, H.I. Smith and M.L. Schattenburg, presented at the *Microcircuit Engineering 93 - International Conference on Microlithography*, Sept. 27-29, 1993, Maastricht, The Netherlands (*paper 4A.2*).

1994

- P89. "Fabrication of transmission gratings for x-ray/EUV spectroscopy and polarization," M.L. Schattenburg, poster presented at the *Astronomy & Astrophysics Workshop*, Cambridge, Massachusetts, Jan. 24, 1994 (*paper 006*).
- P90. "The HETG spectrometer on AXAF," M.L. Schattenburg, private briefing for U.S. Sen. Barbara Mikulsky and MIT President Chuck Vest and staffs, Cambridge, Massachusetts, Feb. 18, 1994.
- P91. "Fabrication of transmission gratings for x-ray/EUV spectroscopy and polarization," M.L. Schattenburg, poster presented at the *Industrial Liaison Program - Research Directors Conference: A Window on Emerging Technologies*, Cambridge, Massachusetts, Mar. 5, 1994.

- P92. "Efficiency data and models for x-ray transmission gratings," Y.S. Song, T.H. Markert, C.S. Nelson, M.L. Schattenburg, D.E. Graessle and R.L. Blake, poster presented at the *Spring Meeting of the New England Section of the American Physical Society*, Cambridge, Massachusetts, Apr. 8-9, 1994 (*paper PA-5*); *Bulletin of the A.P.S.* **39**, p. 1279 (1994).
- P93. "Fabrication and testing of x-ray transmission gratings for the Advanced X-ray Astrophysics Facility," M.L. Schattenburg, *Lawrence Berkeley Laboratory - X-ray Science and Technology Weekly Seminar*, Berkeley, California, June 17, 1994 (*invited*).
- P94. "Fabrication and testing of x-ray transmission gratings for the Advanced X-ray Astrophysics Facility," M.L. Schattenburg, *Lawrence Livermore National Laboratory - Advanced Microtechnology Program Seminar*, Livermore, California, June 24, 1994 (*invited*).
- P95. "Fabrication of high energy x-ray transmission gratings for AXAF," M.L. Schattenburg, R.J. Aucoin, R.C. Fleming, I. Plotnik, J. Porter and H.I. Smith, presented (by R.J. Aucoin) at the *SPIE Conference on EUV, X-ray and Gamma-Ray Instrumentation for Astronomy V*, San Diego, California, July 24-29, 1994 (*paper 2280-17*).
- P96. "The High Energy Transmission Grating Spectrometer for AXAF," T.H. Markert, C.R. Canizares, D. Dewey, M. McGuirk, C. Pak and M.L. Schattenburg, presented at the *SPIE Conference on EUV, X-ray and Gamma-Ray Instrumentation for Astronomy V*, San Diego, California, July 24-29, 1994 (*paper 2280-19*).
- P97. "Efficiency measurements and modelling of AXAF high energy transmission gratings," C.S. Nelson, T.H. Markert, Y.S. Song, H.L. Marshall, M.L. Schattenburg, D.E. Graessle, K.A. Flanagan, R.L. Blake, J. Bauer and E.M. Gullikson, presented at the *SPIE Conference on EUV, X-ray and Gamma-Ray Instrumentation for Astronomy V*, San Diego, California, July 24-29, 1994 (*paper 2280-18*).
- P98. "Maskless single-sided wet etching process for the fabrication of ultra-low distortion polyimide membranes," M.L. Schattenburg, R.I. Fuentes, G. Czernienko, R.C. Fleming and J. Porter, poster presented at the *1994 Materials Research Society Fall Meeting Symposium - Thin Films: Stresses and Mechanical Properties V*, Boston, Massachusetts, Nov. 28-Dec. 2, 1994 (*paper B2-3.14*).

1995

- P99. "The HETG spectrometer on AXAF," M.L. Schattenburg, private briefing for NASA Chief Administrator Daniel Goldin and staff, Cambridge, Massachusetts, Mar. 6, 1995.
- P100. "Optically-matched tri-level resist process for nanostructure fabrication," M.L. Schattenburg, R.J. Aucoin and R.C. Fleming, presented at the *39th International Conference on Electron, Ion and Photon Beam Technology and Nanofabrication*, Scottsdale, Arizona, May 30-June 2, 1995 (*paper C75*).
- P101. "X-ray and XUV transmission gratings," M.L. Schattenburg, *University of Southern California - Department of Aerospace Engineering Seminar*, Los Angeles, California, June 15, 1995 (*invited*).
- P102. "Achromatic-interferometric lithography for 100 nm-period gratings and grids," T.A. Savas, S.N. Shah, M.L. Schattenburg, J.M. Carter and H.I. Smith, poster presented at the *39th International Conference on Electron Ion and Photon Beam Technology and Nanofabrication*, Scottsdale, AZ, May 30-June 2, 1995 (*paper C53*).
- P103. "Fabrication and applications of nanometer periodic structures," T.A. Savas, *Max Planck Institute Special Seminar*, Göttingen, Germany, Aug. 9, 1995 (*invited*).

1996

- P104. "The AXAF High Energy Transmission Grating Spectrometer," C.R. Canizares, D. Dewey, K. Flanagan, T. Markert, M. McGuirk and M.L. Schattenburg, presented at the *1996 Meeting of the American Astronomical Society - High Energy Astrophysics Division*, San Diego, California Apr. 30 - May 3, 1996.
- P105. "Analysis of distortion in interferometric lithography," J. Ferrera, M.L. Schattenburg and H.I. Smith, poster presented at the *40th International Conference on Electron, Ion and Photon Beam Technology and Nanofabrication*, Atlanta, Georgia, May 28-31, 1996 (*paper C8*).
- P106. "Large-area achromatic interferometric lithography for 100 nm-period gratings and grids; with novel applications," T. Savas, M.L. Schattenburg, J.M. Carter and H.I. Smith, presented at the *40th International Conference on Electron, Ion and Photon Beam Technology and Nanofabrication*, Atlanta, Georgia, May 28-31, 1996 (*paper A3*).
- P107. "A diffractive-optic telescope for x-ray astronomy," D. Dewey, T.H. Markert and M.L. Schattenburg, presented at the *SPIE Conference on Multilayer and Grazing Incidence X-ray/EUV Optics III*, Denver, Colorado, Aug. 4-9, 1996 (*paper 2805-29*).

- P108. "Iridium and gold optical constants from foil transmission measurements over 2,00-12,000 eV," B. Harris, D.E. Graessle, J.J. Fitch, J. Juda, R.L. Blake, E.M. Gullikson and M.L. Schattenburg, poster presented at the *SPIE Conference on Multilayer and Grazing Incidence X-ray/EUV Optics III*, Denver, Colorado, Aug. 4-9, 1996 (paper 2805-44).
- P109. "The HETG Spectrometer," M.L. Schattenburg, *Center for Space Research Friday Lunch Seminar*, Cambridge, Massachusetts, Sept. 20, 1996 (invited).
- P110. "A one-dimensional demonstration of spatial-phase-locked electron-beam lithography," J. Goodberlet, S. Silverman, J. Ferrera, M. Mondol, M.L. Schattenburg and H.I. Smith, presented at the *International Conference on Micro- and Nano-Engineering 96*, Glasgow, Scotland, Sept. 22-25, 1996 (paper K.3).
- P111. "Super-smooth x-ray reflection grating technology," A. Franke and M.L. Schattenburg, poster presented at the *High Throughput X-ray Spectroscopy Workshop*, Cambridge, Massachusetts, Sept. 30-Oct. 1, 1996.
- P112. "Interferometric lithography and its applications," J. Carter, M. Farhoud, J. Ferrera, A. Franke, T. Savas, M.L. Schattenburg and H.I. Smith, poster presented at the *50th Anniversary Celebration of the Research Laboratory of Electronics*, Cambridge, Massachusetts, Nov. 1, 1996.
- P113. "Super-smooth x-ray reflection grating technology," A. Franke and M.L. Schattenburg, poster presented at the *Structure and Evolution of the Universe Technology Workshop*, College Park, Maryland, Dec. 2-3, 1996.
- P114. "A research program leading to a 1 arcsec foil mirror x-ray telescope," M.L. Schattenburg and C.R. Canizares, presented at the *Structure and Evolution of the Universe Technology Workshop*, College Park, Maryland, Dec. 2-3, 1996.
- P115. "A research program leading to a 1 arcsec foil mirror x-ray telescope," M.L. Schattenburg and C.R. Canizares, *Harvard-Smithsonian Astrophysical Observatory Seminar*, Cambridge, Massachusetts, Dec. 6, 1996 (invited).

1997

- P116. "Fabrication of super-smooth x-ray reflection gratings," A. Franke and M.L. Schattenburg, poster presented at the *Microsystems Technology Laboratories Annual Review*, Dedham, Massachusetts, Jan. 17, 1997.
- P117. "Interferometric lithography: techniques and applications," M.L. Schattenburg, *1997 IEEE-LEOS Spring Short-Course Series: Optical Grating Technology and Applications*, Lexington, Massachusetts, Mar. 18, 1997 (invited).
- P118. "Super-smooth x-ray reflection grating fabrication," A.E. Franke and M.L. Schattenburg, poster presented at the *41st International Conference on Electron, Ion and Photon Beam Technology and Nanofabrication*, Dana Point, California, May 27-30, 1997 (paper C59).
- P119. "An inverted x-ray mask configuration compatible with pellicle protection," M.H. Lim, M.L. Schattenburg and H.I. Smith, presented at the *41st International Conference on Electron, Ion and Photon Beam Technology and Nanofabrication*, Dana Point, California, May 27-30, 1997 (paper J5).
- P120. "Spatial-phase locked electron beam lithography using a global fiducial grid," G. Goodberlet and M.L. Schattenburg, *Etec Corporation Seminar*, Hayward, California, June 10, 1997 (invited).
- P121. "Patterned magnetic media for ultra high density data storage," M.S. Farhoud, *University of Aachen - RWTH Institute*, Aachen, Germany, July 3, 1997 (invited).
- P122. "Comparison of iridium optical constants derived by transmission and reflection methods from 50-1000 eV," B. Harris, J.J. Fitch, D.E. Graessle, D.A. Schwartz, R.L. Blake, E.M. Gullikson and M.L. Schattenburg, presented at the *SPIE Conference on Grazing Incidence and Multilayer X-Ray Optical Systems*, San Diego, California, July 27-29, 1997 (paper 3113-05).
- P123. "Magnetic storage media defined by submicron lithography," M.F. Farhoud, H.I. Smith, M. Huang, D. Twisslemann, C.A. Ross, M.L. Schattenburg, J.M. Bae and K. Youcef-Toumi, poster presented at the *Materials Processing Center "Materials Day" Symposium*, Cambridge, Massachusetts, Oct. 20, 1997.
- P124. "Fabrication of freestanding gratings for the MENA atom imager," J. van Beek, *Center for Space Research Seminar*, Cambridge, Massachusetts, Oct. 31, 1997 (invited).

1998

- P125. "The road to nanoaccuracy in lithography," H.I. Smith, J.G. Goodberlet and M.L. Schattenburg, "Fabrication of large area nanostructured magnets by interferometric lithography," M.F. Farhoud, M. Hwang, J.M. Bae, M.L. Schattenburg, H.I. Smith, K. Youcef-Toumi and C.A. Ross, presented at the *7th Joint MMM-Intermag Conference*, San Francisco, California, Jan. 6-9, 1998.

- P126. "Accuracy and precision for the sub-100 nm domain: laying the foundation with optical interference," J. Ferrera, T. Savas, J. Goodberlet, M. Mondol, J. Carter, M.L. Schattenburg and H.I. Smith, poster presented at the *Microsystems Technology Laboratories Student Research Review*, Cambridge, Massachusetts, Jan. 12, 1998 (*paper 7*).
- P127. "Fabrication of large area nanostructured magnets by interferometric lithography," M.F. Farhoud, M. Hwang, J.M. Bae, M.L. Schattenburg, H.I. Smith, K. Youcef-Toumi and C.A. Ross, poster presented at the *Microsystems Technology Laboratories Student Research Review*, Cambridge, Massachusetts, Jan. 12, 1998 (*paper 28*).
- P128. "The road to nanoaccuracy in lithography," H.I. Smith, J.G. Goodberlet and M.L. Schattenburg, *Defense Advanced Research Projects Administration - Advanced Lithography Program Review*, San Antonio, Texas, Jan. 27, 1998 (*invited*).
- P129. "Nano-scale freestanding gratings for UV blocking filters," J. van Beek, R.C. Fleming, P.S. Hindle, J.D. Prentiss, S. Ritzau and M.L. Schattenburg, poster presented at the *42nd International Conference on Electron, Ion and Photon Beam Technology and Nanofabrication*, Chicago, Illinois, May 26-29, 1998 (*paper NFP2*).
- P130. "Analysis and modeling of anomalous scattering in the AXAF HETGS," J.E. Davis, H.L. Marshall, D. Dewey and M.L. Schattenburg, presented at the *SPIE Conference on X-ray Optics, Instruments and Missions*, San Diego, California, July 19, 1998 (*paper 3444-07*).
- P131. "100 nm gate aperture field emitter arrays," D.G. Pflug, M.L. Schattenburg, A.I. Akinwande and H.I. Smith, poster presented at the *International Vacuum Microelectronics Conference*, Asheville, North Carolina, July 19-24, 1998 (*paper P42*).
- P132. "Magnetospheric physics using energetic neutral atom (ENA) imaging: anticipating IMAGE," C.J. Pollock, J.L. Burch, H. Funsten, D. McComas, S. Ritzau and R. Skoug, M.C. Fok, M. Grande, M. Gruntman, M. Lampton, T. Mukai, E. Scime, M.L. Schattenburg and P. Valek, presented at the *New Millennium Magnetosphere: Integrating Imaging, Discrete Observations and Global Simulations, Sixth Huntsville Modeling Workshop*, Guntersville, Alabama, 26-30 Oct. 1998.
- P133. "100 nm aperture field emitter arrays for low voltage applications," D.G. Pflug, M.L. Schattenburg, H.I. Smith and A.I. Akinwande, presented at the *IEEE International Electron Device Meeting*, San Francisco, California, Dec. 6-9, 1998 (*paper 32-1*).

1999

- P134. "Scanning beam interference lithography," P. Konkola, P. Everett and M.L. Schattenburg, poster presented at the *Microsystems Technology Laboratories Student Research Review*, Dedham, Massachusetts, Jan. 11, 1999 (*paper A12*).
- P135. "Sub 100 nm metrology via interferometric lithography," M.L. Schattenburg, *Defense Advanced Research Projects Administration - Advanced Lithography Program Review*, Washington, D.C., Apr. 15, 1999 (*invited*).
- P136. "Sub-100 nm metrology using interferometrically produced fiducials," M.L. Schattenburg, presented at the *43rd International Conference on Electron, Ion and Photon Beam Technology and Nanofabrication*, Marco Island, Florida, June 1-4, 1999 (*invited paper AMT4*).
- P137. "A holographic phase-shifting interferometer technique to measure in-plane distortion," M.H. Lim, J. Ferrera, K.P. Pipe and H.I. Smith, *43rd International Conference on Electron, Ion and Photon Beam Technology and Nanofabrication*, Marco Island, Florida, June 1-4, 1999 (*paper AMTP1*).
- P138. "Fabrication of 200 nm period nanomagnet arrays using interferometric lithography and a negative resist," M. Farhoud, J. Ferrera, A.J. Lochtefeld, M.L. Schattenburg, C.A. Ross and H.I. Smith, poster presented at the *43rd International Conference on Electron, Ion and Photon Beam Technology and Nanofabrication*, Marco Island, Florida, June 1-4, 1999 (*paper NFP2*).
- P139. "Fabrication of patterned media for high density magnetic storage," C.A. Ross, H.I. Smith, T. Savas, M.L. Schattenburg, M. Farhoud, M. Hwang, M. Walsh, M.C. Abraham and R.J. Ram, presented at the *43rd International Conference on Electron, Ion and Photon Beam Technology and Nanofabrication*, Marco Island, Florida, June 1-4, 1999 (*invited paper ND3*).
- P140. "Segmented x-ray mirror development for Constellation-X," R. Petre, C. Chen, L. Cohen, D. Content, R.J. Harms, O. Mongrard, G. Monnelly, T. Saha, M.L. Schattenburg and W. Zhang, presented at the *SPIE Conference on X-Ray Optics, Instruments and Missions II*, Denver, Colorado, July 18, 1999 (*paper 3766-02*).
- P141. "Large-area reflection grating spectrometer for the Constellation-X mission," S.M. Kahn, F.B. Paerels, J.R. Peterson, A.P. Rasmussen, M.L. Schattenburg, G.R. Ricker, Jr., M.W. Bautz, J.P. Doty, G.Y. Prigozhin, J.A.

- Nousek, D.N. Burrows, J.E. Hill, W.C. Cash, presented at the *SPIE Conference on EUV, X-ray and Gamma-ray Instrumentation in Astronomy X*, Denver, Colorado, July 21, 1999 (paper 3765-11).
- P142. "X-ray telescope prototype," O. Mongrard, *Space Nanotechnology Laboratory Internship Presentation*, MIT Center for Space Research, Cambridge, Massachusetts, July 27, 1999.
- P143. "Fabrication of patterned media for high density magnetic storage," C.A. Ross, H.I. Smith, T. Savas, M.L. Schattenburg, M. Farhoud, M. Hwang, M. Walsh, M.C. Abraham and R.J. Ram, presented at the *25th International Conference on Micro- and Nano-Engineering*, Rome, Italy, Sept. 21-23, 1999 (invited as 'best paper' from EIPBN-99 conference).
- P144. "Initial Results from the *Chandra* High Energy Transmission Grating Spectrometer," C.R. Canizares, D.S. Davis, D. Dewey, K. Flanagan, J. Houck, D. Huenemoerder, H. Marshall and M.L. Schattenburg, N. Schulz and M. Wise, presented at the *Atomic Data Needs for X-ray Astronomy Meeting*, NASA Goddard Space Flight Center, Greenbelt, Maryland, Dec. 16-17, 1999 (invited).

2000

- P145. "Nanometrology," M.L. Schattenburg, presented at the *Nanogathering Symposium*, Cambridge, Massachusetts, Jan. 6, 2000.
- P146. "Microcomb design and fabrication for high accuracy optical assembly," C. Chen, O. Mongrard, L. Cohen, R.K. Heilmann, P. Konkola, G. Monnelly and M.L. Schattenburg, poster presented at the *Microsystems Technology Laboratories Student Research Review*, Dedham, Massachusetts, Jan. 10, 2000.
- P147. "Spectral line imaging observations of E0102-72," D.S. Davis, K.A. Flanagan, J.C. Houck, G.E. Allen, N.S. Schulz, D. Dewey, M.L. Schattenburg and C.R. Canizares, presented at the *American Astronomical Society 195th Meeting: SN 1987A and Other Supernova Remnants*, Atlanta, Georgia, Jan. 13, 2000 (paper 43.06).
- P148. "*Chandra* HETG observations of the supernova remnant E0102-72," J.C. Houck, K.A. Flanagan, D.S. Davis, G.E. Allen, N. Schulz, D. Dewey, M.L. Schattenburg and C.R. Canizares, presented at the *American Astronomical Society 195th Meeting: Chandra*, Atlanta, Georgia, Jan. 15, 2000 (paper 112.09).
- P149. "Space Nanotechnology Laboratory," M.L. Schattenburg, private briefing to Lt. Gen. Spence (Sam) M. Armstrong, NASA Associate Administrator, Cambridge, Massachusetts, Mar. 22, 2000.
- P150. "Development of segmented x-ray mirrors for Constellation-X," R. Petre, C. Chen, L.M. Cohen, D.A. Content, R.J. Harms, G. Monnelly, T.T. Saha, M.L. Schattenburg, P.J. Serlemitsos and W.W. Zhang, poster presented at *SPIE Astronomical Telescopes and Instrumentation 2000 -- X-Ray Optics, Instruments and Missions III*, Munich, Germany, Mar. 27-31 2000 (paper 4012-36).
- P151. "Beam steering system and spatial filtering applied to interference lithography," P. Konkola, C.G. Chen, R.K. Heilmann and M.L. Schattenburg, poster presented at the *44th International Conference on Electron, Ion and Photon Beam Technology & Nanofabrication*, Palm Springs, California, May 30-June 2, 2000 (paper P7-1).
- P152. "Microcomb design and fabrication for high accuracy optical assembly," C. Chen, L. Cohen, R.K. Heilmann, P. Konkola, O. Mongrard, G. Monnelly and M.L. Schattenburg, presented at the *44th International Conference on Electron, Ion and Photon Beam Technology & Nanofabrication*, Palm Springs, California, May 30-June 2, 2000 (paper 16-4).
- P153. "Relativistic corrections in displacement measuring interferometry," R.K. Heilmann, P. Konkola, C. Chen and M.L. Schattenburg, presented at the *44th International Conference on Electron, Ion and Photon Beam Technology & Nanofabrication*, Palm Springs, California, May 30-June 2, 2000 (paper 16-5).
- P154. "First Medium Energy Neutral Atom Imager results from the IMAGE Mission," C.J. Pollock, K. Asamura, M.M. Balkey, J.L. Burch, M.-C. Fok, H.O. Funsten, M. Grande, M. Gruntman, J.-M. Jahn, M. Lampton, D.J. McComas, T. Mukai, S. Ritzau, M.L. Schattenburg, E. Scime, R. Skoug, P. Valek and M. Wuest, presented at the *2000 American Geophysical Union Spring Meeting*, Washington, D.C., May 30 - June 3, 2000 (invited paper SM51B-16).
- P155. "High resolution spectroscopy of the supernova remnant E0102-72," K.A. Flanagan, C.R. Canizares, D.S. Davis, D. Dewey, J.C. Houck and M.L. Schattenburg, presented at the *American Astronomical Society 196th Meeting: A New Era in X-ray Astronomy*, Rochester, New York, June 7, 2000 (paper 34.09).
- P156. "First Medium Energy Neutral Atom Imager results from the IMAGE mission," J.-M. Jahn, K. Asamura, M.M. Balkey, J.L. Burch, M.-C. Fok, H.O. Funsten, M. Grande, M. Gruntman, M. Lampton, D.J. McComas, T. Mukai, C.J. Pollock, S. Ritzau, M.L. Schattenburg, E. Scime, R. Skoug and P. Valek, poster presented at the *NSF: Geospace Environment Modeling (GEM 2000) - Snowmass Summer Workshop*, Snowmass Village, Colorado, June 19-23, 2000.
- P157. "Early ENA results from the IMAGE Mission," C.J. Pollock, K. Asamura, M.M. Balkey, J.L. Burch, M.-C.

- Fok, H.O. Funsten, M. Grande, M. Gruntman, J.-M. Jahn, M. Lampton, D.J. McComas, T. Mukai, S. Ritzau, M.L. Schattenburg, E. Scime, R. Skoug, P. Valek and M. Wuest, poster presented at the *NATO Advanced Study Institute on Space Storms and Space Weather Hazards*, Hersonissos (Crete), Greece, June 19-29, 2000.
- P158. "Magnetospheric ENAs observed with the IMAGE/MENA imager," J.-M. Jahn, C. Pollock, J. Burch, D. McComas, M. Gruntman, E. Scime, T. Mukai, H. Funsten, M. Grande, M. Lampton, S. Ritzau, M.L. Schattenburg, R. Skoug, P. Valek and M. Wuest, presented at the *33rd COSPAR Scientific Assembly: Advances in Global Magnetospheric Structure, Dynamics and Region Coupling*, Warsaw, Poland, July 16-23, 2000 (*paper D3.3-0047*).
- P159. "High-accuracy x-ray foil optic assembly," G.P. Monnelly, D. Breslau, N. Butler, C.C. Chen, L. Cohen, W. Gu, R.K. Heilmann, P.T. Konkola, O. Mongrard, G.R. Ricker and M.L. Schattenburg, presented at the *SPIE Conference on X-Ray Optics, Instruments, and Missions*, San Diego, California, July 30-31, 2000 (*paper 4138-23*).
- P160. "Precision assembly station for high-resolution segmented optics," L.M. Cohen, H. Bergner, M.L. Schattenburg and G. Monnelly, presented at the *SPIE Conference on X-Ray Optics, Instruments, and Missions*, San Diego, California, July 30-31, 2000 (*paper 4138-20*).
- P161. "Progress toward meeting the Constellation-X performance goals using segmented x-ray mirrors," R. Petre, L.M. Cohen, D.A. Content, J. Hein, T.T. Saha, M.L. Schattenburg and W.W. Zhang, presented at the *SPIE Conference on X-Ray Optics, Instruments, and Missions*, San Diego, California, July 30-31, 2000 (*paper 4138-06*).
- P162. "Modeling the *Chandra* High Energy Transmission Gratings below 2 keV," K.A. Flanagan, T.H. Markert, J.E. Davis, M.L. Schattenburg, R.L. Blake, F. Scholze, P. Bulicke, R. Fliegau, S. Kraft, G. Ulm and E.M. Gullikson, presented at the *SPIE Conference on X-Ray and Gamma-Ray Instrumentation for Astronomy XI*, San Diego, California, Aug. 2-4, 2000 (*paper 4140-67*).
- P163. "Ionization and velocity structure in the supernova remnant E0102-72," K.A. Flanagan, C.R. Canizares, D.S. Davis, D. Dewey, J.C. Houck and M.L. Schattenburg, presented at *X-Ray Astronomy 2000*, Mondello (Palermo), Italy, Sept. 4-9, 2000 (*poster 4.2*).
- P164. "Spectral line imaging observations of 1E0102.2-7219," D.S. Davis, K.A. Flanagan, J.C. Houck, G.E. Allen, N.S. Schulz, D. Dewey, M.L. Schattenburg and C.R. Canizares, poster presented at the *Eleventh Annual Oct. Astrophysics Conference in Maryland -- Young Supernova Remnants*, College Park, Maryland, Oct. 16-18, 2000.
- P165. "Ionization structure and the reverse shock in E0102-72," K.A. Flanagan, C.R. Canizares, D.S. Davis, D. Dewey, J.C. Houck and M.L. Schattenburg, poster presented at the *Eleventh Annual Oct. Astrophysics Conference in Maryland -- Young Supernova Remnants*, College Park, Maryland, Oct. 16-18, 2000.
- P166. "High resolution spectroscopy of two oxygen-rich SNRs with the *Chandra* HETG," C.R. Canizares, K.A. Flanagan, D.S. Davis, D. Dewey, J.C. Houck and M.L. Schattenburg, presented at the *Eleventh Annual Oct. Astrophysics Conference in Maryland -- Young Supernova Remnants*, College Park, Maryland, Oct. 16-18, 2000.
- P167. "The shocking story of E0102-72," K.A. Flanagan, C.R. Canizares, D.S. Davis, D. Dewey, J.C. Houck and M.L. Schattenburg, *Harvard-Smithsonian Center for Astrophysics -- High Energy Astrophysics Division Lunch Talk*, Cambridge, Massachusetts, Oct. 25, 2000 (*invited*).
- P168. "Spectral line imaging observations of E0102-72," D.S. Davis, K.A. Flanagan, J.C. Houck, G.A. Allen, N.S. Schulz, D. Dewey, M.L. Schattenburg and C.R. Canizares, poster presented at the *American Astronomical Society - High Energy Astrophysics Division Meeting #32*, Honolulu, Hawaii, Nov. 9, 2000 (*paper 32.05*).
- P169. "High resolution spectroscopy of supernova remnants with *Chandra*," K.A. Flanagan, C.R. Canizares, D.S. Davis, J.C. Houck, G.E. Allen, D. Dewey, M.L. Schattenburg and N. S. Schulz, presented at the *American Astronomical Society - High Energy Astrophysics Division Meeting #32*, Honolulu, Hawaii, Nov. 10, 2000 (*paper 40.01*).
- P170. "Interference lithography for space optics, nanometrology and integrated optics," M.L. Schattenburg, *EECS/RLE Seminar Series on Optics and Quantum Electronics*, Cambridge, Massachusetts, Nov. 29, 2000 (*invited*).

2001

- P171. "Alignment and control architecture for scanning beam interference lithography," C. Chen, P. Konkola, R.K. Heilmann and M.L. Schattenburg, poster presented at the *Microsystems Technology Laboratories Student Research Review*, Dedham, Massachusetts, Jan. 9, 2001.

- P172. "Advanced interference lithography and applications," M.L. Schattenburg, *University of Central Florida, School of Optics/CREOL Seminar*, Orlando, Florida, Feb. 15, 2001 (*invited*).
- P173. "From nanometers to gigaparsecs: the role of nanostructures in unraveling the mysteries of the cosmos," M.L. Schattenburg, *Nanostructures Seminar*, Cambridge, Massachusetts, Mar. 14, 2001 (*invited*).
- P174. "Metrology for the sub-100 nm domain via fiducial grids," M.L. Schattenburg, C. Chen, R.K. Heilmann, P. Konkola and H.I. Smith, *National Institute of Standards and Technology -- Manufacturing Engineering Laboratory Seminar*, Gaithersburg, Maryland, Mar. 30, 2001 (*invited*).
- P175. "Metrology for the sub-100 nm domain via fiducial grids," M.L. Schattenburg, C. Chen, R.K. Heilmann, P. Konkola and H.I. Smith, *Defense Advanced Research Projects Administration - Advanced Lithography Program Review*, Charleston, South Carolina, Apr. 2-5, 2001 (*invited*).
- P176. "X-ray reflection grating update," M.L. Schattenburg, *Constellation X-ray Mission Facility Science Team Meeting*, Cambridge, Massachusetts, May 4, 2001.
- P177. "From nanometers to gigaparsecs: the role of nanostructures in unraveling the mysteries of the cosmos," M.L. Schattenburg, *45th International Conference on Electron, Ion and Photon Beam Technology and Nanofabrication*, Washington, D.C., May 30, 2001 (*invited plenary talk 1-1*).
- P178. "Spatial phase locking with shaped beam lithography," J.G. Hartley, T.R. Groves, H.I. Smith, M.K. Mondol, J.G. Goodberlet, M.L. Schattenburg, J. Ferrera and A. Bernshteyn, *45th International Conference on Electron, Ion and Photon Beam Technology and Nanofabrication*, Washington, D.C., May 29-June 1, 2001 (*paper P2-2*).
- P179. "Image metrology and system controls for scanning beam interference lithography," C.G. Chen, P.T. Konkola, R.K. Heilmann, G.S. Pati and M.L. Schattenburg, *45th International Conference on Electron, Ion and Photon Beam Technology and Nanofabrication*, Washington, D.C., May 29-June 1, 2001 (*invited paper P7-1*).
- P180. "Digital heterodyne interference fringe locking system," R.K. Heilmann, C.G. Chen, P.T. Konkola, G.S. Pati and M.L. Schattenburg, *45th International Conference on Electron, Ion and Photon Beam Technology and Nanofabrication*, Washington, D.C., May 29-June 1, 2001 (*paper 4-5*).
- P181. "Novel methods for shaping thin-foil optics for x-ray astronomy," R.K. Heilmann, G.P. Monnelly, O. Mongrard, N. Butler, C.G. Chen, L.M. Cohen, C.C. Cook, L.M. Goldman, P.T. Konkola, M. McGuirk, G.R. Ricker and M.L. Schattenburg, presented at the *SPIE Conference on X-ray Optics for Astronomy: Telescopes, Multilayers, Spectrometers and Missions*, San Diego, California, July 30, 2001 (*paper 4496-06*).
- P182. "Segmented x-ray mirror for the Constellation-X Spectroscopy X-ray Telescope," R. Petre, L.M. Cohen, D.A. Content, T.T. Saha, M.L. Schattenburg, J. Stewart and W.W. Zhang, *SPIE Conference on X-ray Optics for Astronomy: Telescopes, Multilayers, Spectrometers and Missions*, San Diego, California, July 30, 2001 (*paper 4496-10*).
- P183. "Wavefront sensors for x-ray and EUV optics fabrication," M. McGuirk, G.P. Monnelly, M.L. Schattenburg and C.R. Canizares, *SPIE Conference on X-ray Optics for Astronomy: Telescopes, Multilayers, Spectrometers and Missions*, San Diego, California, July 30, 2001 (*paper 4496-12*).
- P184. "Progress towards a general grating patterning technology using phase-locked scanning beams," M.L. Schattenburg, C.G. Chen, R.K. Heilmann, P.T. Konkola and G.S. Pati, *SPIE Conference on Optical Spectroscopic Techniques and Instrumentation for Atmospheric and Space Research IV*, San Diego, California, Aug. 2, 2001 (*paper 4485-61*).
- P185. "Alignment combs - status review and outlook," R.K. Heilmann, G.P. Monnelly, D. Breslau, N. Butler, C.G. Chen, L.M. Cohen, W. Gu, P.T. Konkola, O. Mongrard, G.R. Ricker, Jr. and M.L. Schattenburg, *Constellation-X SXT Optics Team Meeting*, NASA Goddard Space Flight Center, Greenbelt, Maryland, Aug. 7-8, 2001.
- P186. "Pattern placement metrology in the nanometer domain," M.L. Schattenburg, *Seminar of the Laboratory of Photonics and Nanostructures, National Center for Scientific Research*, Bagneux, France, Aug. 9, 2001 (*invited*).
- P187. "Pattern placement metrology in the nanometer domain," M.L. Schattenburg and H.I. Smith, talk and poster presented at the *SPIE/NIST/ONR Workshop on Nanostructure Science, Metrology and Technology*, Gaithersburg, Maryland, Sept. 5-7, 2001 (*invited*).
- P188. "X-ray emission line measurements of SNR 1E0102.2-7219," A.C. Fredericks, K.A. Flanagan, D.S. Davis, C.R. Canizares, D. Dewey, J.C. Houck and M.L. Schattenburg, presented at the *12th Maryland Annual Astrophysics Conference – Two Years of Science with Chandra*, Washington, D.C., Sept. 5-7, 2001 (*paper 185*).
- P189. "The *Chandra* high resolution x-ray spectrum of N103B," K.A. Flanagan, C.R. Canizares, D.S. Davis, D.

- Dewey, A.C. Fredericks, J.C. Houck, T.G. Pannuti and M.L. Schattenburg, presented at the *12th Maryland Annual Astrophysics Conference – Two Years of Science with Chandra*, Washington, D.C., Sept. 5-7, 2001 (paper 227).
- P190. "Precision machine design: x-ray optics alignment project," C.R. Forest, *Dover Instrument Corporation*, Westborough, Massachusetts, Oct. 12, 2001 (invited).
- P191. "Microcomb/alignment bar design update," R.K. Heilmann, C.G. Chen, O. Mongrard, M.L. Schattenburg and Y. Sun, *Constellation-X SXT Engineering Unit Technical Interchange Meeting*, NASA Goddard Space Flight Center, Greenbelt, Maryland, Nov. 6, 2001.
- P192. "Scanning beam interference lithography," P.T. Konkola, C.G. Chen, R.K. Heilmann, G. Pati and M.L. Schattenburg, presented at the *16th Annual Meeting of the American Society for Precision Engineering*, Arlington, Virginia, Nov. 10-15, 2001 (invited paper I-1).
- P193. "High precision assembly and metrology of x-ray foil optics," M.L. Schattenburg, O. Mongrard, N. Butler, C.G. Chen, R.K. Heilmann, P.T. Konkola, M. McQuirk, G. Monnelly, G.S. Pati, G.R. Ricker and L. Cohen, presented at the *16th Annual Meeting of the American Society for Precision Engineering*, Arlington, Virginia, Nov. 10-15, 2001 (paper II-4).
- P194. "A novel sub-microradian beam diagnostic and alignment system," C.G. Chen, R.K. Heilmann, P.T. Konkola, G.S. Pati and M.L. Schattenburg, *16th Annual Meeting of the American Society for Precision Engineering*, Arlington, Virginia, Nov. 10-15, 2001 (poster *Novel Systems #1*).
- P195. "Silicon microcombs for precision x-ray foil assembly," Y. Sun, O. Mongrard, C. Chen, R.K. Heilmann, C. Forest, J. You, M. Spenko and M.L. Schattenburg, *Constellation X Mission Facility Science Team Meeting*, NASA Goddard Space Flight Center, Greenbelt, Maryland, Nov. 15-16, 2001.
- P196. "X-ray reflection grating update," C.R. Forest, A. Lapsa, O. Mongrard, J. Przybylowski, M. Spenko, Y. Sun, J. You, M.L. Schattenburg, *Constellation X Mission Facility Science Team Meeting*, NASA Goddard Space Flight Center, Greenbelt, Maryland, Nov. 15-16, 2001.
- P197. "Proposed off-plane reflection grating fabrication process," M.L. Schattenburg and G.R. Ricker, presented at the *Constellation X Mission Facility Science Team Meeting*, NASA Goddard Space Flight Center, Greenbelt, Maryland, Nov. 15-16, 2001.
- P198. "The importance of nanotechnology and nanometrology for space instrumentation," M.L. Schattenburg, *Space Nano-technology Workshop, Tsukuba Space Center, National Space Development Agency of Japan*, Tsukuba, Japan, Nov. 27, 2001 (invited).
- P199. "Advanced technology for future x-ray astronomy missions," M.L. Schattenburg, *Institute for Space and Astronautical Science*, Sagamihara, Japan, Nov. 28, 2001 (invited).
- P200. "Space nanotechnology," M.L. Schattenburg, private briefing to the *Council for Science and Technology Policy, Japanese Cabinet Office*, Tokyo, Japan, Nov. 29, 2001 (invited).
- P201. "Field emitter arrays for low voltage applications with sub 100 nm apertures and 200 nm period," D.G. Pflug, M.L. Schattenburg, H.I. Smith and A.I. Akinwande, presented at the *IEEE International Electron Devices Meeting*, Washington, D.C., Dec. 3-5, 2001 (paper 8.5).
- P202. "Nanometrology," M.L. Schattenburg, *US/Germany Joint Meeting on Nanoscale Science and Engineering at MIT*, Cambridge, Massachusetts, Dec. 5-6, 2001 (invited).
- P203. "2.75 Precision Machine Design Project: x-ray optics assembly truss," C. Forest, Y. Sun, M. Spenko, M.L. Schattenburg and A. Slocum, *Precision Machine Design Class (2.75) Final Presentation*, Cambridge, Massachusetts, Dec. 12, 2001.

2002

- P204. "Plasma diagnostics with x-ray emission lines of 1E0102.2-7219," A.C. Fredericks, K.A. Flanagan, C.R. Canizares, D. Dewey, J.C. Houck and M.L. Schattenburg, poster presented at the *199th Meeting of the American Astronomical Society*, Washington, D.C., Jan. 6-10, 2002 (paper 126.18).
- P205. "Space Nanotechnology Lab x-ray optics assembly truss," C. Forest, Y. Sun, M. Spenko, M.L. Schattenburg and A. Slocum, *Constellation-X SXT Engineering Unit Technical Interchange Meeting*, NASA Goddard Space Flight Center, Greenbelt, Maryland, Jan. 23, 2002.
- P206. "Nanometrology research at MIT," M.L. Schattenburg and H.I. Smith, *University of Central Florida, School of Optics/CREOL Seminar*, Orlando, Florida, Feb. 19, 2002 (invited).
- P207. "Nanometrology research at MIT," M.L. Schattenburg and H.I. Smith, *International SEMATECH -- Metrology Council Meeting*, Austin, Texas, Feb. 26, 2002 (invited).
- P208. "The critical role of metrology in nanotechnology," M.L. Schattenburg, *Mechanical Engineering Department*

- Seminar*, Cambridge, Massachusetts, Mar. 1, 2002 (*invited*).
- P209. "Grating-based nanometer metrology," M.L. Schattenburg, C. Chen, C. Joo, R.K. Heilmann, P. Konkola, G.S. Pati and H.I. Smith, *Defense Advanced Research Projects Administration - Advanced Lithography Program Review*, New Orleans, Louisiana, Apr. 9-11, 2002.
- P210. "Reflection Grating Spectrometer (RGS) progress report," M.L. Schattenburg and R.K. Heilmann, *Constellation X Mission Facility Science Team Meeting*, Greenbelt, Maryland, May 1, 2002.
- P211. "Technology for a large-area reflection grating spectrometer on Constellation-X," S.M. Kahn, F. Paerels, A. Rasmussen, M.L. Schattenburg, G.R. Ricker, M.W. Bautz, J.P. Doty, G.Y. Prigozhin, J. Nousek, D. Burrows, J.E. Hill and W. Cash, *Constellation X Mission Facility Science Team Meeting*, Greenbelt, Maryland, May 1, 2002.
- P212. "Beam alignment and wavefront metrology for scanning beam interference lithography," C.G. Chen, R.K. Heilmann, C. Joo, P.T. Konkola, G.S. Pati and M.L. Schattenburg, *46th International Conference on Electron, Ion and Photon Beam Technology and Nanofabrication*, Anaheim, California, May 28-31, 2002 (*paper 10B4*).
- P213. "Nanometer-accurate fringe metrology using a Fresnel zone plate," C. Joo, G.S. Pati, P.T. Konkola, C.G. Chen, R.K. Heilmann, E.H. Anderson and M.L. Schattenburg, *46th International Conference on Electron, Ion and Photon Beam Technology and Nanofabrication*, Anaheim, California, May 28-31, 2002 (*paper 10B5*).
- P214. "A generalized scanning beam interference lithography system for patterning gratings with variable period progressions," G.S. Pati, P.T. Konkola, C.G. Chen, C. Joo, R.K. Heilmann and M.L. Schattenburg, *46th International Conference on Electron, Ion and Photon Beam Technology and Nanofabrication*, Anaheim, California, May 28-31, 2002 (*poster PG7*).
- P215. "Nanoaccuracy in nanolithography," H.I. Smith and M.L. Schattenburg, presented at the *US-Korea Nanofabrication Workshop*, Hanyang University, Seoul, Korea, June 3-5 (2002).
- P216. "Thin foil optic," V. Guillaume, *Space Nanotechnology Laboratory Internship Presentation*, MIT Center for Space Research, Cambridge, Massachusetts, June 19, 2002.
- P217. "Grating production methods," M.L. Schattenburg and R.K. Heilmann, *Constellation X-ray Mission Reflection Grating/CCD Team Technical Working Meeting*, Cambridge, Massachusetts, July 3, 2002.
- P218. "Shack-Hartmann surface metrology system," C.R. Forest, *Precitech Corporation*, Keene, New Hampshire, July 27, 2002 (*invited*).
- P219. "Shack-Hartmann surface metrology system," C.R. Forest, *Zygo Corporation*, Milford, Connecticut, July 28, 2002 (*invited*).
- P220. "Probing the cosmic X-ray laboratory with the Chandra HETGS," K.A. Flanagan, C.R. Canizares, D. Dewey, A. Fredericks, J.C. Houk, J.C. Lee, H.L. Marshall and M.L. Schattenburg, *SPIE Conference on X-ray and Gamma-ray Telescopes and Instruments for Astronomy*, Waikoloa, Hawaii, Aug. 25-28, 2002 (*paper 4851-04*).
- P221. "Constellation-X spectroscopy x-ray telescope (SXT)," R. Petre, W.W. Zhang, D.A. Content, T. T. Saha, J. Stewart, J.H. Hair, D.Nguyen, W.A. Podgorski, W.R. Davis, Jr., M.D. Freeman, L.M. Cohen, M.L. Schattenburg, R.K. Heilmann, Y. Sun and C. Forest, *SPIE Conference on X-ray and Gamma-ray Telescopes and Instruments for Astronomy*, Waikoloa, Hawaii, Aug. 25-28, 2002 (*paper 4851-50*).
- P222. "Constellation-X soft x-ray telescope assembly and alignment," W.A. Podgorski, D.A. Content, J.H. Hair, R. Petre, T.T. Saha, M.L. Schattenburg, J. Stewart and W.W. Zhang, *SPIE Conference on X-ray and Gamma-ray Telescopes and Instruments for Astronomy*, Waikoloa, Hawaii, Aug. 25-28, 2002 (*paper 4851-57*).
- P223. "Precision shaping, assembly and metrology of foil optics for x-ray reflection gratings," C.R. Forest, M.L. Schattenburg, C.G. Chen, R.K. Heilmann, P. Konkola, J. Przybylowski, Y. Sun, J. You, S.M. Kahn and D. Golini, *SPIE Conference on X-ray and Gamma-ray Telescopes and Instruments for Astronomy*, Waikoloa, Hawaii, Aug. 25-28, 2002 (*paper 4851-62*).
- P224. "Constellation-X soft x-ray telescope segmented optic assembly and alignment implementation," J.H. Hair, J. Stewart, R. Petre, W.W. Zhang, D.A. Content, T.T. Saha, W.A. Podgorski, P.E. Glenn, M.L. Schattenburg, R.K. Heilmann, Y. Sun and G. Nanan, *SPIE Conference on X-ray and Gamma-ray Telescopes and Instruments for Astronomy*, Waikoloa, Hawaii, Aug. 25-28, 2002 (*poster 4851-76*).
- P225. "Nanotech research at MIT," C.G. Chen, *Victoria State Department of Regional Development*, Melbourne, Australia, Aug. 26, 2002 (*invited*).
- P226. "The Space Nanotechnology Laboratory," M.L. Schattenburg, poster presented at the *Summer School on: Nano and Giga Challenges in Microelectronics Research and Opportunities in Russia*, Department of Physics, M.V. Lomonosov Moscow State University, Moscow, Russia, Sept. 10-11, 2002 (*invited*).

- P227. "Fabrication of ultra-high accuracy diffraction gratings for nanometrology and spectroscopy applications." P. N. Lebedev Physical Institute of the Russian Academy of Sciences (FIAN), Moscow, Russia, Sept. 11, 2002 (*invited*).
- P228. "The critical role of metrology in nanotechnology," M.L. Schattenburg, presented at the *Symposium on: Nano and Giga Challenges in Microelectronics Research and Opportunities in Russia*, Palace of Science of the Russian Academy of Sciences, Moscow, Russia, Sept. 12-13, 2002 (*invited*).
- P229. "X-ray reflection gratings: shaping, metrology, assembly," C.R. Forest, M.J. Spenko, Y. Sun, A.H. Slocum, R.K. Heilmann, M.L. Schattenburg and D. Golini, *Constellation X Mission Facility Science Team Meeting*, Cambridge, Massachusetts, Sept. 19, 2002.
- P230. "Microcomb fabrication update," Y. Sun, R.K. Heilmann, C. Chen, C. Forest and M.L. Schattenburg, *Constellation X Mission Facility Science Team Meeting*, Cambridge, Massachusetts, Sept. 19, 2002.
- P231. "Interference fringe locking using Fresnel zone plates," C. Joo, G.S. Pati, C.G. Chen, P.T. Konkola, R.K. Heilmann and M.L. Schattenburg, presented at the *17th Annual Meeting of the American Society of Precision Engineering*, St. Louis, Missouri, Oct. 20-25, 2002 (*paper V-4*).
- P232. "Precision assembly and metrology of x-ray foil optics," C.R. Forest, M.J. Spenko, Y. Sun, M. McGuiirk, M.L. Schattenburg, and A.H. Slocum, presented at the *17th Annual Meeting of the American Society of Precision Engineering*, St. Louis, Missouri, Oct. 20-25, 2002 (*poster MEMS and Nanotech #2*).
- P233. "Precision microcomb design and fabrication for Constellation-X soft x-ray telescope segmented optic assembly," Y. Sun, C.G. Chen, R.K. Heilmann, C. Forest, M. Spenko, P.T. Konkola, M. McGuiirk, C. Joo and M.L. Schattenburg, presented at the *17th Annual Meeting of the American Society of Precision Engineering*, St. Louis, Missouri, Oct. 20-25, 2002 (*poster MEMS and Nanotech #7*).
- P234. "Scanning beam interference lithography," P. Konkola, presented at Brion Technologies, Inc., Mountain View, California, Nov. 1, 2002 (*invited*).
- P235. "Evaporated electron beam sensitive organic resist for the back-patterning of x-ray lithography masks," E. Lavalée, J. Beauvais, D. Drouin, M. Cloutier, L.K. Mun, Y. Awad, H.I. Smith, M.H. Lim, J. Carter and M.L. Schattenburg, presented at the *2002 International Microprocesses and Nanotechnology Conference*, Tokyo Fashion Town, Japan, Nov. 6-8, 2002 (*paper 8A-11-5*).
- P236. "Nanometer-accurate grating fabrication with scanning beam interference lithography," G.C. Chen, P.T. Konkola, R.K. Heilmann, C. Joo and M.L. Schattenburg, *Conference on Nano- and Microtechnology: Materials, Processes, Packaging, and Systems -- part of SPIE International Symposium on Smart Materials, Nano- and Micro-Smart Systems*, Melbourne, Australia, Dec. 16-18, 2002 (*paper 4936-28*).

2003

- P237. "Spatially resolved plasma diagnostics with x-ray emission lines of 1E0102.2-7219," A.C. Fredericks, K.A. Flanagan, C.R. Canizares, D. Dewey, J.C. Houck and M.L. Schattenburg, *201st Meeting of the American Astronomical Society*, Seattle, Washington, Jan. 5-9, 2003 (*poster 87.06*).
- P238. "Environmental enclosure for the Nanoruler," M.L. Schattenburg, P. Konkola, C.-H. Chang and C. Joo, *Buildings for Advanced Technology Workshop*, National Institute of Standards and Technology, Gaithersburg, Maryland, Jan. 14-16, 2003 (*invited*).
- P239. "Nanoaccuracy: an essential element of nanotechnology," J.T. Hastings, M.L. Schattenburg, P. Konkola, E.E. Moon and H.I. Smith, *Japan-US Symposium on Tools and Metrology for Nanotechnology*, Cornell University, Ithaca, New York, Jan. 21-24, 2003 (*invited*).
- P240. "Precision microcomb design and fabrication for x-ray optics assembly," Y. Sun, R.K. Heilmann, C.G. Chen, M.J. Spenko, C.R. Forest and M.L. Schattenburg, poster presented at the *Microsystems Technology Laboratories Student Research Review*, Dedham, Massachusetts, Jan. 28, 2003.
- P241. "Reflection Grating Spectrometer grating array," M.L. Schattenburg, *NASA Constellation X-ray Mission – Technology Readiness and Implementation Plan Site Visit Briefing*, NASA Goddard Space Flight Center, Greenbelt, Maryland, Mar. 20, 2003.
- P242. "Design and analysis of a scanning beam interference lithography system for patterning gratings with nanometer-level distortion," P.T. Konkola, *Ph.D. Defense, MIT Department of Mechanical Engineering*, Cambridge, Massachusetts, Apr. 3, 2003.
- P243. "The importance of metrology in nanofabrication," M.L. Schattenburg, *MIT Microsystems Technology Laboratories – Microlunch Seminar*, Cambridge, Massachusetts, Apr. 8, 2003.
- P244. "The role of nanometer-level accuracy and precision in nanomanufacturing," H.I. Smith and M.L. Schattenburg, *First International Symposium on Nanomanufacturing*, Cambridge, Massachusetts, Apr. 24-26,

- 2003 (*invited*).
- P245. "Beam alignment and image metrology for scanning beam interference lithography – fabricating gratings with nanometer phase accuracy," C.G. Chen, *Ph.D. Defense, MIT Department of Electrical Engineering and Computer Science*, Cambridge, Massachusetts, Apr. 29, 2003.
- P246. "X-ray microscopy with atomic resolution," I. McNulty, J. Miao and M.L. Schattenburg, *MIT X-ray Laser Collaboration Workshop*, MIT-Bates Linear Accelerator Center, Middleton, Massachusetts, May 2, 2003.
- P247. "Nano-metrology using the Nanoruler," M.L. Schattenburg, P. Konkola, C. Chen, R.K. Heilmann, C. Joo, J. Montoya and C.-H. Chang, *Defense Advanced Research Projects Agency (DARPA) - Advanced Lithography Program Review*, Santa Fe, New Mexico, May 5-8, 2003.
- P248. "Con-X reflection gratings: process development updates," R.K. Heilmann, C.-H. Chang, Y. Sun, C.G. Chen, C.R. Forest, P.T. Konkola, C. Joo, J. Montoya, M. Akilian, J. You, E. Murphy, R. Fleming, and M.L. Schattenburg, *Constellation X Mission Facility Science Team Meeting*, Columbia University, New York, New York, May 7-8, 2003.
- P249. "Nanometer-level repeatable metrology using the Nanoruler," P. Konkola, C. Chen, R.K. Heilmann, C. Joo, J. Montoya, C.-H. Chang and M.L. Schattenburg, *47th International Conference on Electron, Ion and Photon Beam Technology and Nanofabrication*, Tampa, Florida, May 27-30, 2003 (*paper 2B3*).
- P250. "Precision microcomb design and fabrication for x-ray optics," Y. Sun, R.K. Heilmann, C.G. Chen, M.J. Spenko, C.R. Forest and M.L. Schattenburg, *47th International Conference on Electron, Ion and Photon Beam Technology and Nanofabrication*, Tampa, Florida, May 27-30, 2003 (*poster PJ12*).
- P251. "Fabrication of saw-tooth diffraction gratings using nanoimprint lithography," C.-H. Chang, J. Carter, R. Fleming, R.K. Heilmann, E. Murphy, M.L. Schattenburg, T.C. Bailey, R.D. Frankel and R. Voisin, *47th International Conference on Electron, Ion and Photon Beam Technology and Nanofabrication*, Tampa, Florida, May 27-30, 2003 (*poster PC7*).
- P252. "Precision microcomb progress report," R. K. Heilmann, Y. Sun, C. G. Chen, C. R. Forest, and M.L. Schattenburg, *Constellation-X SXT Technical Interchange Meeting*, Goddard Space Flight Center, Greenbelt, Maryland, June 11, 2003.
- P253. "Reengineering project of the thin foil optic holder," A. Lamure, *Space Nanotechnology Laboratory Internship Presentation*, MIT Center for Space Research, Cambridge, Massachusetts, June 13, 2003.
- P254. "Grating arrays for high-throughput soft x-ray spectrometers," A.P. Rasmussen, J. Bookbinder, W. Cash, Jr., R.K. Heilmann, S.M. Kahn, F. Paerels and M.L. Schattenburg, *SPIE Conference AM121: Optics for EUV, X-ray, and Gamma-ray Astronomy* (O. Citterio and S.L. O'Dell), San Diego, California, Aug. 3-8, 2003 (*paper 5168-28*).
- P255. "Advances in reflection grating technology for Constellation-X," R. K. Heilmann, M. Akilian, C. Chang, C.G. Chen, C. Forest, C. Joo, P. Konkola, J. Montoya, Y. Sun, J. You, and M. L. Schattenburg, *SPIE Conference AM121: Optics for EUV, X-ray, and Gamma-ray Astronomy* (O. Citterio and S.L. O'Dell), San Diego, California, Aug. 3-8, 2003 (*paper 5168-30*).
- P256. "On improving the dynamic range of the CLAS-2D Shack-Hartmann system," A. Lapsa, *Space Nanotechnology Laboratory Internship Presentation*, MIT Center for Space Research, Cambridge, Massachusetts, Aug. 15, 2003.
- P257. "The Space Nanotechnology Lab: from nanometers to gigaparsecs," R.K. Heilmann, M. Akilian, C.-H. Chang, R. Fleming, C. Joo, J. Montoya, E. Murphy, A. Torkaman, and M.L. Schattenburg, *MIT Astrophysics Internal Symposium*, Cambridge, Massachusetts, Sept. 9-11, 2003.
- P258. "Nanometrology in nanomanufacturing," M.L. Schattenburg, *NASA Tech Briefs - Nanotech 2003 Conference*, Cambridge, Massachusetts, Oct. 23-24, 2003 (*invited*).
- P259. "Thin glass optic and silicon wafer deformation and kinematic constraint," C. Forest, M. Akilian, A. Lapsa, G. Vincent, A. Lamure and M.L. Schattenburg, *18th Annual Meeting of the American Society of Precision Engineering*, Portland, Oregon, Oct. 26-31, 2003 (*paper III-2*).
- P260. "Reflection grating development update," R.K. Heilmann, M. Akilian, C.-H. Chang, C.R. Forest, C. Joo, J.C. Montoya, A. Torkaman and M.L. Schattenburg, *Constellation X Mission Facility Science Team Meeting*, NASA Goddard Space Flight Center, Greenbelt, Maryland, Nov. 20, 2003.
- P261. "The MIT Nanoruler: a tool for patterning large high-accuracy gratings," M.L. Schattenburg, *University of Rochester, Laboratory for Laser Energetics, Workshop on Large Scale MLD Gratings for OMEGA EP*, Rochester, NY, December 16, 2003 (*invited*).

2004

- P262. "The Space Nanotechnology Lab: high resolution x-ray optics with nanometer precision," R.K. Heilmann, MIT IAP symposium *Frontiers of Astronomy, Astrophysics, and Space Science*, Cambridge, Massachusetts, Jan. 20, 2004.
- P263. "The metrology crisis in nano manufacturing," M.L. Schattenburg, *National Nanotechnology Initiative Interagency Workshop on Instrumentation and Metrology for Nanotechnology*, National Institute of Standards and Technology, Gaithersburg, Maryland, Jan. 27-29, 2004 (*invited*).
- P264. "Fabrication of saw-tooth diffraction gratings using nanoimprint lithography," C.-H. Chang, R.K. Heilmann and M.L. Schattenburg, poster presented at the *Microsystems Technology Laboratories Student Research Review*, Waterville Valley, New Hampshire, Jan. 28-29, 2004.
- P265. "Dimensional metrology for nanoscale science and engineering," R.K. Heilmann and M.L. Schattenburg, *IEEE Conference on Nanoscale Devices and System Integration*, Miami, Florida, Feb. 15-19, 2004 (*invited paper F2*).
- P266. "Fabrication of saw-tooth diffraction gratings using nanoimprint lithography," C.-H. Chang, J.C. Montoya, C. Joo, M. Akilian, A. Lapsa, R.K. Heilmann, M.L. Schattenburg, M. Li and A. Rasmussen, poster presented at the *MIT Photonics & Roadmapping Spring Conference*, Cambridge, Massachusetts, May 3-4, 2004.
- P267. "Metrology for nanometer scale science and engineering," M.L. Schattenburg, R.K. Heilmann and H.I. Smith, presented at *The 1st China-US Symposium on Nano Science and Technology*, Beijing, China, May 17-20, 2004 (*invited*).
- P268. "The MIT Nanoruler: A tool for patterning large high-accuracy gratings," M.L. Schattenburg, Institute for Laser Engineering, Osaka University, Osaka, Japan, May 22, 2004 (*invited*).
- P269. "High fidelity grating replication using thermal nanoimprint lithography," C.-H. Chang, J.C. Montoya, M. Akilian, A. Lapsa, R.K. Heilmann and M.L. Schattenburg, *48th International Conference on Electron, Ion and Photon Beam Technology and Nanofabrication*, San Diego, California, June 1-4, 2004 (*paper 6B5*).
- P270. "Thin foil reflection gratings for Constellation-X," R.K. Heilmann, M. Akilian, C.-H. Chang, C.R. Forest, C. Joo, A. Lapsa, J.C. Montoya and M.L. Schattenburg, presented at the *SPIE Symposium on Astronomical Telescopes and Instrumentation 2004 -- Space Telescope Systems (UV-Gamma) (AS02)*, Glasgow, Scotland, June 21-25, 2004 (*paper 5488-82*).
- P271. "The Constellation-X RGS options: raytrace modeling of the off-plane gratings," K.A. Flanagan, J.E. Davis, R.K. Heilmann, M. McGuirk, G.R. Ricker, M.L. Schattenburg, M. Wise, A. Rasmussen, J. Bookbinder, M. Freeman, T. Gaetz, D. Jerius, D. Nguyen, W. Podgorski, P. Reid, W. Cash, A. Shipley, D. Gallagher, P. Huang, and S. Jordan, presented at the *SPIE Symposium on Astronomical Telescopes and Instrumentation 2004 -- UV-Gamma Ray Space Telescope Systems*, Glasgow, Scotland, June 21-25, 2004 (*paper 5488-31*).
- P272. "Nanometer precision metrology and constraint of thin optics for a high resolution x-ray telescope," M. Akilian, C.-H. Chang, C. Chen, C.R. Forest, R.K. Heilmann, C. Joo, P. Konkola, J. Montoya, Y. Sun and M.L. Schattenburg, Institute for Experimental Physics, Technische Universität Graz, Graz, Austria, July 15, 2004 (*invited*).
- P273. "Large-area gratings for nanometer-accurate positioning and metrology," R.K. Heilmann and M.L. Schattenburg, *Center for Functional Nanomaterials Seminar*, Brookhaven National Laboratory, Upton, NY, July 21, 2004 (*invited*).
- P274. "Space Nanotechnology Laboratory," M.L. Schattenburg, *MIT Center for Space Research Advisory Committee Review*, Cambridge, MA, Sept. 20, 2004.
- P275. "The Nanoruler: A tool for rapid high-precision patterning of large-area gratings," R.K. Heilmann, C.G. Chen, P.T. Konkola and M.L. Schattenburg, poster presented at the *R&D 100 Award Ceremony*, Chicago, Illinois, Oct. 14, 2004 (*invited*).
- P276. "Advances in x-ray reflection grating technology," M. Akilian, C.-H. Chang, R.K. Heilmann, J. Montoya and M.L. Schattenburg, *Constellation-X Mission Facility Science Team Meeting*, NASA Goddard Space Flight Center, Greenbelt, Maryland, Oct. 14-15, 2004.
- P277. "Thin optics constraint," M. Akilian, C. Forest, A. Slocum, D. Trumper and M.L. Schattenburg, *19th Annual Meeting of the American Society of Precision Engineering*, Orlando, Florida, Oct. 24-29, 2004 (*Poster 2, Equipment, Machines & Instruments - Design & Testing*).
- P278. "Measuring two-axis stage mirror non-flatness using linear/angular interferometers," J. Montoya, R.K. Heilmann and M.L. Schattenburg, *19th Annual Meeting of the American Society of Precision Engineering*, Orlando, Florida, Oct. 24-29, 2004 (*Poster 5, Metrology - Analysis & Modeling*).
- P279. "Metrology for nanometer scale lithography," M.L. Schattenburg and R.K. Heilmann, *Materials Research*

Society Symposium on Progress in Semiconductor Materials IV — Electronic and Optoelectronic Applications, Boston, MA, Nov. 30, 2004 (*invited paper C3.4*).

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- P280. "Nanoruler II progress report," M.L. Schattenburg, Laboratory for Laser Energetics, Rochester, New York, Jan. 13, 2005.
- P281. "The MIT Nanoruler: A tool for patterning large high-accuracy gratings," M.L. Schattenburg, Lawrence Livermore National Laboratory, Livermore, California, Jan. 20, 2005 (*invited*).
- P282. "How to build a spectroscopy x-ray telescope," R.K. Heilmann, MIT CSR IAP Lecture Series *Frontiers of Astronomy, Astrophysics, and Space Science & Technology*, Cambridge, Massachusetts, Jan. 20, 2005.
- P283. "Toward improved linewidth control in scanning beam interference lithography," J. Montoya, R.K. Heilmann and M.L. Schattenburg, poster presented at the *Microsystems Technology Laboratories Annual Research Conference*, Waterville Valley Conference & Event Center, Waterville Valley, NH, Jan. 26-27, 2005.
- P284. "Large-area lithography: where special relativity and nanotechnology meet," R.K. Heilmann, J.C. Montoya and M.L. Schattenburg, Joint New England Sections of APS and AAPT 2005 Spring Meeting at MIT, Cambridge, MA, April 1-2, 2005.
- P285. "Linewidth control in scanning beam interference lithography," J. Montoya, C. Chang, R.K. Heilmann and M.L. Schattenburg, *49th International Conference on Electron, Ion and Photon Beam Technology and Nanofabrication*, Orlando, Florida, May 31-June 3, 2005 (*paper Fr1.5*).
- P286. "Space-based precision engineering challenges," M.L. Schattenburg, Precision Engineering: Fundamentals, Research and Practical Applications, MIT Summer Professional Program (jointly offered by MIT & Cranfield University), Cambridge, MA, Aug. 2, 2005 (*invited*).
- P287. "Shaping of thin grazing-incidence reflection grating substrates via magnetorheological finishing," R.K. Heilmann, M. Akilian, C.-H. Chang, R. Hallock, E. Cleaveland and M.L. Schattenburg, *SPIE conference on Optics for EUV, X-ray, and Gamma-ray Astronomy II*, San Diego, CA, Aug. 3-4, 2005 (*paper 5900-09*).
- P288. "Off-plane grazing-incidence Constellation-X grating calibrations using polarized synchrotron radiation and PCGRATE code calculations," J.F. Seely, L.I. Goray, M. Laming, B. Kjornrattanawanich, K.A. Flanagan, R.K. Heilmann, A.P. Rasmussen, C. Chang and M.L. Schattenburg, *SPIE conference on Optics for EUV, X-ray, and Gamma-ray Astronomy II*, San Diego, CA, Aug. 3-4, 2005 (*paper 5900-11*).
- P289. "Precision gratings and optics for space research," M.L. Schattenburg, Center for Applied Optics, University of Alabama at Huntsville, Huntsville, AL, Aug. 5, 2005 (*invited*).
- P290. "Using 2D scan SEM images for measuring grating line widths," M. Zou, *Space Nanotechnology Laboratory Internship Presentation*, MIT Kavli Institute for Astrophysics and Space Research, Cambridge, MA, Aug. 26, 2005.
- P291. "Interferometric lithography – a nanotechnology enabler," S.R.J. Brueck and M.L. Schattenburg, DARPA-NSF Workshop on Nanopatterning for High-Complexity, High-Functionality Systems, Washington, D.C., Sept. 13, 2005 (*invited*).
- P292. "Advanced interference lithography for writing nano-photon patterns," M.L. Schattenburg, C.-H. Chang, R.K. Heilmann, J. Montoya and Y. Zhang, European Optical Society Topical meeting: *Optical MicroSystem '05*, Capri Island, Napoli – Italy, Sept. 15-18, 2005 (*invited*).
- P293. "Advanced heterodyne fringe-locking system using multiple frequency shifts," C.-H. Chang, R.K. Heilmann and M.L. Schattenburg, *20th Annual Meeting of the American Society of Precision Engineering*, Norfolk, Virginia, Oct. 9-14, 2005 (*poster OI-1*).
- P294. "Measurement of milli-degree temperature gradients in environmental enclosures," Y. Zhao, C.-H. Chang, J. Montoya, R.K. Heilmann and M.L. Schattenburg, *20th Annual Meeting of the American Society of Precision Engineering*, Norfolk, Virginia, Oct. 9-14, 2005 (*poster DT-5*).
- P295. "Patterning ultra-precision gratings for dimensional metrology," M.L. Schattenburg, *Symposium on Nanoscale Science & Engineering: Convergence of the Top-Down and Bottom-Up Approaches*, University of North Carolina, Charlotte, NC, Oct 24-25, 2005 (*invited*).
- P296. "Toward nano-accuracy in scanning beam interference lithography," J. Montoya, Intel Corporation, Hillsboro, OR, Oct 28, 2005 (*invited*).
- P297. "Reflection Grating Array (RGA) technology," M.L. Schattenburg, R.K. Heilmann, K.A. Flanagan and P. Glenn, NASA Con-X Technology Assessment (RGA), MIT, Cambridge, MA, Dec. 2, 2005.

2006

- P298. "Highlights of Constellation-X Reflection Grating Spectrometer technology development," K. Flanagan, R. Heilmann, G. Prego-zhin, G. Ricker, M. Schattenburg, J. Cottam and A. Rasmussen, 207th Meeting of the American Astronomical Society, Washington, D.C., Jan. 8-12, 2006 (*poster 12.01*).
- P299. "Efficiency of a grazing incidence off-plane grating in the soft x-ray region," J.F. Seely, J.M. Laming, L.I. Goray, B. Kjornrattanawanich, G.E. Holland, K.A. Flanagan, R.K. Heilmann, C.-H. Chang, M.L. Schattenburg and A.P. Rasmussen, 207th Meeting of the American Astronomical Society, Washington, D.C., Jan. 8-12, 2006 (*poster 12.02*).
- P300. "Soft x-ray reflection grating technology development for Constellation-X," R.K. Heilmann, M. Akilian, C.-H. Chang, J.C. Montoya, Y. Zhao and M.L. Schattenburg, 207th Meeting of the American Astronomical Society, Washington, D.C., Jan. 8-12, 2006 (*poster 12.15*).
- P301. "Advanced interference lithography for patterning nano-optics," M.L. Schattenburg, C.-H. Chang, R.K. Heilmann, J. Montoya, Y. Zhao, P. Glenn, D.J. Smith, D. Chargin and S. Ivanov, SPIE Conference on MOEMS-MEMS Micro & Nanofabrication 2006, Micromachining Technology for Micro-Optics and Nano-Optics IV (MF06), San Diego, CA, Jan. 23-25, 2006 (*invited paper 6110-1*).
- P302. "Progress on grating fabrication," M.L. Schattenburg, C.-H. Chang, R.K. Heilmann, J. Montoya and Y. Zhao, P. Glenn, D. J. Smith, D. Chargin and S. Ivanov, Constellation X-ray Mission Facility Science Team meeting, Cambridge, MA, Feb. 16, 2006.
- P303. "Grating assembly," M. Akilian, M. Ahn, C.-H. Chang, R. Fleming, R. Heilmann, Y.-O. Jung, J. Montoya, Y. Zhao and M.L. Schattenburg, Constellation X-ray Mission Facility Science Team meeting, Cambridge, MA, Feb. 16, 2006.
- P304. "The Constellation-X Reflection Grating Spectrometer," J. Cottam, W. Cash, K.A. Flanagan, R.K. Heilmann, G.Y. Prigozhin, A.P. Rasmussen, G.R. Ricker and M.L. Schattenburg, International Workshop on High Resolution X-ray Spectroscopy: Towards Xeus and Con-X, Mullard Space Science Laboratory, Holmbury St. Mary, Dorking, Surrey, UK, Mar. 27-28, 2006 (*poster 2-2*).
- P305. "The Constellation-X Reflection Grating Spectrometer," J. Cottam, W. Cash, K.A. Flanagan, R.K. Heilmann, G.Y. Prigozhin, A.P. Rasmussen, G.R. Ricker and M.L. Schattenburg, SPIE Conference AS02 on Space Telescopes and Instrumentation II: UV to Gamma Ray, Orlando, FL May 24-31, 2006 (*poster 6266-70*).
- P306. "Assembly of thin gratings for soft x-ray telescopes," M. Akilian, R.K. Heilmann and M.L. Schattenburg, SPIE Conference on Space Telescopes and Instrumentation II: UV to Gamma Ray, Orlando, FL, May 24-31, 2006 (*poster 6266-135*).
- P307. "History of the EIPBN conference," M.L. Schattenburg, special plenary presentation, 50th International Conference on Electron, Ion and Photon Beam Technology and Nanofabrication, Baltimore, MD, May 31, 2006 (*invited plenary presentation*).
- P308. "Nanometrology for nanoscale science and engineering," R. Hocken, M.L. Schattenburg, J. Overcash, D. Trumper, H.I. Smith and J. Joannopoulos, 2006 NSF Design, Service, and Manufacturing Grantees and Research Conference, St. Louis, MO, July 24-27, 2006 (*poster G17*).
- P309. "Needs and advances in metrology for precision motion control in mechatronics," R.J. Hocken and M.L. Schattenburg, International Measurement Confederation (IMEKO) XVIII World Congress -- Metrology for a Sustainable Development, Rio de Janeiro, Brazil, Sept. 17-22, 2006 (*invited*).
- P310. "New techniques for fabricating gratings for pulse compression using scanning-beam interference lithography," M.L. Schattenburg, C.-H. Chang, R.K. Heilmann, J. Montoya and Y. Zhao, D.J. Smith, M. Imus, P. Glenn, D. Chargin and S. Ivanov, International Conference on Ultrahigh Intensity Lasers, Cassis, France, Sept. 25-29, 2006 (*paper 103*).
- P311. "Nanoruler II large grating lithography tool status," M.L. Schattenburg, Heidenhain Corp., Traunreut, Germany, Sept. 29, 2006.
- P312. "Sub-millidegree stability air thermal control for a large-volume lithography enclosure," Y. Zhao, D. Trumper and M.L. Schattenburg, 21st Annual Meeting of the American Society of Precision Engineering, Monterey, CA, Oct. 15-20, 2006.
- P313. "Precision assembly of thin gratings for x-ray telescopes," M. Akilian, R.K. Heilmann and M.L. Schattenburg, poster presented at the 21st Annual Meeting of the American Society of Precision Engineering, Monterey, CA, Oct. 15-20, 2006.
- P314. "Advanced interference lithography for nanomanufacturing," M.L. Schattenburg, C.-H. Chang, R.K. Heilmann, J. Montoya, Y. Zhao, P. Glenn, D.J. Smith, D. Chargin and S. Ivanov, International Symposium on Nanomanufacturing (ISNM 2006), MIT, Cambridge, MA, Nov. 1-3, 2006 (*paper TS3C-44*).
- P315. "Progress in scanning interference lithography," M.L. Schattenburg, DARPA/MTO NanoFab Workshop,

Midway, UT, Nov. 6-7, 2006 (*invited*).

- P316. "Nanometrology for nanoscale science and engineering," M.L. Schattenburg, R. Heilmann, Y. Zhao, R. Hocken, J. Overcash, D.L. Trumper, poster presented at the 2006 Nanoscale Science and Technology Grantee Conference, National Science Foundation, Arlington, VA, Dec. 4-6, 2006.
- P317. "Transmission Grating Spectrometer for Constellation-X," K. Flanagan, M. Schattenburg, R. Heilmann and N. Schulz, NASA Constellation X Facility Science Team meeting, Greenbelt, MD, Dec. 18-20, 2006.

2007

- P318. "Fabrication of ultra-high aspect ratio freestanding silicon gratings," M. Ahn, R.K. Heilmann and M.L. Schattenburg, poster presented at the MIT *Microsystems Technology Laboratories Annual Research Conference*, Waterville Valley Conference & Event Center, Waterville Valley, NH, Jan. 24-25, 2007.
- P319. "Research in the Space Nanotechnology Laboratory," M.L. Schattenburg, R.K. Heilmann, M. Ahn, M. Akilian, C.-H. Chang and Y. Zhao, presented at the MIT Precision Engineering Center Technology Summit, MIT, Cambridge, MA, Feb. 19-20, 2007.
- P320. "Thin substrate metrology, constraint and assembly," M. Akilian and M.L. Schattenburg, poster presented at the MIT Precision Engineering Center Technology Summit, MIT, Cambridge, MA, Feb. 19-20, 2007.
- P321. "Fabrication of large-area ultra-fine periodic nanostructures with spatial-frequency multiplication," Chih-Hao Chang, Y. Zhao, R. K. Heilmann, and M. L. Schattenburg, poster presented at the MIT Precision Engineering Center Technology Summit, MIT, Cambridge, MA, Feb. 19-20, 2007.
- P322. "Sub-millidegree-stability air thermal control for a large-volume lithography enclosure," Y. Zhao, D.L. Trumper, R.K. Heilmann and M.L. Schattenburg, poster presented at the MIT Precision Engineering Center Technology Summit, MIT, Cambridge, MA, Feb. 19-20, 2007.
- P323. "Phase control in spatial frequency multiplication," Y. Zhao, C.-H. Chang, R.K. Heilmann and M.L. Schattenburg, *51st International Conference on Electron, Ion and Photon Beam Technology and Nanofabrication*, Denver, CO, May 29-June 1, 2007 (*paper 6C.4*).
- P324. "Fabrication of ultra-high aspect ratio freestanding gratings on silicon-on-insulator wafers," M. Ahn, R.K. Heilmann and M. L. Schattenburg, *51st International Conference on Electron, Ion and Photon Beam Technology and Nanofabrication*, Denver, CO, May 29-June 1, 2007 (*paper 8C.2*).
- P325. "The critical angle transmission grating spectrometer" M.L. Schattenburg, presented at the *Workshop in Honor of Gordon Garmire's 70th birthday - 40 Years of X-ray Astronomy*, Penn State University, State College, PA, June 14-15, 2007 (*invited*).
- P326. "Blazed transmission gratings for soft x-ray spectroscopy," R.K. Heilmann, M. Ahn, and M.L. Schattenburg, X-ray Grating Spectroscopy Workshop, Chandra X-Ray Center, Cambridge, MA, July 11-13, 2007.
- P327. "From Nanometers to Gigaparsecs: the Role of Nanotechnology in Unraveling the Mysteries of the Universe," M.L. Schattenburg, *LeadAmerica* lecture, Franklin W. Olin College of Engineering, Needham, MA, July 16, 2007 (*invited*).
- P328. "Fabrication and characterization of blazed transmission gratings for x-ray astronomy," R.K. Heilmann, M. Ahn, K.A. Flanagan and M.L. Schattenburg, SPIE Conference on Optics for EUV, X-Ray, and Gamma-Ray Astronomy III, San Diego, CA, Aug. 29-30, 2007 (*paper 6688-26*).
- P329. "Spectrometer concept and design using a blazed transmission grating for x-ray astronomy," K. Flanagan, J. Davis, R.K. Heilmann, D. Huenemoerder, G. Prigozhin, G. Ricker, M.L. Schattenburg, N. Schulz and A. Rasmussen, SPIE Conference on Optics for EUV, X-Ray, and Gamma-Ray Astronomy III, San Diego, CA, Aug. 29-30, 2007 (*paper 6688-27*).
- P330. "Development of 91 cm size gratings and mirrors for LEX laser system," T. Jitsuno, S. Motokoshi, T. Okamoto, T. Mikami, D. Smith, M.L. Schattenburg, H. Kitamura, H. Matsuo, T. Kawasaki, K. Kondo, H. Shiraga, Y. Nakata, H. Habara, K. Tsubakimoto, R. Kodama, K.A. Tanaka, N. Miyanaga and K. Mima, The Fifth International Conference on Inertial Fusion Sciences and Applications (IFSA 2007), Kobe, Japan, Sept. 9-14, 2007.
- P331. "Precision motion and control for scanning beam interference lithography," Andre Sharon, Fraunhofer Ctr. for Manufacturing Innovation, Boston Univ., USA, *Frontiers in Optics 2007/Laser Science XXIII*, San Jose, CA, Sept. 16-20, 2007 (*invited talk FTuE3*).

2008

- P332. "Nanometrology for nanoscale science and engineering," M. Schattenburg, R. Heilmann, Y. Zhao, R. Hocken, J. Overcash, D. L. Trumper and D. Ljubicic, NSF CMMI Engineering Research and Innovation Conference,

- Knoxville, TN, Jan. 7-10, 2008.
- P333. "Fabrication of ultra-high aspect ratio free-standing transmission gratings," M. Ahn, R. Heilmann and M.L. Schattenburg, Center for Nano & Molecular Science & Technology, University of Texas at Austin, Austin, TX, Jan 24, 2008 (*invited*).
- P334. "Blazed transmission gratings for Constellation-X: EUV and soft x-ray results," R.K. Heilmann, M. Ahn and M.L. Schattenburg, Constellation-X Facility Science Team Meeting, Boulder, CO, Feb. 21-22, 2008.
- P335. "Fabrication of 200 nm period blazed transmission gratings on silicon-on-insulator wafers," M. Ahn, R.K. Heilmann and M.L. Schattenburg, *52nd International Conference on Electron, Ion and Photon Beam Technology and Nanofabrication*, Portland, Oregon, May 27-30, 2008 (*poster P-2B-1*).
- P336. "Spatial-frequency multiplication with multilayer interference lithography," C.-H. Chang, Y. Zhao, R.K. Heilmann and M.L. Schattenburg, *52nd International Conference on Electron, Ion and Photon Beam Technology and Nanofabrication*, Portland, Oregon, May 27-30, 2008 (*paper 9B-1, best student paper award*)
- P337. "Fabrication of 200 nm period blazed transmission gratings on silicon-on-insulator wafers," M. Ahn, R.K. Heilmann and M.L. Schattenburg, *Center for X-ray Optics, Lawrence Berkeley National Laboratory*, Berkeley, CA, June 2, 2007 (*invited*);
- P338. "Spatial-frequency multiplication with multilayer interference lithography," M.L. Schattenburg, C.-H. Chang, Y. Zhao, and R.K. Heilmann, *Center for X-ray Optics, Lawrence Berkeley National Laboratory*, Berkeley, CA, June 2, 2007 (*invited*).
- P339. "A tutorial on critical-angle transmission (CAT) gratings," R.K. Heilmann, NASA Goddard Space Flight Center, Greenbelt, MD, June 5, 2008 (*invited*).
- P340. "Fabrication and performance of blazed transmission gratings for x-ray astronomy," R.K. Heilmann, M. Ahn and M.L. Schattenburg, *SPIE Conference on Space Telescopes and Instrumentation II: Ultraviolet to Gamma Ray*, Palais des Congrès Parc Chanot, Marseille, France, June 23-28, 2008 (*paper 7011-5*).
- P341. "Critical-angle transmission gratings for the International X-Ray Observatory," R.K. Heilmann, M. Ahn and M.L. Schattenburg, IXO Facility Science Team Meeting, NASA Goddard Space Flight Center, Greenbelt, MD, Aug. 20-22, 2008.
- P342. "Spatial-frequency multiplication with multilevel interference lithography," C.-H. Chang, Y. Zhao, R.K. Heilmann, and M.L. Schattenburg, *34th International Conference on Micro and Nano Engineering 2008*, Athens, Greece, Sept. 15-18, 2008 (*invited poster MLL-PO9*).
- P343. "Slumping of hot glass against porous air bearings," M. Akilian, *MIT Workshop on Lightweight Optics for X-ray Astronomy*, Cambridge, MA, Sept. 25, 2008 (*invited*).
- P344. "Assembly and metrology of thin optics," M. Akilian, *MIT Workshop on Lightweight Optics for X-ray Astronomy*, Cambridge, MA, Sept. 25, 2008 (*invited*).
- P345. "Large area pulse compression gratings fabricated onto fused silica substrates using scanning beam interference lithography, D.J. Smith, M. McCulloch, B. Xu, S. Smith, M.L. Schattenburg, T. Jitsuno and T. Mikami, *International Conference on Ultrahigh Intensity Lasers -- Development, Science and Emerging Applications (ICUIL 2008)*, Shanghai-Tongli, China, Oct. 27-31, 2008.
- P346. "From nanometers to gigaparsecs: Critical-angle transmission gratings and the WHIM," R.K. Heilmann, Condensed Matter and Biological Physics Seminar, Carnegie Mellon University, Pittsburgh, PA, Dec. 11, 2008 (*invited*).

2009

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