# CURRICULUM VITAE

**TOM D. MILSTER** 08/07/14
College of Optical Sciences
University of Arizona
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## CHRONOLOGY OF EDUCATION

Colleges and universities attended:

| | | |
|---|---|---|
| University of Arizona | (Optical Sciences) | 1981-1987 |
| University of Missouri-Rolla | (Electrical Engineering) | 1979-1981 |
| Southwest Mo. State University | (Math) | 1977-1979 |
| Rochester Institute of Tech. | (Photographic Science) | 1976-1977 |

Institutions, degrees and dates awarded:

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|---|---|---|
| University of Arizona Ph.D. | Optical Sciences | 1987 |
| University of Missouri B.S. | Electrical Engineering | 1981 |

Title of doctoral dissertation and name of advisor:
"Design and construction of a modular gamma camera"
Advisor: Dr. Harrison Barrett

Major Fields:
Optical Sciences and Electrical Engineering

## CHRONOLOGY OF EMPLOYMENT

| | | |
|---|---|---|
| University of Arizona College of Optical Sciences | Professor | 2007-date |
| University of Arizona Optical Sciences Center | Research Professor | 2000-2007 |
| University of Arizona Optical Sciences Center | Assoc. Research Professor | 1995-2000 |
| University of Arizona Optical Sciences Center | Assist. Professor | 1989-1995 |
| Lawrence Livermore National Laboratory | Optical Engineer | 1989(summer) |
| IBM General Products Division | Staff Engineer, Optical Storage | 1986-1989 |
| University of Arizona Optical Sciences Center | Graduate Research Assoc. | 1982-1986 |
| University of Arizona Electrical Engineering | Graduate Teaching Assist. | 1981 |
| University of Missouri Electrical Engineering | Undergrad Research Assist. | 1980-1981 |
| Argonne National Laboratory | Summer Research Assist. | 1980 |

## HONORS AND AWARDS

Paper "Highly efficient near-field probes," *Appl. Opt.*, 2000, selected for Optics in 2001 as published in *Optics and Photonics News*, **12**(12), p. 38 (2001)

Society of Photo-Optical Instrumentation Engineers (SPIE) – Elected Fellow (2001)

Optical Society of America – Elected Fellow (1999)

Paper "Linear behavior of a near-field optical scanning system," *JOSA- A,* 1995, selected by SPIE as a landmark paper in near-field optics.

Paper "Objective lens design for multiple-layer optical data storage," *Opt. Eng.* (1997) selected by SPIE as one of 300 most influential papers in lens design (1999).

## SERVICE AND OUTREACH

**Departmental committees**:

(Includes Previous Service - multiple years in each position : Admissions Committee (Chair); Comprehensive Exam Committee (Chair); Graduate Curriculum Committee (Chair 2014-2016); ABET Undergraduate Academic Accreditation Committee (Chair 2014-2016); In addition, too many oral defense exams to list, including comprehensive examinations, master's defenses, and Ph.D. defenses.

**Profession**:

Co-Chair, Topical Meeting on Optical Data Storage, SPIE Optics and Photonics, Optical Engineering and Applications, Conference OP233, San Diego Convention Center, San Diego, California, August 17-21, 2014.

Member, Emmett N. Leith Medal Committee, Optical Society of America, 2013, Chair 2014.

Editorial Board, *Journal of Microsystem Technologies: Micro and Nanosystems, Information Storage and Processing Systems*, Springer-Verlag, 2005-2009

Advisory Committee Member, Topical Meeting on Optical Data Storage, 2006-2014

Program Committee Member, International Symposium on Optical Memory, 2006-2014

Elected Advisory Committee Co-Chair, Joint International Symposium on Optical Memory, 2005

Elected General Co-Chair, Optical Data Storage Topical Meeting, 2004

Program Committee Member, International Symposium on Optical Memory, 2004

Elected Technical Program Committee Co-Chair, Optical Data Storage Topical Meeting, 2004

Program Committee Member for "Laser Beam Shaping IV through VII", held as part of SPIE's Annual Meeting, San Diego, CA, 2003-2006

Program Committee Member, Topical Meeting on Optical Data Storage, OSA, Vancouver, May 2002

Conference cochair: "Laser Beam Shaping II," held as part of Soc. Photo-Opt. Inst. Eng. Annual Meeting, San Diego, CA, August 2-3, 2001

Program Committee Member, International Symposium on Optical Memories, 2001

Conference cochair, "SPIE Photonics Taiwan Conference on Optical Storage and Optical Information Processing," held July, 2000

Chair, "OIDA Workshop on High Throughput Optical Data Storage," held June 2000

Reviewer for the following professional journals since 1988: Nature, Journal of the Optical Society of America, Optics Letters, Journal of Modern Optics, Applied Optics, Optical Engineering, Journal of Vacuum Science and Technology, Journal of Modern Optics, Journal of Microwave System Technologies – Micro and Nanosystems and Information Storage and Processing Systems

Group Leader "Near Field and Alternative Recording Technologies," Optical Data Storage Roadmap Report 2006 (Information Storage Industry Consortium, San Diego, CA, 2005)

Team leader for "Light Delivery Team" on NIST ATP Award entitled "Hybrid Assisted Magnetic Recording", 2003-2006

Group Leader "Near Field Recording Technologies," Optical Data Storage Roadmap Report 2003 (Information Storage Industry Consortium, San Diego, CA, 2003)

**Community:**

"Color in our world" presented to grade-school children (4 times/year, 1992-2000)

Assistant coach, American Youth Soccer Association (1997-2000)

Head coach, American Youth Soccer Association, National 'D' License (2001)

## PUBLICATIONS

**Chapters in scholarly books:**

1. T. Milster and T. Tkaczyk, "Miniature and Micro Optics," Chapter 22, Handbook of Optics, 3rd Ed. Optical Society of America 2010.
2. T. Milster; J. J. Butz, T. Nakano, J. Tominaga, W. L. Bletscher, "Signal power in the angular spectrum of AgOx SuperRENS media," in Optical Nanotechnologies: Manipulation of Surface and Local Plasmons. J. Tominaga and D. P. Tsai, eds., (Springer-Verlag, Berlin, Germany 2003) pp. 119-39 (2003).
3. E. P. Walker and T.D. Milster, "Beam Shaping for Optical Data Storage," submitted for publication in Laser Beam Shaping Applications, F. M. Dickey, S. C. Holswade and D. L. Shealy, eds. (Marcel Decker, New York, 2005 and 20114).
4. T. D. Milster, "Optical Data Storage," in The Optics Encyclopedia: Basic Foundations and Practical Applications, Volume 1 T. G. Brown, K. Creath, H. Kogelnik, M. A. Kriss, J. Schmit and M. J. Weber, eds. (Wiley-VCH Verlag GmbH &Co. KGaA, Weinheim, Germany, 2003), pp. 227-274 (2003).
5. T. D. Milster and G. T. Sincerbox, "Future of Optical Data Storage," in McGraw-Hill 2002 Yearbook of Science and Technology, pp. 252-255 (2002).
6. T. D. Milster, "Optical Data Storage," in Handbook of Laser Technology and Applications, Volume 3: Applications, C E Webb, University of Oxford, UK; J D C Jones, eds., (Institute of Physics Publishing, Bristol, UK, 2003). pp. 2391-2420 (2003).
7. T.D. Milster and G. T. Sincerbox, "Optical Data Storage," in McGraw-Hill Encyclopedia of Science and Technology, Vol 12, pp. 457-461 (2001).

8. T. D. Milster and S. B. Hamilton, "Testing," in MO Data Recording -- Materials, Subsystems, Techniques, T. McDaniel and R. Victora, eds. (Noyes Publications, Park Ridge, NJ., 1997).
9. T. D. Milster, "Miniature and Micro-optics," in Handbook of Optics, Volume 2, B. Wolfe, ed. (McGraw-Hill, New York, 1995), ch. 7 (1995).

**Peer-Reviewed Papers:**

1. Craig Ament, Lee Johnson, Andreas Schmitt-Sody, Adrian Lucero, Thomas Milster, and Pavel Polynkin, "Generation of multiterawatt vortex laser beams," *Appl. Opt.* **53**(15), pp. 3355-3360 (2014).
2. Olivier Guyon, Josh A. Eisner, Roger Angel, Neville J. Woolf, Eduardo A. Bendek, Thomas D. Milster, S. Mark Ammons, Michael Shao, Stuart Shaklan, Marie Levine, Bijan Nemati, Frantz Martinache, Joe Pitman, Robert A. Woodruff, and Ruslan Belikov, "Simultaneous exoplanet characterization and deep wide-field imaging with a diffractive pupil telescope," *The Astrophysical Journal*, **767**(1), 2013, pp. 1-14.
3. Youngsik Kim, Phat Lu, Tom D. Milster and Khanh Kieu, "Hyper-numerical aperture (NA = 2.8) microscope using $\lambda = 1.56$ μm femtosecond source for multi-photon imaging," *Biomedical Opt Express*, **4**(10), 2013, pp. 1786-1794.
4. Guyon, O., Bendek, E. A., Eisner, J. A., Angel, R., Woolf, N. J., Milster, T. D., ... & Belikov, R. (2012). High-precision Astrometry with a Diffractive Pupil Telescope. *The Astrophysical Journal Supplement Series*, *200*(2), 11.
5. Park, Jong Rak, et al. "Characterization of photoresist and simulation of a developed resist profile for the fabrication of gray-scale diffractive optic elements." *Optical Engineering* 51.2 (2012): 023401-1.
6. A. George and T. Milster, "Spot distribution measurement using a scanning nanoslit," Appl. Opt. **50**(24) 2011, pp. 4746-4754.
7. H. Noble, W. Dallas, R Chipman, I. Matsubara, S. McClain, P. Khulbe, D. Hansen and T. Milster, "Square-wave retarder for polarization computer-generated holography," Appl. Opt. **50**(20) 2011, pp. 3703-3710.
8. J. Park, Y. Kim and T. Milster, "Analysis of a direct laser writer with acousto-optic modulator employed for dose gray-scaling," J. Korean Physical Soc. **59**(5) 2011, pp. 3289-3292.
9. J. Tamkin, W. Dallas, and T. Milster, "Theory of point-spread function artifacts due to structured mid-spatial frequency surface errors," Appl. Opt., 49, (2010), 4814-4824.
10. H. Noble, E. Ford, W. Dallas, R. Chipman, I. Matsubara, Y. Unno, S. McClain, P. Khulbe, D. Hansen, and T. Milster, "Polarization synthesis by computer-generated holography using orthogonally polarized and correlated speckle patterns," Opt. Lett., 35, (2010), 3423-3425.
11. George and T. Milster, "Characteristics of a scanning nano-slit image sensor for line-and-space patterns," Appl. Opt., 49, (2010), 3821-3830.
12. S. Yang, T. Milster, J. Park, and J. Zhang, "High-numerical-aperture image simulation using Babinet's principle," J. Opt. Soc. Am. A, 27, (2010), 1012-1023.
13. J. Zhang, Y. Kim, S. Yang, and T. Milster, "Illumination artifacts in hyper-NA vector imaging," J. Opt. Soc. Am. A, 27, (2010), 2272-2284.

14. J. Zhang, S. Yang, Y. Kim, T. Milster, and J. Park, "Microscope system for Blu-ray disc samples," Appl. Opt., 49, (2010), 6878-6887.
15. J. Tamkin and T. Milster, "Effects of structured mid-spatial frequency surface errors on image performance," Appl. Opt., 49, (2010), 6522-6536.
16. J. Tamkin, T. Milster, and W. Dallas, "Theory of modulation transfer function artifacts due to mid-spatial-frequency errors and its application to optical tolerancing," Appl. Opt. 49, (2010), 4825-4835.
17. S. Yang, T. Milster, J. Zang, and T. Chen, "Characteristics of evanescent polarization imaging," Journal of Modern Optics, 57, no. 9, (2010), 783-797.
18. D. Kang and T. D. Milster, "Effect of fractal rough-surface Hurst exponent on speckle in imaging systems," *Opt. Lett.* **34**, pp. 3247-3249 (2009).
19. J. Yeo, M. Kim, N. Choi, S. E. Choi, T. D. Milster, and J. Kim, "Pupil Plane Characteristics and Filtering for Optical Data Storage Using Circular Polarization with a Solid Immersion Lens," *Jpn. J. Appl. Phys.* **48**, pp. 03A019-1-03A019-7 (2009).
20. J. Zhang, Y. Kim, Y. S. Kim, R. Valencia, T. D. Milster, and D. Dozer, "High Resolution Semiconductor Inspection by Using Solid Immersion Lens," *Jpn. J. Appl. Phys.* **48**, pp. 03A043-1-03A043-3 (2009).
21. Y. S. Kim, J. Zhang, and T. D. Milster, "GaP Solid Immersion Lens Based on Diffraction," *Jpn. J. Appl. Phys.* **48**, pp. 03A047-1-03A047-4 (2009).
22. D. Kang, E. Clarkson, and T. D. Milster, "Effect of optical aberration on Gaussian laser speckle," *Opt. Express* **17**, pp. 3084-3100 (2009).
23. E. Aspnes, T. D. Milster, and K. Visscher, "Optical force model based on sequential ray tracing," *Appl. Opt*. **48**, pp. 1642-1650 (2009).
24. D. Kang and T. D. Milster, "Simulation method for non-Gaussian speckle in a partially coherent system," *J. Opt. Soc. Am. A* **26**, pp. 1954-1960 (2009).
25. M. Lang, E. Aspnes, and T. D. Milster, "Geometrical analysis of third-order aberrations for a solid immersion lens," *Opt. Express* **16**, pp. 20008-20028 (2008).
26. N. Fukutake and T. D. Milster, "Proposal of three-dimensional phase contrast holographic microscopy," *Opt. Express* **15**, pp. 12662-12679 (2007).
27. N. Choi, S. Shim, T. D. Milster and J. Kim, "Optical Design for the Optimum Solid Immersion Lens with High Numerical Aperture and Large Tolerance," *Jpn. J. Appl. Phys.* **46**, pp. 3724-8 (2007).
28. T. Chen and T. D. Milster, "Properties of induced polarization evanescent reflection with a solid immersion lens (SIL)," *Opt. Express* **15**, pp. 1191-1204 (2007).
29. M. Lang, T. D. Milster, T. Minamitani and G. Borekm, "Investigation of Micro Solid Immersion Lens Mounting Systems," *Jpn. J. Appl. Phys.* **46**, pp. 3737-40 (2007).
30. T. Chen, T. D. Milster, S.H. Yang, and D. Hansen, "Evanescent imaging with induced polarization by using a solid immersion lens," *Opt. Lett.* **32**, pp.124-126 (2007).
31. T. Chen, T. D. Milster, S. K. Park , B. McCarthy , D. Sarid, C. Poweleit and J. Menendez "Near-field solid immersion lens (SIL) microscope with advanced compact mechanical design", *Opt. Eng.* **45**(10), p. 103002, 2006.
32. T. Choi and T. D. Milster, "Change in Data Marks and Groove Structures of CD-Recordable Discs in Response to a High Power Laser Beam" *Opt. Eng.*, **45**(6), pp. 64302-1-5 (2006).
33. N.A. Beaudry and T.D. Milster, "Imaging properties of a patterned rough surface: Effects of

defocus", *Opt. Eng.* **44**(6), pp. 63201-1 - 63201-10 (2005).
34. N.A. Beaudry and T.D. Milster, "Imaging properties of a patterned rough surface: Effects of roughness correlation and partial coherence", *Opt. Eng.* **44**(7), pp. 78001-1 – 78001-7 (2005).
35. M. Lang, T. Milster, T. Minamitani, G. Borek and D. Brown, "Fabrication and Testing of a Gallium Phosphide Solid Immersion Lens," *Jap. J. of Appl. Phys., Part 1,* **44**(No. 5B), pp. 3385-3387 (2005).
36. S. K. Park, T.D. Milster, T.M. Miller, J. Butz, and W. Bletscher, "Master and Slave Beam Servo Technique for Volumetric Bit-Wise Optical Data Storage," *Jap. J. of Appl. Phys., Part 1,* **44**(5B), pp. 3442-3444 (2005).
37. T. Choi, T. Milster and M. Lang, "Wavelength-domain tracking in multiple-beam optical storage systems," *Opt. Eng.*, **44**(5), pp. 55201-1-9 (2005).
38. Y. Zhang, T. D. Milster, J. S. Kim, S. K. Park, "Advanced lens design for bit-wise volumetric optical data storage," *Jap. J. of Appl. Phys. Part1,* **43**(7B), pp.4929-4936 (2004).
39. F. H. Wu, H. P. D. Shieh, T. D. Milster and D. R. Huang, "Write-Once Volumetric Optical Disk Using Transparent Recording Material with an Optical Switching Layer, "*Jap. J. of Appl. Phys, Part 1*, **43**(7B), pp. 4937-4940 (2004).
40. Y. Zhang, J. Butz, J. Curtis, N. Beaudry, W. L. Bletscher, K. J. Erwin, D. Knight, T. D. Milster and E. Walker, "Characterization of a bit-wise volumetric storage medium for a space environment," *Opt. Express* **12**(12), pp. 2662-2669 (2004).
41. A. Khoh, G. S. Samudra, W. Yihong, T. D. Milster and C. Byoung II, "Image formation using geometrical theory of diffraction," *JOSA A*, **21**(6), pp. 959-67 (2004).
42. S. G. Tang, T. D. Milster,"Consideration and Control of Writing Conditions with Near-field Aperture-SIL Probe," *Jap. J. Appl. Phys., Part 1*, **42** (2B), pp. 1090-1094 (2003).
43. T. D. Milster and S. G. Tang, "Generation of Compact Near-Field Energy for Optical Recording: Transducer Efficiency and Signal Detection," *Jap. J. Appl. Phys., Part 1*, **42** (2B), pp. 1095-1100.
44. C. H. Tien, H. L. Chou, Y. Chiu, W. Hsu, T.D. Milster, Y. C. Lai. H. P. D. Shieh, "Fiber-lens-based module for optical recording applications," *Jap. J. Appl. Phys., Part 1,* **42** (7A), pp. 4345-4348.
45. T. D. Milster, "Physical Optics Simulation in Matlab for High-Performance Systems," *Optical Review* **10**, pp. 246-50, 2003.
46. S. G. Tang, T.D. Milster, "Consideration and Control of Writing Conditions with Near-Field Aperture Solid Immersion Lens Probe," *Jap. J. Appl. Phys., Part 1,* **42** (2B), pp.1090-4, 2003.
47. J. S. Jo, T. D. Milster, and J. K. Erwin, **"**Phase and amplitude apodization induced by focusing through an evanescent gap in a solid immersion lens microscope," *Opt. Eng.* **41**(8), pp. 1866-1875, 2002.
48. N. A. Beaudry and T. D. Milster, "Interferometeric phase reconstruction by nonuniform shifting of the reference beam," *Appl. Opt.*, **41**(10), pp. 1915-1921, 2002.
49. H. Tien, Y. C. Lai, T. D. Milster, H. Shieh, P. D., "Design and fabrication of fiberlenses for optical recording applications," *Jap. J. Appl. Phys*, *Part 1*, **41**(3B), pp. 1834-37, 2002.
50. S. G. Tang, T. D. Milster, J. K. Erwin, W. L. Bletscher, "High-performance readout and recording by a combination aperture," *Opt. Lett.*, **26**(24), pp. 1987-1989, 2001.

51. K. Shimura and T. D. Milster, "Vector diffraction analysis by discrete-dipole approximation," *JOSA-A*, **18**(11), pp. 2895-2900, 2001.
52. T.D. Milster, "Near-field optical data storage: Avenues for improved performance," invited paper to *Opt. Eng.* **40**(10) pp. 2255-2260, 2001.
53. R. S. Upton and T. D. Milster, "Detector patterns from optical disks," *Opt. Eng.*, **40**(6), pp. 1030-1044, 2001.
54. T. D. Milster, F. Akhaven, M. Bailey, J. K. Erwin, D. M. Felix, K. Hirota, S. Koester, K. Shimura, Y. Zhang, "Super-Resolution by combination of a solid immersion lens and an aperture," *Jap. J. Appl. Phys*, *Part 1*, **40**(3B), pp. 1778-1782, 2001.
55. T. D. Milster, "Near-field optics: A new tool for data storage," *Proc. IEEE*, **88**(9), pp. 1480-1490 (2000).
56. K. Hirota, T. D. Milster, Y. Zhang, J. K. Erwin, "Design of a near-field probe for optical recording using a 3-dimensional finite difference time domain method," *Jap. J. Appl. Phys*, *Part 1*, **39**(2B), pp.973-5, 2000.
57. R. S. Upton, F. Akhavan, T. D. Milster, M. Schweisguth, W. L. Bletscher, J. K. Erwin, A. M. Nichol, "Electronic crosstalk cancellation with a quadrant cell detector," *Jap. J. Appl. Phys*, *Part 1*, **39**(2B), pp. 837-9, 2000.
58. N. A. Beaudry, T. D. Milster, "Effects of object roughness on partially coherent image formation," *Opt. Lett.* **25**(7), pp.454-6, 2000.
59. K. Hirota, T. D. Milster, K. Shimura, Y. Zhang, J. S. Jo, "Near-field phase change optical recording using GaP hemispherical lens," *Jap. J. Appl. Phys*, *Part 1*, **39**(2B), pp. 968-72, 2000.
60. K. Shimura, T. D. Milster, J. S. Jo, K. Hirota, "Pupil plane filtering for optical pickup heads with effective numerical aperture of 1.1 and 2.0," *Jap. J. Appl. Phys*, *Part 1*, **39**(2B), pp. 897-901, 2000.
61. T. D. Milster, R. S. Upton, L. Hui, "Objective lens design for multiple-layer optical data storage," *Opt. Eng*., **38**(2), pp. 295-301, 1999.
62. T. D. Milster, R. S. Upton, "Fundamental principles of crosstalk in optical data storage," *Jap. J. Appl. Phys*, *Part 1*, **38**(3B), pp. 1608-13, 1999.
63. T. D. Milster, "Chromatic correction of high-performance solid immersion lens systems," *Jap. J. Appl. Phys*, *Part 1*, **38**(3B), pp. 1777-9, 1999.
64. T. D. Milster, J. S. Jo, K. Hirota, K. Shimura, Y. Zhang, "The nature of the coupling field in optical data storage using solid immersion lenses," *Jap. J. Appl. Phys*, *Part 1*, **38** (3B), pp.1793-4, 1999.
65. T. D. Milster, K. Shimura, J. S. Jo, K. Hirota, "Pupil-plane filtering for improved signal detection in an optical data-storage system incorporating a solid immersion lens," *Opt. Lett.* **24**(9), pp. 605-7, 1999.
66. T. D. Milster, J. S. Jo, K. Hirota, "Roles of propagating and evanescent waves in solid immersion lens systems," *Appl. Opt.* **38**(23), pp. 5046-57, 1999.
67. T. D. Milster, W. Jiang, E. P. Walker, D. Burak, P. Claisse, P. Kelly, R. Binder, "A single-mode high-power vertical cavity surface emitting laser," *Appl. Phys. Lett*. **72**(26), pp. 3425-7, 1998.
68. T. Hong and T. D. Milster, "Modulation transfer function of bar code scanning," *Opt. Eng.* **37**(9), pp. 2574-80, 1998.

69. T. D. Milster, "New way to describe diffraction from optical disks," *Appl. Opt*. **37**(29), pp. 6878-83, 1998.
70. F. F. Froehlich and T. D. Milster, "Mechanical resonance behavior of near-field optical microscope probes," *Appl. Phys, Lett*. **70**(12), pp. 1500-2, 1997.
71. W. Schlichting, Faris, B. Ran, J. Haag, Z. Lu, S. Kane, L. Li, T. D. Milster, H. Lug, "Recording and readout of a cholesteric liquid crystal based multilayer disk," *Jap. J. Appl. Phys*, *Part 1*, **36**(1B), pp. 587-8, 1997.
72. T. H. Russell, T. D. Milster, "Polarization switching control in vertical-cavity surface-emitting lasers," *Appl. Phys. Lett*., **70**(19), pp.2520-22, 1997.
73. J. L. Kann, T. D. Milster and F. F. Froehlich, R. W. Ziolkowski, J. B. Judkins, "Heating mechanisms in a near-field optical system," *Appl. Opt.,* **36**(24), pp. 5951-8, 1997.
74. D. G. Flagello, T. D. Milster, "High-numerical-aperture effects in photoresist," *Appl. Opt.*, **36**(34), pp. 89944-51, 1997.
75. D. G. Flagello, T. D. Milster, Rosenbluth, AE, "Theory of high-NA imaging in homogeneous thin films," *JOSA A*, **12**(1), pp.53-64, 1996.
76. T. D. Milster, Z. Chen, E. P. Walker, M. T. Tuell, E. C. Gage, "Optical data storage readout with quadrant pupil detection," *Appl. Opt.,* **35**(14), pp. 2471-6, 1996.
77. T. D. Milster, E. P. Walker, "Mechanism for improving the signal-to-noise ratio in scanning optical microscopes," *Opt. Lett*. **21**(16), pp. 1304-6, 1996.
78. T. D. Milster, Z. Chen, E. P. Walker, M .T. Tuell, E. C. Gage , "Optical data storage readout with quadrant pupil detection," *Appl. Opt.*, **35**(14), pp. 2471-76, 1996.
79. J. L. Kann, T. D. Milster, F. F. Froehlich, R. W. Ziolkowski, J. B. Judkins, "Near-field optical detection of asperities in dielectric surfaces," *JOSA-A*. **12**(3), pp. 501-12, 1995.
80. J .L. Kann, T. D. Milster, F. F. Froehlich, R. W. Ziolkowski, J. B. Judkins, "Numerical analysis of a two-dimensional near-field probe," *Ultramicroscopy*. **57**(2-3) p. 251-6, 1995.
81. J. L. Kann, T. D. Milster, F. F. Froehlich, R. W. Ziolkowski, J. B. Judkins, "Linear behavior of a near-field optical scanning system," *JOSA-A*, **12**(8), pp. 1677-82, 1995.
82. E. P. Walker and T. D. Milster, "High-frequency enhancement of magneto-optic data storage signals by optical and electronic filtering," *Opt. Lett.,* **20**(17), pp. 1815-17, 1995.
83. C. L. Vernold and T. D. Milster, "Technique for aligning optical and mechanical axes based on a rotating linear grating," *Opt. Eng*., **34**(10), pp.2840-5, 1995.
84. F. F. Froehlich and T. D. Milster, "Detection of probe dither motion in near-field scanning optical microscopy," *Appl. Opt*., **34**(31), pp. 7273-9, 1995.
85. W. Schlichting, T. D. Milster, M. S. Wang, C. Brucker, "Signal and noise with a magnetic circular dichroism detection system in optical data storage," *J. Appl. Phys.*, **75**(5), pp. 2322-4, 1994.
86. F. F. Froehlich and T. D. Milster, "Minimum detectable displacement in near-field scanning optical microscopy," *Appl. Phys. Lett.,* **65**(18), p. 2254-6, 1994.
87. T. D. Schlichting, T. D. Milster, C. J. Campillo, "Optical data storage based on magnetic circular dichroism," *Appl. Phys. Lett*., **62**(22), pp. 2751-53, 1993
88. M. S. Wang and T. D. Milster, "Differential wax-wane focus servo," *Appl. Opt.*, **32**(25), pp. 4797-807, 1993.
89. M. S. Wang, T. D. Milster, "Crosstalk cancellation using differential wax-wane focus technique," *Jap. J. Appl. Phys.*, *Part 1*, **32**(11B), pp. 5277-83, 1993.

90. T. D. Milster, M. S. Wang, W. Li, E. Walker, "Optical filtering in the collection path of a data storage device," *Jap. J. Appl. Phys., Part 1*, **32**(11B), pp. 5397-401, 1993.
91. T. D. Milster, C. H. Curtis, "Analysis of superresolution in magneto-optic data storage devices," *Appl. Opt.*, **31**(29), pp. 6272-9, Oct. 1992.
92. F. F. Froehlich, T. D. Milster and M. S. Wang, "Technique for simultaneous alignment and collimation of a laser diode in an optical data storage head," *Appl. Opt.*, **30**(31), pp.4481-3, 1991.
93. *T. D. Milster, J. N. Aarsvold, H. H. Barrett, A. L. Landesman, L. S. Mar, D. D. Patton, T. J. Roney, R. K. Rowe, R. H. Seacat III, "A full-field modular gamma camera," *J. Nuc. Med.*, **31**(5), pp.632-9, 1990.
94. *R. G. Paxman, H. H. Barrett, Smith, WE, T. D. Milster, "Image reconstruction from coded data II Code design," *JOSA-A*. **2**(4), pp. 501-9, April 1985.
95. *T. D. Milster, L. A. Selberg, H. H. Barrett, A. L. Landesman, R. H. Seacat III, "Digital position estimation for the modular scintillation camera," *IEEE Transactions on Nuclear Science*. **NS-32**, no.1; pp.748-52, 1985.
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(*) Indicates publication substantially based on work done as a graduate student.

**MEDIA**

*T. D. Milster, L.A. Selberg, R.L. Easton, H.H. Barrett, and G.Rossi, "A modular imaging system for use in nuclear medicine," scientific exhibit, Society of Nuclear Medicine's 30th annual meeting (1983).

**SCHOLARLY PRESENTATIONS (Since 2000)**

**Invited Presentations:**

1. T. D. Milster, "Hyper-NA (NA = 2.8) Microscope Using 1.55um fs Source For Multi-photon Imaging," **Conference Paper,** Bio-Optics: Design and Application,Waikoloa Beach, Hawaii United States, April 14-18, 2013,ISBN: 978-1-55752-966-4 Microscopy (BT1A).
2. Tom D. Milster, "Hyper numerical aperture imaging systems and applications," presented at Imperial College, London, and University of Nottingham, Nottingham, England, September 2010.
3. T. D. Milster, "Review of ODS Technology: Advanced Level and Recent Research," Presented at the Optical Technology Education Center (OTEC), Inha University, Korea, November 14, 2008.
4. T. D. Milster, "Application of ODS Technology to Lithography," Presented at LG Electronics, Korea, November 14, 2008.

5. T. D. Milster, “Application of ODS Technology to Lithography,” Invited Paper WB06, International Symposium on Optical Memory and Optical Data Storage, Waikoloa, HI, July 14, 2008.
6. T. D. Milster, “Near-Field Technologies,” Presented at CISD/ Yonsi University, Seoul, Korea, November 13, 2008.
7. T. D. Milster, “Status and Trends of Optical Data Storage Technology,” Presented at the THIC Meeting at the National Center for Atmospheric Research, Boulder CO, August 21-22, 2007.
8. T. D. Milster, “Engineering Considerations for Multiple-Layered Optical Memories,” presented at the Terabyte Optical Memory Consortium (TBOC) Workshop on Multilayered Optical Discs, Awaji Island, Japan, October 20, 2006, sponsored by TBOC.
9. T. D. Milster, S. K. Park and Y Zhang, “Prospects and limitations for large numbers of multi-layers in optical data storage”, presented at Optical Society of America’s Topical Meeting on Optical Data Storage, Montreal, Canada, April 26, 2006.
10. M. Lang and T. D. Milster, “Investigation of nicro-optical systems,” International Conference on Optical Design and Fabrication, (ODF 2006), Nara, Japan, December 6-8, 2006, sponsored by the Optical Society of Japan.
11. T. Milster, "Near Field and Alternative Technologies for Optical Data Storage", presented as part of a panel discussion at OSA Topical Meeting on Optical Data Storage, Montreal, Canada, April 26, 2006.
12. T. Milster, S. K. Park and Y. Zhang, "Characteristics and Limitations of Multiple-Layered Optical Memories”, Paper MC2, Presented at Joint International Symposium on Optical Memories, Honolulu, Hawaii, July 11, 2005.
13. T. Milster and T. Chen, "Techniques and Potential of Near-Field Optical Data Storage", Presented at Keio University Workshop on Nano Photonics and Functional Device Technology, San Jose, California, January 27, 2005.
14. T. Chen and T. Milster, “Evanescent Imaging with a Solid Immersion Lens (SIL)”, Department of Physics and Astronomy, Arizona State University, Tempe, AZ, December 2, 2005.
15. T.D. Milster, “Optics Beyond the Diffraction Limit,” Optical Sciences Center Colloquium Series, November 16, 2005, Tucson, Arizona.
16. Milster, TD, “Forth-Generation Optical Data Storage,” presented at University of California – San Diego, San Diego, California, January 21, 2005.
17. T.D. Milster, “Near-field optics: Introduction and application,” Optical Sciences Center Colloquium Series, February 5, 2004, Tucson, Arizona.
18. T.D. Milster, “Near-Field Maskless Lithography,” presented at ASML Technology Center, Tempe, Arizona, April 8, 2004.
19. T.D. Milster, “Near-field, volumetric and alternative geometries,” as part of Panel Discussion on Fourth Generation Optical Storage and Alternatives, which was part of SPIE’s Topical Meeting on Optical Data Storage, April 18-21, 2004, Monterey, California.
20. T.D. Milster, “Development of Volumetric Bit-Wise Optical Data Storage for Space and Ground Applications,” National Reconnaissance Office Technology Seminar Series, Chantilly, Virginia, June 7, 2004.

21. T.D. Milster, Y. Zhang, T. Choi, J. Butz, S. K. Park, W. Bletscher, "Potential for Volumetric Bit-Wise Optical Data Storage in Space Applications" paper A8P1 (presentation + digest), NASA Earth Science Technology Conference, June 24, 2004, at the Crowne Plaza Cabana in Palo Alto, CA.
22. T.D. Milster, D. S. Nam and T. Chen, "Solid Immersion Lithography," presented at the IEEE Lithography Workshop, July 26-30, 2004, Whistler, Canada.
23. T. D. Milster, D. S. Nam and T. Chen, "Maskless Dry Immersion," presented at the Intel Research Center, Hillsboro, OR, August 27, 2004.
24. T. D. Milster, "Nano-Probes for Lithography," presented at Samsung Electronics, Seoul, Korea, October 11, 2004.
25. T.D. Milster, "Terabyte optical disks," presented at the Industrial Affiliates Workshop, Optical Sciences Center, University of Arizona, Tucson, Arizona, March 28, 2003
26. T.D. Milster, Zhang, Y, Butz, J, Miller, T, Walker, E, "Volumetric Bit-Wise Optical Data Storage for Space Applications" paper A5P2, NASA Earth Science Technology Conference, June 25, 2003, at the University of Maryland Inn and Conference Center, College Park, Maryland.
27. T.D. Milster, "Physics and Applications of Volumetric Optical Storage," presented at the Industrial Advisory Board Meeting, Optical Data Storage Center, University of Arizona, Tucson, Arizona, October 10, 2003.
28. T.D. Milster, "Near-Field Recording Technologies," panelist presentation, INSIC Roadmap Symposium, Optical Data Storage Topical Meeting, Vancouver, BC, Canada, May 11-14, 2003.
29. T.D. Milster, "Terabyte Optical Disks" presented at DataPlay, Inc., July 29. 2003, Boulder, Colorado.
30. T. D. Milster, "Physical Optics Simulation in Matlab for High-Performance Systems," presented at the 3rd International Conference on Optics-photonics Design and Fabrication ODF2002, Tokyo, Japan, Oct 30-Nov 2, 2002.
31. T. D. Milster, "Near-Field Optics: Powerful Tools for Microscopy, Data Storage, and Lithography," presented at Cannon Research Center, Utsunomiya-Shi, Japan, Oct. 29, 2002.
32. T. D. Milster. "Solid Immersion Lenses and Near-field optics: Powerful tools for microscopy, data storage, and other applications," Physics Seminar; Tempe, Arizona, September 16, 2002
33. T. D. Milster, S. G. Tang, "Generation of compact near-field energy for optical recording," International Syposium on Optical Memory, Waiakaloa, Hawaii, July 10, 2002.
34. T. D. Milster, Y. Zhang, J. Butz, T. Miller, E. P. Walker, "Volumetric bit-wise memories, NASA Earth Science Enterprise, Earth Science Technology Conference, NASA Ames Research Center, California, June 13, 2002.
35. T. D. Milster, S. G. Tang, "High performance readout and recording by a combination aperture," International Syposium on Optical Memory, Taipei, Taiwan, October 18, 2001.
36. T. D. Milster, Y. Zhang, C. D. Pinto, E. P. Walker, "A volumetric memory device based on photo-chromic compounds," NASA Earth Sciences Technology Conference, August 28-30, 2001, University of Maryland Conference Center, College Park, Maryland.
37. T. D. Milster, "Interesting Near-Field Geometries and Their Application to Data Storage," National Institute for Advanced Interdisciplinary Research NAIR/OITDA Workshop on

Ultrahigh Density Data Storage, AIST Tsukuba Research Center, Tsukuba, Ibaragi, Japan, March 15-16, 2001.

38. T.D. Milster, "High Throughput Optical Data Storage," presented at the Optoelectronic Industries Development Association Annual Forum, Washington, D.C., Feb 22, 2001.
39. (*Plenary*) T. D. Milster, F. Akhavan, M. Bailey, K. Erwin, D. Felix, K Hirota, S. Koester, K. Shimura, Y. Zhang, "Research in near-field optical data storage," the Satellite International Symposium on Optical Memory 2000, Kyoung-ju, Korea, September 22, 2000.
40. T.D. Milster, F. Akhavan, M. Bailey, K. Erwin, D. Felix, K Hirota, S. Koester, K. Shimura, Y. Zhang 'Superresolution by combination of a SIL and an aperture," International Symposium on Optical Memory 2000, Japan Society of Applied Physics, Chitose, Hokkaido, Japan, September 8, 2000.
41. T.D. Milster, "Near-field recording," SPIE Photonics Taiwan 2000, Conference 4081 on Optical Storage and Optical Information Processing, Taipei, Taiwan, July 27, 2000.
42. T.D. Milster, K. Hirota, Y. Zhang, K. Shimura, W. Bletscher, J. S. Jo, K. Erwin, M. Bailey, F. Akhavan, "Research in near-field optical storage," International Symposium of the Near-Field Optical Storage, Department of Physics, National Taiwan University, July 25, 2000.
43. T. D. Milster, "Potential of near-field recording for optical data storage," IEEE International Conference on Communications, Workshop WK01, Data Storage Signal Processing, New Orleans, June 18, 2000.
44. T. D. Milster, "Multiple-Beam Systems with Conventional Media," Optoelectronic Industries Development Association Workshop on High Throughput Optical Data Storage, Honolulu, Hawaii, June 7, 2000.
45. T. D. Milster, "Combination of SIL technology with super-resolution techniques," National Institute for Advanced Interdisciplinary Research NAIR/OITDA Workshop on Ultrahigh Density Data Storage, AIST Tsukuba Research Center, Tsukuba, Ibaragi, Japan, March 7-8, 2000.

**Other Presentations**:

1. Chris Summitt, Sunglin Wang, Lee Johnson, Melissa Zaverton, Tom Milster, Yuzuru Takashima, "Flexible micro-optics fabrication by direct laser writing toward CMOS compatible 3D optical circuit," *Proc. SPIE* 8613, Advanced Fabrication Technologies for Micro/Nano Optics and Photonics VI, 86130K (March 5, 2013);
2. Eduardo A. Bendek, Olivier Guyon, Ruslan Belikov, S. Mark Ammons, Thomas Milster, Young-Sik Kim, Lee Johnson, "Exoplanet detection and characterization using combined coronagraphy and sub-UAS astrometry from space," *Proc. SPIE* 8864, Techniques and Instrumentation for Detection of Exoplanets VI, 886405 (September 26, 2013); doi:10.1117/12.2024316.
3. Guyon, Olivier, Eduardo Bendek, S. Mark Ammons, Michael Shao, Stuart Shaklan, Robert A. Woodruff, Ruslan Belikovf, and Thomas Milster. "Characterization of habitable Exoplanets with simultaneous Coronagraphy and Astrometry with a single Aperture Telescope." In *Proc. of SPIE Vol*, vol. 8442, pp. 84420K-1. 2012.
4. Y. Kim and T. Milster, "Hyper NA Blu-Ray Disc Recording," Joint International Symposium on Optical Memory and Optical Data Storage (ISOM/ODS) 2011, Paper OTuD13.

5. I. Murray, V. Densmore, V. Bora, M. Pieratt, D. Hibbard and T. Milster, “Numerical comparison of grid pattern diffraction effects through measurement and modeling with OptiScan software,” Proc. SPIE **8016**, 2011, p. 80160U
6. T. Milster, H. Noble, E. Ford, W. Dallas, R. Chipman, I. Matsubara, Y. Unno, S. McClain, P. Khulbe, W. Lam and D. Hansen, “Polarization holograms for source-mask optimization,” Proc. SPIE **7973**, 2011, p. 79731A.
7. J. Tamkin and T. Milster, "Point Spread Function Artifacts from Structured Mid-Spatial Frequency Errors," in International Optical Design Conference, OSA Technical Digest (CD) (Optical Society of America, 2010), paper ITuD4.
8. M. Zaverton, J. Sierchio, Y. Kim, D. Hansen, W. Bletcher, J. Tamkin, and T. Milster, "Maskless Lithography Tool for Fabrication and Inspection of Diffractive Optical Elements and Computer Generated Holograms," in Optical Fabrication and Testing, OSA Technical Digest (CD) (Optical Society of America, 2010), paper OTuC5.
9. J. Park, Y. Kim, M. Zaverton, J. Sierchio, and T. Milster, "Characterization of Photoresist and Study on Developed Resist Profile for the Fabrication of Gray-Scale Diffractive Optic Elements," in Optical Fabrication and Testing, OSA Technical Digest (CD) (Optical Society of America, 2010), paper OTuC4.
10. Analysis and tolerancing of structured mid-spatial frequency errors in imaging systems John M. Tamkin and Tom D. Milster, Proc. SPIE 7652, 765218 (2010), DOI:10.1117/12.871013
11. Characteristics of the depth of focus in a high-NA optical system with a SIAX for data storage
    Jaisoon Kim, Moonseok Kim, Sukjoon Hong, and Tom D. Milster, Proc. SPIE 7730, 77300M (2010), DOI:10.1117/12.859234.
12. Hyper-NA imaging with solid-immersion optics and induced polarization imaging Jun Zhang, Seung-Hune Yang, Tom D. Milster, Warren Bletscher, and Delbert Hansen, Proc. SPIE 7570, 757012 (2010), DOI:10.1117/12.848971.
13. J. Zhang, M. Lang, T. D. Milster, T. Chen, E. Aspnes and B. Bell, “Two-Step Gallium Phosphide SILs Fabrication and Testing,” Presented at the Topical Conference on Optical Data Storage, Portland, OR, April 23, 2007.
14. M. Lang, T. D. Milster, Takahisa Minamitani, Gregg Borek, “Investigation of micro solid immersion lens mounting systems” presented at ISOM 2006, Takamatsu, Japan, Oct 16-19, 2006, sponsored by JJAP, MSJ and OITDA.
15. N. Choi, S. Shim, T. D. Milster, J. S. Kim, “Optical Design for the Optimum SIL with High NA and Large Tolerance,” presented at ISOM 2006, Takamatsu, Japan, Oct 16-19, 2006, sponsored by JJAP, MSJ and OITDA.
16. T. Chen, T. D. Milster and S. H. Yang, “Experimental investigation of photomask with near-field polarization imaging”, SPIE 26th Annual BACUS Symposium on Photomask Technology ,Monterey, CA, September 19, 2006.
17. T. Chen and T. D. Milster,“ Near-Field Induced Polarization Imaging for Optical Data Storage”, Presented at Optical Society of America’s Topical Meeting on Optical Data Storage, Montreal, Canada, April 26, 2006.
18. T. D. Milster, “Data destruction for optical disks,” presented at the THIC – The Premier Advanced Recording Technology Forum – Meeting July18, 2006, Boulder, Colorado.

19. T. D. Milster, "Data recovery from optical media," presented at the THIC – The Premier Advanced Recording Technology Forum – Meeting July18, 2006, Boulder, Colorado.
20. S.B. Shim, K.J. Lee, J.H. Lee, Y.H. Hwang, S.O. Han, J.H. Pak, S.E. Choi, T. D. Milster, J.S. Kim, "Preconditions for High Speed Confocal Image Acquisition with DMD Scanning," presented at the Annual Meeting of the Optical Society of Korea, Jeju Island Korea, July14-16, 2006.
21. F. Y. Li, T. D. Milster, S. Kasanavesi, W. Bletscher, D. Hansen, D. Felix, M. Lang and P. Hauser, "Dynamic Data Recovery from Damaged CD Media," Paper WC5 Presented at ISOM/ODS 05, Optical Society of America Topical meeting on Optical Data Storage, Honolulu, Hawaii, July 2005.
22. T. Choi and T. D. Milster, "Change in data marks and groove structure of CD Recordable disks in response to a high power laser beam", Poster presentation (WP11), ISOM/ODS 05, Optical Society of America Topical meeting on Optical Data Storage, Honolulu, Hawaii, July 2005.
23. T. Chen, T. Milster, and S. H. Yang, "Semiconductor pattern analysis with induced polarization", 25th Annual BACUS Symposium on Photomask Technology, Monterey, CA, October 5, 2005.
24. T. Chen, D. Felix, S. K. Park, B. McCarthy, D. Sarid, and T. Milster, "Near-field Solid Immersion Lens (SIL) Microscope", 89th OSA Annual Meeting, Frontiers in Optics 2005, Laser Science XXI, Tucson, AZ, October 19, 2005
25. T. Chen, T. Milster and S. H. Yang, "Evanescent Imaging with Induced Polarization", 89th OSA Annual Meeting, Frontiers in Optics 2005, Laser Science XXI, Tucson, AZ, October 19, 2005
26. J. Olkkonena, K. Kataja, J. Aikio, D. G. Howe and T. D. Milster, "Analysis of sub-wavelength apertures via the extended scattered field FDTD technique," poster paper P30 presented at SPIE's Topical Meeting on Optical Data Storage, Monterey, California, April 18-21, 2004, Technical Digest, pp. 162-164.
27. L. Zhou, J. A. Bain, T. E. Schlesinger, M. Lang and T. D. Milster, "Prototype of a mode index lens for heat assisted magnetic recording," paper MB2 presented at SPIE's Topical Meeting on Optical Data Storage, Monterey, California, April 18-21, 2004, Technical Digest, pp. 22-24.
28. S. Kasanavesi and T. D. Milster, "Data recovery from a Compact Disc fragment," paper MC6 presented at SPIE's Topical Meeting on Optical Data Storage, Monterey, California, April 18-21, 2004, Technical Digest, pp. 49-51.
29. T. Choi, T. D. Milster and M. Lang, "Wavelength-Domain Tracking in Multiple-Beam Optical Storage Systems," paper TuA6 presented at SPIE's Topical Meeting on Optical Data Storage, Monterey, California, April 18-21, 2004, Technical Digest, pp. 216-218.
30. T. Chen, D. Felix, S. K. Park, P. Hauser, B. McCarthy, Dror Sarid, Christian Poweleit, Jose Menendez and Tom Milster, "Near-Field Solid Immersion Lens (SIL) Microscope with Advanced Compact Mechanical Design," poster paper P26 presented at SPIE's Topical Meeting on Optical Data Storage, Monterey, California, April 18-21, 2004, Technical Digest, pp. 150-152.
31. Y. Zhang and T. D. Milster, "Simulation of a fluorescent bit-wise volumetric optical data storage system," paper WB4 presented at SPIE's Topical Meeting on Optical Data Storage,

Monterey, California, April 18-21, 2004, Technical Digest, pp. 296-298.

32. T. D. Milster, T. Choi, B. Putz, W. Bletscher, J. Butz, D. Felix, "Degree of Erasure for Optical Recording Media" presented at the THIC – The Premier Advanced Recording Technology Forum – Meeting June 29-30, 2004, Boulder, Colorado.
33. T. D. Milster, S. Kasanavesi, T. Choi, B. Putz, W. Bletscher , J. Butz, D. Felix, "Data Recovery from CD-R Fragments" presented at the THIC – The Premier Advanced Recording Technology Forum – Meeting June 29-30, 2004, Boulder, Colorado.
34. T. D. Milster, T. Chen and D. S. Nam, "Maskless Lithography with Solid Immersion Lens Nano Probes," presented at SPIE's Photomask Technology (BACUS) Conference, Monterey, California, September 15, 2004.
35. S. K. Park, T.D. Milster, T.M. Miller, J. Butz, and W. Bletscher, "Master and Slave Beam Servo Technique for Volumetric Bit-Wise Optical Data Storage," paper We-E-07 presented at the Japan Society of Applied Physics International Symposium on Optical Memory, October 11-15, 2004, Jeju Island, Korea, Technical Digest pp. 62-63.
36. T. Y. Choi and T. D. Milster, "Broad-Stripe High-Power Laser Diode Focus Servo," poster paper We-G-12 presented at the Japan Society of Applied Physics International Symposium on Optical Memory, October 11-15, 2004, Jeju Island, Korea, Technical Digest pp. 106-107.
37. M. Lang, T. Milster, T. Minamitani, G. Borek and D. Brown, "Fabrication and Testing of a Gallium Phosphide Solid Immersion Lens," paper Th-I-02 presented at the Japan Society of Applied Physics International Symposium on Optical Memory, October 11-15, 2004, Jeju Island, Korea, Technical Digest pp. 162-163.
38. T. D. Milster, Y. Zhang, J. S. Kim, S. K. Park, "Advanced lens design for bit-wise volumetric optical data storage," paper Fr-J-04 presented at the Japan Society of Applied Physics International Symposium on Optical Memory, November 3-7, 2003, Nara, Japan.
39. T. D. Milster, "Review of methods to achieve optical recording at 1 Tb/in$^2$", presented at the Optical Society of America Annual Meeting, October 8, 2003, Tucson, Arizona.
40. T. D. Milster, "Optical Recording at 1 Tb/in$^2$" presented at the THIC – The Premier Advanced Recording Technology Forum – Meeting July 22-23, 2003, Louisville, Colorado.
41. F. H. Wu, U. Rambabu, T.D. Milster and H. P. Shieh, "Optical nonlinearity of silver oxide super resolution structure as a function of oxygen content," paper MB4 presented at the Optical Society of America's Topical Meeting on Optical Data Storage, May 11-14, 2003, Vancouver, BC, Canada.
42. T. N. Miller, J. Butz, T.D. Milster, "A novel method for tracking in homogeneous volumetric media," poster paper TuE19 presented at the Optical Society of America's Topical Meeting on Optical Data Storage, May 11-14, 2003, Vancouver, BC, Canada.
43. Y. Zhang, T. D. Milster, J. Butz, D. Knight, W. L. Bletscher and E. Walker, "Characterization of a three-dimensional bit-wise volumetric storage media in a space environment", poster paper TuE38 presented at the Optical Society of America's Topical Meeting on Optical Data Storage, May 11-14, 2003, Vancouver, BC, Canada.
44. Y. Zhang, T. D. Milster, J. Butz, W. Bletscher, "A new test stand for dynamically testing coupon samples," poster paper TuE39 presented at the Optical Society of America's Topical Meeting on Optical Data Storage, May 11-14, 2003, Vancouver, BC, Canada.
45. F. S. Wu, T. D. Milster and H. P. Sheih, "Write-once multilayer optical disk using transparent recordable material with an optical switching layer," paper Fr-J-06 presented at

the Japan Society of Applied Physics International Symposium on Optical Memory, November 3-7, 2003, Nara, Japan.

46. K. Shimura, T. D. Milster, "Analysis of three-dimensional distributions of scattered light by the discrete dipole approximation," Trends in Optics and Photonics, Diffractive Optics and Micro Optics Technical Digest Postconference Edition, Vol. 41, pp. 162-64, 2000.
47. J. S. Jo, T. D. Milster and J. K. Erwin, "Amplitude and phase apodization caused by focusing light through an evanescent gap in SIL recorders," Paper 4081-21, SPIE Photonics Taiwan, 26-27 July, 2000, Taipei, Taiwan.
48. R. S. Upton and T. D. Milster, "Exit pupil irradiance patterns from optical disks," paper 4081-22, SPIE Photonics Taiwan, 26-27 July, 2000, Taipei, Taiwan.
49. S. Jo, T. D. Milster and J. K. Erwin, "Characteristics of gap-induced aberration," Paper MC4 at the 2000 Optical Data Storage Conference sponsored by IEEE/LEOS, SPIE and OSA, May 14-17, Whistler, British Columbia, Canada,(2000). Also technical digest ISBN 0-7803-5950-X.
50. R. S. Upton and T. D. Milster, "Crosstalk cancellation for DVD-RAM type media with 0.5 micron track pitch," Paper WD1 at the 2000 Optical Data Storage Conference sponsored by IEEE/LEOS, SPIE and OSA, May 14-17, Whistler, British Columbia, Canada,(2000). Also technical digest ISBN 0-7803-5950-X.

**Patents:**

1. T. D. Milster and J. S. Kim, "Alignment feature for near-field transducers," USP 8,737,178 (2014).
2. B. Gelernt and T. D. Milster, "Apparatus and method for deep ultraviolet microscopy," USP 8,472,111 (2013).
3. B. Gelernt, T. D. Milster and J. Thiago, "Interferometric systems and methods," USPTO Publication 20130278922 (2013).
4. T. D. Milster, K. R. Denninghoff , P. K. Kulbe and J. Zhang, "In-vivo optical sensor," USPTO Publication 20130012793 (2013).
5. T. Milster and S. K. Park, "Optimized media structure for bit-wise multi-layer optical data storage," USP 8,003,187 (2011).
6. I. Matsubara, Y. Unno, W. Dallas and T. D. Milster, "Hologram and exposure apparatus," USPTO Publicaiton 20110216296 (2011).
7. T. Milster and S. Kannan, "Application of wavelet transform filtering for processing data signals from optical data storage devices," USP 7,974,170 (2011.).
8. T. Milster, P. Khulbe and B. Gelernt, "Apparatus and method for spectroscopy," USP 7,916,291 (2011)
9. P. B. Chu, M. I. Lutwyche, T. Rausch, W. A. Challener and T. D. Milster, "Optical system for data storage devices," 7,796,487 (2010).
10. W. Jiang, C. H. Ping and T. D. Milster, USP 6,901,221, "Method and apparatus for improved optical elements for vertical PCB fiber optic modules," (2005).
11. T. D. Milster and K. Shimura, USP 6,577,584, "Method and apparatus for detecting light from a multilayered object," (2003)
12. W. Jiang and T. D. Milster, USP 6,498,875, "Optical fiber corrector for connecting a plurality of light sources to a plurality of light sinks," (2002).

13. T. D. Milster, W. Jiang and M. S. Lebby, USP 6,111,839, “Optical pickup head including a coherent first order mode laser light source,” (2000).
14. T. D. Milster and S. S. Yao, 4,823,220, “Detector for magnetooptic recorders,” (1989).
15. T. D. Milster and J. S. Kim, “Alignment Feature for near-field transducers,” USPTO Publication 200080056080, UA 02-055, selected for patent prosecution by the Information Storage Industry Consortium (INSIC) through cooperative agreement #70NANB1H3056.

**Invention Disclosures:**

1. S. K. Park and T.D. Milster, "Linear Segmented Inclined Scanning," UA06-002.
2. M. Lang and T. D. Milster, "Micro lens mounting system" invention disclosure, reference# UA05-067.
3. T. D. Milster, A. Gelbart, “A Diffractive Bar Code Scanner with Stigmatic Focus,” UA00-009
4. T. D. Milster, N.A. Beaudry, “Interferometric Phase reconstruction using tilt or defocus,” UA00-082
5. T. D. Milster, C. Tien, H. Shieh, “Micro Optical Integration of a Fiberlens and Solid Immersion Lens (SIL),” UA02-009
6. T .D. Milster, J. Sseunhyeun, “Method for Improving Readout Performance in Magneto-Optical Data Recorders Using Optical Filtering” UA02-010
7. T. D. Milster, J.S. Kim, “Optimum Performance Objective Lens Design for the Multiple-Layer Focus Access SIL System,” UA02-056
8. T. D. Milster, D. O’Connell, “Solid Immersion Lens Fabry-Perot Resonator with Near-Field Apertures (APSILRES),” UA02-057
9. T. D. Milster, J. Butz, T.N. Miller, “A Closed-Loop Disc-Servo System to Lock Track and Focus Volumetric Optical Storage Media,” UA02-080. Provisional Patent Application filed April 21, 2003.
10. T. D. Milster, “Direct-Write Near-Field SIL Array Lithography System,” UA02-093. Provisional Patent Application filed April 21, 2003.
11. T. D. Milster, A. Khoh, “Assist-Sticks and Butterfly Corner,” UA03-026
12. T. D. Milster, “Media formulation for volumetric bit-wise storage,” UA03-050
13. T. D. Milster, “Volumetric bit-wise storage with a new media geometry,” UA03-051
14. T. D. Milster, “Wavelength-domain tracking in multiple-beam optical systems,” UA03-083, Provisional Patent Application filed April 21, 2003.
15. L. Weller-Brophy and T. D. Milster, “Multi-layer integrated optical read/write head for magneto-optic data storage,” UA1016.
16. J. Wong and T. D. Milster, “Highly efficient and compact beam deflection optical system,” UA91-067
17. F. Froehlich and T. Milster, “Fabrication of micro-Fresnel lenses on curved substrates,” UA91-051
18. T. D. Milster, W. Schlichting and C. Brucker, “Magneto-optic Data Detector using Magnetic Circular Dichroism,” UA94-043
19. T. Milster, Z. Chen, E. Gage, “Quadrant pupil detection for increased track density,” UA95-054
20. T. Milster, Z. Chen, E. Gage, “Quadrant pupil detection for tracking error signal generation,”

UA95-055
21. T. D. Milster, “Optical Pickup Head for High Density Optical Data Storage Applications,” UA98-003
22. T. D. Milster, “Improved User Interface for Diffraction Modeling Programs,” UA98-012
23. T. D. Milster and K. Shimura, “Pupil-plane filtering for improved signal detection in an optical data storage system incorporating a solid immersion lens,” UA99-052

**Statement of Accomplishments and Objectives on Research, Teaching and Service/Outreach:**

***Research Accomplishments and Goals***

My research pushes the boundaries of known optical engineering and science to produce the maximum amount of information from a given volume of space and time. For example, I typically deal with systems that go well beyond what standard laboratory instruments are capable of resolving, thus breaking the physical optics "diffraction barrier". Applications of the research include data storage, lithography and microscopy. To be effective, I must understand not only theoretical concepts, but I must also be able to simulate complex problems and carry out proof-of-principle experiments.

A challenging problem is to increase the resolving power of optical systems beyond classical limits imposed by diffraction. I have accomplished breaking the "diffraction barrier" by applying the techniques of near-field scanning optical microscopy (NSOM), developing specialized near-field probes, and applying the solid immersion lens (SIL) in various ways.

My NSOM work resulted in understanding the linearity of an NSOM scanning-type imaging system.[Kann *et al.*, *JOSA-A*, 1995] This paper was selected for inclusion in the Society of Photo-Optical Instrumentation Engineers (SPIE) Milestone Series in Near-Field Optics. [SPIE, 2002] Other work determined the minimum detectable displacement of an NSOM probe tip,[Froehlich and Milster, *APL*, 1994] described detection of asperities in dielectric surfaces,[Kann *et al.*, *JOSA-A*, 1995] and discussed numerical analysis of an NSOM probe tip.[Kann *et al*., *Ultramicrosopy*, 1995]

Understanding the limitations of NSOM probes led me to develop the 'combination probe', which combines a dielectric NSOM-type tip with a special lens coupled directly to it.[Tang *et al.*, *Opt. Lett*., 2001 and Milster *et al.*, *JJAP*, 2001] The combination probe has orders of magnitude higher illumination/collection efficiency than other coated-tip NSOM probes that produce similar resolution. In addition, the combination probe allows generation of servo signals in reflection that are useful for applications like data storage, if designed properly.[Hirota *et al.*, *JJAP*, pp.973-5, 2000] This work was selected as a feature item in the Optical Society of America's *Optics and Photonics News* special edition on *Optics in 2001*.[Milster *et al*., *OPN,* 2001]

Breaking the diffraction barrier is also accomplished in my group by a specialized lens called a solid immersion lens (SIL). The SIL effectively increases the numerical aperture of the optical system beyond a value of 1.0, which is the limit for standard microscopes. One of my specialties is in understanding how SILs can improve resolution and function in various applications. In data storage, I was the first to demonstrate optical recording with a lens system having a numerical aperture of 2.0, which improves resolution by a factor of two and data density by a factor of four over the best system theoretically possible without immersion.[Hirota *et al.*, *JJAP*, pp. 968-72, 2000] I also studied various aspects of using SILs in data storage systems, like understanding the nature of the coupling field between the SIL and the object [Milster *et al.*, *JJAP*, 1999] and understanding the roles of propagating and evanescent waves in these devices [Milster *et al.*, *Appl. Opt.*, 1999]. This

work led to the discovery of using optical filtering techniques to improve readout signal contrast in SIL-based data storage devices [Milster *et al*., *Opt. Lett.*, 1999] and one patent [Milster and Shimura, *USP* 6,577,584, 2003]. I also investigated the optical effects of waves propagating through the evanescent gap [Jo *et al.*, *Opt. Eng.*, 2002]. In order to miniaturize the components for very large NA devices (NA>2), I introduced the concept of wafer processing to fabricate micro-SIL systems.[Lang *et al.*, *JJAP*, 2005, and Lang *et al. JJAP*, 2006]

Recently, I discovered the technique of using a SIL-generated evanescent induced polarization signal to obtain topographical, as well as high-resolution reflectivity, information from a surface.[Chen *et al.*, *Opt. Lett.*, 2006] This technique is being applied to measure etch depths on lithographic masks heretofore not measurable without contacting the surface.[Chen and Milster, *JM3*, 2006] The analysis of the induced polarization signal is described in detail in another recent submission.[Chen and Milster, *Opt. Express*, 2006] In lithography, I was the first to show exposure of contact holes with a SIL system.[Milster *et al.* SPIE Proc. 5567, 2004] The analysis of the induced polarization image is turning out to be a fascinating subject, and we expect to apply it to microscopy for analysis of biological samples as well as other areas of surface science. In the near future, I expect to demonstrate an imaging microscope with a numerical aperture of 2.5, which will be the highest ever achieved in the visible wavelength range. I expect this work to continue into the indefinite future.

Another way to obtain more information from a given volume of space is to use the third dimension, depth, to store data. My work with volumetric systems, which store data in hundreds of planar layers on a spinning disc, increases the data storage capacity of a disc by a factor nearly equal to the number of layers. For example, a 100-layer system of DVD-like layers stores almost 0.5 terabytes (500,000,000,000 bytes). It is not unreasonable to imagine over one terabyte discs in the next few years. My work on lens design for these systems [Milster *et al*., *Opt. Eng*., 2003] was selected as one of the 300 most influential papers on lens design [SPIE, Volume CDP02, 1999]. I have also considered specific lens designs and capacity limits for fluorescent bit-wise volumetric storage [Zhang *et al.*, *JJAP*, 2004] and servo systems for these discs [Park *et al*., *JJAP*, 2005]. My recent paper on volumetric storage addresses reflective-type data layers.[Park *et al.*, *Appl. Opt.*, 2006]

I have constructed the world's first system to recover data from severely damaged optical discs, [Kannon *et al.*, *IEEE Trans. Info. Sec. and Forensics*, 2006] and have published several papers on servo system development [for example, Wang *et al.*, *Appl. Opt.*, 1993] and understanding the detection process [Milster, *Appl. Opt.*, 1998]. These efforts improve our expertise in signal processing, so that more data can be stored in each location through improvement of signal-to-noise ratio, rather than reduction of physical dimension.

Some mention must be made of my publications in the refereed *Japanese Journal of Applied Physics* (*JJAP*). Since a large amount of optical data storage research occurs in the Asia-Pacific Rim, the premier journal that produces the latest and significant optical data storage research is the yearly topical issue of the *JJAP* dedicated to optical data storage. It is important to me to publish my data storage research in this journal.

Since the resolution of optical systems is linearly related to the wavelength, I have been investigating the properties of illumination systems for extreme ultra violet (EUV) lithographic exposure devices. As the next generation of semiconductor fabrication tools, EUV ($\lambda$ ~13.5 nm) systems should produce features in the tens-of-nanometer size range. EUV systems must use mirrors to form images, not lenses, because no refractive material is available at this wavelength. These mirrors must be ultra smooth to limit effects due to aberrations, and they are expensive. Even with the best fabrication technology available, residual mirror roughness is typically 1 nm, which is a large fraction of the EUV wavelength. I study the line-edge roughness (LER) in the exposed patterns that results from residual mirror roughness and mask defects.[Beaudry and Milster, *Opt. Lett.*, 2000, and Beaudry and Milster, *Opt. Eng.*, 2005] This effect can be significant, depending on where the mirrors are placed in the optical system. As you might expect, there is a strong interest in specifying how well mirrors must be polished in these systems, due to the expense involved in their fabrication.

The software tools that are commercially available are not appropriate for the types of problems that I need to solve. Therefore, I spend a considerable amount of effort in developing a collection of software simulators in Matlab called OptiScan.[Milster, *Opt. Review*, 2003] It is utilized extensively by my students.

In summary, my research efforts involve advanced physical optics on the nanoscale, with applications in optical data storage, lithography and microscopy. I have maintained a strong research group (6-10 students each year over the past ten years). I am a Fellow of both the Society of Photo-optical Instrumentation Engineers (SPIE) and the Optical Society of America (OSA). My research support has been excellent (over $4.8M in the last five years) from a variety of industrial and government sources. I am very enthusiastic about the research I am doing and the potential for its applications in the future.

***Philosophy on Teaching and Advising***

I look forward to teaching every year. My philosophy on teaching is to convey conceptual understanding that builds intuition, with solid reference material in the form of high-quality class notes. My lectures often contain demonstrations and dynamic simulations that illustrate concepts and relationships. I also think that it is important to develop teaching techniques that others can use. For example, I have developed various teaching aids, like inexpensive and compact demonstration devices, that can be used by science instructors at various levels, from high school to graduate college. My assigned teaching duties are at the graduate level, but I also teach several short courses to the scientific and engineering community at large.

My teaching assignments are the core graduate level Diffraction and Interferometry lecture class (OPTI505R) and the associated laboratory (OPTI505L). The three-credit-hour lecture class teaches basic concepts of interference, coherence, thin films, multiple-beam interference, various interferometers, the development of rigorous diffraction theory, Fresnel and Fraunhofer diffraction, the optical transfer function, holography and laser speckle. The one-credit-hour laboratory reinforces the lecture class by having the students perform experiments on topics from the lecture

class. These are concepts that I know well, because they are used in my research on a daily basis. I have developed a set of comprehensive notes for these classes, which I have contracted to submit for publication as a book late next year (2010). It is important for me to teach well, because teaching well is an excellent recruitment tool for hiring good graduate students.

As an example of my teaching aids, I have recently developed a simple demonstration system for explaining coherence in microscopy. The setup is made from ordinary ABS pipe (available from most any hardware store), surplus lenses, inexpensive LEDs, various sizes of metallic washers, and glue. Last year, I took the six copies of the setup to a professional conference ["Basics of Optical imaging in Photolithography, A Hands-On Course", Course 707, SPIE Microlithography 2005, San Jose, CA] for use in a first-of-its-kind 'hands on' short course. The response was overwhelming. I was told by one scientist that, "I have been simulating these effects in lithography for twenty years, and this is the first time I have ever seen the effects with my own eyes." He loved the course. The course organizers stated that the student evaluations ranked my course among the highest ever recorded (over a period of about ten years) for that conference. This demonstration system is also used in my laboratory class and is being applied to demonstrate other physical optics concepts in the near future.

In my research group, I emphasize cooperation and teamwork. The problems that we solve are difficult and often require a multiple-facetted approach, including custom fabrication of optical components, electronics, and mechanics. Although each student has their particular emphasis, they also work together, especially when constructing complicated experiments. This environment suits my students well, because they often easily find jobs in industry, where teamwork is essential.

***Service***

Within the College of Optical Sciences, I have served on the Admissions Committee, as well as, several terms on the Comprehensive Examination Committee. In addition, I have regularly served on oral exams.

My three-day computer generated holography (CGH) workshop, which is held yearly on the U of A campus, is a service to the industrial and scientific community. From the exposure generated by this workshop, I have increased interaction with other research groups. For example, I use the workshop's Maskless Lithography Tool (MLT) to provide components at no or nominal charge. I recently made a hologram to demonstrate the concept of saving the earth from global warming by directing sunlight away from the earth with an array of diffractive elements in L1 orbit. Some of the other elements I have provided include various slits and patterns for optical testing, holograms and imaging masks for optical trapping experiments, a diffractive vortex generator and spherical aberration compensators. Custom elements of this type are also used in my research group for various experiments that would otherwise be difficult to perform. The MLT is also used in one graduate class and the undergraduate laboratory classes.

The short courses that I teach are a service to the profession. I teach short courses covering microoptics for laser diodes and beam shaping, ultraviolet optics, imaging and coherence in

microscopy, solid immersion lenses, near-field optics, and physical optics. These courses are well attended, and I receive good reviews.

I have twice served as the conference chair of the topical meeting on optical data storage, which is the premier international conference in this field of research. I also serve as a program committee member for the International Symposium on Optical Memory (ISOM), which is a Japanese-centered conference dedicated to optical storage. I have also served on several other conference committees, including Laser Beam Shaping, Laser Diode Chip and Packaging Technologies, and Modeling and Control of Laser Beam Optics.

Other miscellaneous service duties I perform include serving in a leadership role for two optical data storage roadmap studies and one joint research project, organizing and running several technical workshops, serving as member of the editorial board for the *Journal of Microsystem Technologies: Micro and Nanosystems, Information Storage and Processing Systems*, and reviewing articles for publication in scholarly journals associated with my expertise.

Finally, I think that it is important to encourage children to follow a technical education. For example, I have given several interactive presentations to grade-school classes entitled "Color in our World," in which I demonstrate and explain the basics of color using an overhead projector, a prism, various filters, and other visual aids. I explain rainbows, sunsets, why the sky is blue, and lasers. It is a lot of fun to give these demonstrations, because the children are always enthusiastic.

***Summary***

In summary, some of my contributions to the College of Optical Sciences at the University of Arizona are as follows: I have graduated 16 Ph.D.s and 18 M.S. degrees. I publish regularly, with about 80 peer-reviewed articles and over 80 presentations with 44 of those being by invitation. I have a large research group (10-12) with a mixture of graduate and undergraduate students, one research professor and two technicians. I am well supported by industry and government, with average annual funding levels at about $1M. I enjoy teaching, and I am constantly developing ways to improve my teaching methods and to covey those methods to others. I am very active in international activities associated with my profession, like serving as conference chair and on committees.

My research, teaching and service efforts are synergistic, in that my teaching attracts high-quality students to my research group and prepares them for the work they will do. My service includes providing custom components for other research groups, which broadens my exposure and cooperative research arrangements. At the center of the research is the goal of maximizing information from ever smaller volumes using optical techniques.