

GARRET MODEL
BRIEF CURRICULUM VITAE

Address: Department of Electrical, Computer & Energy Engineering
University of Colorado at Boulder, 425 UCB (303) 492-1889
Boulder, CO 80309-0425 modelatcolorado.edu

Professional Experience:

2007-present **President**, Society for Scientific Exploration

1996-present **Professor**, University of Colorado at Boulder, Department of Electrical & Computer Engineering. Research in thin film electronic materials and optoelectronic devices.

2001-2005 **President & CEO**, Phiar Corporation. Venture-backed start-up developing high-speed metal-insulator components.

1989-1996 **Associate Professor**, University of Colorado at Boulder

1990-1994 **Program Manager / Thrust Leader**, Materials & Devices Program / Ferroelectric Liquid Crystals Thrust in NSF Engineering Research Center for Optoelectronic Computing Systems at the University of Colorado

1985-1989 **Assistant Professor**, University of Colorado at Boulder

1981-1985 **Staff Scientist**, SERA Solar Corporation. Carried out research on solar energy materials and devices.

1977-1981 **Research Assistant**, Division of Applied Sciences, Harvard University. Investigated amorphous semiconductors under Professor William Paul.

Education:

Ph.D.	Applied Physics	Harvard University	1981
M.S.	Applied Physics	Harvard University	1978
B.S.	Electrical Engineering	Stanford University	1976

with Distinction, Phi Beta Kappa, Tau Beta Pi

Honors / Professional Service:

Fellow of the Optical Society of America
Lifetime Achievement Award from CU Technology Transfer 2003
Inventor of the Year in the Physical Sciences, 2002, University of Colorado
CU Eta Kappa Nu Teaching Award for Outstanding Professor for 1997/1998
Program Chair: 2005 Annual Meeting of the Society for Scientific Exploration
Chair: 1995 OSA topical meeting on Spatial Light Modulators
Programming and/or Organizing Committees, Local Arrangements, Symposium
Organizer: 2008 Annual Meeting of the SSE, 1997 & 1999 OSA topical meetings on Spatial Light Modulators, 1994 OSA Meeting on Optically Addressed SLMs, 1992 MRS Spring Meeting on Amorphous Silicon Technology, Ferroelectric Liquid Crystal '91 Conference, 1988 IEEE Device Research Conference.

Member:

American Physical Society (APS)
Institute of Electrical & Electronics Engineers (IEEE), Senior Member
incl. Electron Device Society (EDS)
Society for Scientific Exploration

Peer-Reviewed Publications:

1. "A new development in the study of amorphous silicon hydrogen alloys: The story of O," M.A. Paesler, D.A. Anderson, E.C. Freeman, G. Moddel, and William Paul, *Phys. Rev. Lett.* *41*, 1492-1495 (1978).
2. "Importance of argon pressure in the preparation of rf-sputtered amorphous silicon-hydrogen alloys'," D.A. Anderson, G. Moddel, M.A. Paesler, and William Paul, *J. Vac. Sci. Technol.* *16*, 906-912 (1979).
3. "The effect of gap state density on the photoconductivity and photoluminescence of a-Si:H," D.A. Anderson, G. Moddel, R.W. Collins and W. Paul, *Solid State Commun.* *31*, 677-681 (1979).
4. "An assessment of the suitability of rf sputtered amorphous hydrogenated Si as a potential solar cell material," D.A. Anderson, G. Moddel and William Paul, *J. Elect. Mat.* *9*, 141-182 (1980).
5. "Characterization of high gap state densities in heavily hydrogenated a-Si," D.A. Anderson, G. Moddel and William Paul, *J. Non. Cryst. Solids* *35-36*, 345-350 (1980).
6. "Photoluminescence in sputtered amorphous Si:H alloys," R.W. Collins, M.A. Paesler, G. Moddel and William Paul, *J. Non. Cryst. Solids* *35-36*, 681-686 (1980).
7. "Gap states in hydrogenated amorphous silicon: a comparison of photoemission and photoconductivity results," B. von Roedern and G. Moddel, *Solid State Commun.* *35*, 467-471 (1980).
8. "Derivation of the low energy optical absorption spectra of a-Si:H from photoconductivity," G. Moddel, D.A. Anderson and William Paul, *Phys. Rev. B.* *22*, 1918-1925 (1980).
9. "Interpretation of the conductance and capacitance frequency dependence of hydrogenated amorphous silicon Schottky barrier diodes," P. Viktorovitch and G. Moddel, *J. Appl. Phys.* *51*, 4847-4854 (1980).
10. "Carrier collection efficiencies in a-Si:H Schottky barrier solar cells," P. Viktorovitch, G. Moddel, J. Blake and W. Paul, *J. Appl. Phys.* *52*, 6203-6207 (1981).
11. "Density of states study in sputtered a-Si:H: effect of impurities and H-related defects," P. Viktorovitch, G. Moddel, J. Blake, S. Oguz, and W. Paul, *J. de Physique* *42*, Colloquy 4, 455-458 (1981).
12. "Effect of oxygen on the optoelectronic properties of amorphous hydrogenated silicon," B.G. Yacobi, R.W. Collins, G. Moddel, P. Viktorovitch, and W. Paul, *Phys. Rev. B.* *24*, 5907-5912 (1981).
13. "Optical absorption, photoconductivity and photoluminescence of glow discharge amorphous $\text{Si}_{1-x}\text{Ge}_x$ alloys," B. von Roedern, D.K. Paul, J. Blake, R.W. Collins, G. Moddel, and W. Paul, *Phys. Rev. B.* *25*, 7678 (1982).
14. "Correlation of the photoelectrochemistry of the amorphous hydrogenated silicon/methanol interface with bulk semiconductor properties," C.M. Gronet, N.S. Lewis, G.W. Cogan, J.F. Gibbons, G.R. Moddel, and H. Weismann, *J. Electrochem. Soc.* *12*, 2873-2880 (1984).
15. "Design of efficient semiconductor/liquid junction interfaces in nonaqueous solvents," N.S. Lewis, R. Dominguez, C.M. Gronet, M. Lieber, M.D. Rosenblum, G.W. Cogan, J.F. Gibbons and G.R. Moddel, in *The Chemistry and Physics of Electrocatalysis*, J.D.E. McIntyre, M. J. Weaver and E.B. Yeager, editors (The Electrochemical Society, Princeton, 1984), pp. 460-479.
16. "The effect of deposition procedure on the conductivity of hydrogenated amorphous silicon multilayer films," G. Moddel, F.-C. Su and P. E. Vanier, *Materials Issues in Amorphous-Semiconductor Technology*, D. Adler, Y. Hamakawa and A. Madan, editors, Vol. 70 (Materials Research Society, Pittsburgh, 1986) pp. 423-428.

17. "Determination of the density of gap states in a-Si:H from studies of semiconductor/oxide multilayer films," R.B. Jones and G. Moddel, *Amorphous Silicon Semiconductors -- Pure and Hydrogenated*, A. Madan, M. Thompson, D. Adler and Y. Hamakawa, editors, Vol. 95 (Materials Research Society, Pittsburgh, 1987) pp. 393-398.
18. "Electro-optic applications of ferroelectric liquid crystals to optical computing," M.A. Handschy, K.M. Johnson, G. Moddel and L.A. Pagano-Staufffer, *Ferroelectrics* 85, 279-289 (1988).
19. "Optical addressing of high-speed spatial light modulators with a-Si:H," G. Moddel, C.T. Kuo, K.M. Johnson and W. Li, *Amorphous Silicon Technology*, Vol. 118 (Materials Research Society, Pittsburgh, 1988) pp. 405-410.
20. "Drift mobility in hydrogenated amorphous silicon from photoconductivity decay," G. Moddel, and P. Viktorovitch, *J. Appl. Phys.* 1, 205-209 (1989).
21. "Hydrogenated amorphous-silicon photosensor for optically addressed high-speed spatial light modulators," W. Li, R.A. Rice, G. Moddel, L.A. Pagano-Staufffer, and M.A. Handschy, *IEEE Trans. Electron Devices* 36, 2959-2964 (1989).
22. "Motivations for using ferroelectric liquid crystal spatial light modulators in neurocomputing," K.M. Johnson and G. Moddel, *Appl. Opt.*, 28, 4888-4899 (1989).
23. "High speed binary optically addressed spatial light modulators," G. Moddel, K.M. Johnson, W. Li, R. A. Rice L.A. Pagano-Staufffer, and M.A. Handschy, *Appl. Phys. Lett.* 55, 537-539 (1989).
24. "High-speed analog spatial light modulator using an a-Si:H photosensor and an electroclinic liquid crystal," I. Abdulhalim, G. Moddel, and K.M. Johnson, *Appl. Phys. Lett.* 55, 1603-1605 (1989).
25. "A three-terminal spatial light modulator optically addressed by an a-Si:H photosensor," R.A. Rice, G. Moddel, I. Abdulhalim, and C.M. Walker, *J. Non-Cryst. Solids*, 115, 96-98 (1989).
26. "Optically addressed electroclinic liquid crystal spatial light modulator with an a-Si:H photodiode," I. Abdulhalim, G. Moddel, K.M. Johnson, and C.M. Walker, *J. Non-Cryst. Solids*, 115, 162-164 (1989).
27. "Joint transform correlator using an amorphous silicon ferroelectric liquid crystal spatial light modulator," D.A. Jared, K.M. Johnson, and G. Moddel, *Optics Commun.*, 76, 97-102 (1990).
28. "Compensating for light soaking effects in optically addressed spatial light modulators incorporating a-Si:H photodiodes," C.M. Walker, B. Landreth, and G. Moddel, *Amorphous Silicon Technology*, Vol. 192, (Materials Research Society, Pittsburgh, 1990) pp. 467-472.
29. "High-speed, low-power optical phase conjugation using a hybrid amorphous silicon/ferroelectric-liquid-crystal device," K.M. Johnson, C.C. Mao, G. Moddel, M.A. Handschy, and K. Arnett, *Optics Lett.*, 15, 1114-1116 (1990).
30. "Amorphous silicon for optically addressed spatial light modulators," G. Moddel, Ch. 11 in *Amorphous and Microcrystalline Semiconductor Devices: Optoelectronic Devices*, J. Kanicki, editor, (Artech House, Norwood MA, 1991) pp. 369-412.
31. "Optical phase conjugation using optically addressed chiral smectic liquid crystal spatial light modulators," C.C. Mao, K.M. Johnson, and G. Moddel, *Ferroelectrics*, 114, 45-53 (1991).
32. "Switching behavior and electro-optic response due to the soft mode ferroelectric effect in chiral smectic A liquid crystals," I. Abdulhalim, and G. Moddel, *Liq. Cryst.*, 9, 493-518 (1991).

33. "Electrically and optically controlled light modulation and color switching using helix distortion of ferroelectric liquid crystals," I. Abdulhalim, and G. Moddel, *Mol. Cryst. Liq. Cryst.*, *200*, 79-101 (1991).
34. "Operating characteristics of an optically addressed spatial light modulator incorporating distorted helix ferroelectric liquid crystal," B. Landreth, C.C. Mao, and G. Moddel, *Jpn. J. Appl. Phys.*, *30*, 1400-1404 (1991).
35. "Response time of a-Si:H photodiodes for optically addressed spatial light modulators," G. Moddel, and P.B. Barbier, *Amorphous Silicon Technology - 1991*, Vol. 219 (Materials Research Society, Pittsburgh, 1991) pp. 155-165.
36. "Photovoltaic optically addressed spatial light modulator," C.C. Mao, B. Landreth, K.M. Johnson, and G. Moddel, *Ferroelectrics*, *122*, 455-466 (1991).
37. "Transient recovery of a-Si:H p-i-n photodiodes," P. Barbier, and G. Moddel, *J. Non-Cryst. Solids*, *137 & 138*, 1301-1304 (1991).
38. "Director-polarization reorientation via solitary waves in ferroelectric liquid crystals," I. Abdulhalim, G. Moddel, and N.A. Clark, *Appl. Phys. Lett.*, *60*, 551-553 (1992).
39. "Grey-scale response from optically addressed spatial light modulators incorporating surface stabilized ferroelectric liquid crystals," B. Landreth, and G. Moddel, *Appl. Optics*, *31*, 3937-3944 (1992).
40. "Hydrogenated amorphous silicon photodiodes for optical addressing of spatial light modulators," P.B. Barbier, and G. Moddel, *Appl. Optics*, *31*, 3898-3907 (1992).
41. "Dynamic thresholding with the three-terminal optically addressed spatial light modulator," R.A. Rice, P.J. Close, and G. Moddel, *Amorphous Silicon Technology - 1992*, (Materials Research Society, Pittsburgh, 1992), pp. 1087-1092.
42. "Integrating mode for an optically addressed spatial light modulator," A.M. Gabor, B. Landreth, and G. Moddel, *Appl. Optics*, *32*, 3064-3067 (1993).
43. "An asynchronous image subtracting optically addressed spatial light modulator," P.R. Barbier and G. Moddel, *Amorphous Silicon Technology - 1993*, Vol. 297 (Materials Research Society, Pittsburgh, 1993) pp. 993-998.
44. "Analysis of ions in ferroelectric liquid crystals from hysteresis curves," S. Perlmutter, D. Doroski, and G. Moddel, *Ferroelectrics*, *149*, 319-331 (1993).
45. "High-reflectivity patterned metal mirror used in an optically addressed spatial light modulator," Q.h. Wu, S.H. Perlmutter, R.A. Rice, and G. Moddel, *Opt. Engr.*, *33*, 946-950 (1994).
46. "Alignment layers for improved surface-stabilized ferroelectric liquid-crystal devices," D. Doroski, S. H. Perlmutter, and G. Moddel, *Appl. Optics*, *33*, 2608-2610 (1994).
47. "Thin-film photosensor design for liquid crystal spatial light modulators," P.R. Barbier, L. Wang, and G. Moddel, *Opt. Engr.*, *33*, 1322-1329 (1994).
48. "Soliton switching in ferroelectric liquid crystals and their transient electro-optic response," I. Abdulhalim, G. Moddel, and N. Clark, *J. Appl. Phys.*, *76*, 820-831 (1994).
49. "Effects of charge spreading on resolution of optically addressed spatial light modulators," L. Wang, and G. Moddel, *Optics Lett.*, *19*, 2033-2035 (1994).

50. "Ferroelectric liquid crystal spatial light modulators," G. Moddel, Chap. 6 in *Spatial Light Modulator Technology: Materials, Devices, and Applications*, U. Efron, editor, (Marcel Dekker, New York, 1995) pp. 287-359.
51. "Fringe visibility improvement using an asynchronous image-subtracting optically addressed spatial light modulator," J. P. Sharpe, P. R. Barbier, G. Moddel, and K. M. Johnson, *Appl. Optics*, *34*, 4013-4021 (1995).
52. "Resolution limits from charge transport in optically addressed spatial light modulators," L. Wang, and G. Moddel, *J. Appl. Physics*, *78*, 6923-6935 (1995).
53. "A model of size-dependent photoluminescence in amorphous silicon nanostructures: comparison with observations of porous silicon," M. J. Estes and G. Moddel, *Appl. Phys. Lett.*, *68*, 1814-1816 (1996).
54. "Characterization of the visible photoluminescence from anodized porous a-Si:H and a-Si:C:H thin films," M. J. Estes, L. R. Hirsch, S. Wichart, and G. Moddel, *Amorphous Silicon Technology - 1996*, M, Hack, E, A. Schiff, S, Wagner, R, Schropp, and A, Matsuda, ed., Vol. 420 (Materials Research Society, Pittsburgh, 1996) pp. 831-836.
55. "Degradation of liquid crystal device performance due to selective adsorption of ions," S. H. Perlmutter, D. Doroski, and G. Moddel, *Appl. Phys. Lett.*, *69*, 1182-1184 (1996).
56. "Luminescence from amorphous silicon nanostructures," M. J. Estes, and G. Moddel, *Phy. Rev. B* *54*, 14,633-14,642 (1996).
57. "Visible photoluminescence from porous a-Si:H and porous a-Si:C:H thin films," M. J. Estes, L. R. Hirsch, S. Wichart, G. Moddel, and D. L. Williamson, *J. Appl. Phys.*, *82*, 1832-1840 (1997).
58. "Fixed polarizer ellipsometry for simple and sensitive detection of thin films generated by specific molecular interactions: applications in immunoassays and DNA sequence detection," R. M. Ostroff, D. Maul, G. R. Bogart, S. Yang, J. Christian, D. Hopkins, K. Clark, B. Trotter, and G. Moddel, *Clinical Chem.*, *44*, 2031-2035 (1998).
59. "Fixed-polarizer ellipsometry: a simple technique to measure the thickness of very thin films," B. Trotter, G. Moddel, R. Ostroff, and G. R. Bogart, *Opt. Engr.*, *38*, 902-907 (1999).
60. "Fractional bandwidth normalization for optical spectra with application to the solar blackbody spectrum," G. Moddel, *Appl. Optics*, *40*, 413-416 (2001).

(On leave from University from 2001 to 2004 to start-up Phiar Corporation. For publications during this period see list of patents, below.)

61. "Entropy and subtle interactions," G. Moddel, *J. Scientific Exploration*, *18* (2), 293-306 (2004).
62. "Macroelectronics: Perspectives on Technology and Applications," R. Reuss, with G. Moddel, et al., *Proc. IEEE* *93* (7), 1239-1256 (2005).
63. "Entropy and information transmission in causation and retrocausation," G. Moddel, *Frontiers of Time, Retrocausation—Experiment and Theory*, D. P. Sheehan, editor, (American Institute of Physics, Melville, NY, 2006), pp. 62-74.
64. "Effect of Belief on Psi Performance," K. Walsh and G. Moddel, *J. Scientific Exploration*, *21* (3), 501-510 (2007).

Conference Presentations and Non-Peer-Reviewed Publications:

1. "Phototransport and its time decay in rf sputtered a-Si:H," G. Moddel and D.A. Anderson, *Bull. Am. Phys. Soc.* 24, 500 (1979).
2. "Density of states near the valence band edge of hydrogenated a-Si:H," B. von Roedern and G. Moddel, *Chelsea Amorphous and Liquid Semiconductor Meeting*, 1979.
3. "Sub-bandgap absorption in a-Si:H derived from photoconductivity measurements," G. Moddel, J. Blake, D.A. Anderson and W. Paul, *Bull. Am. Phys. Soc.* 25, 331 (1980).
4. "Gap state density determination from conductance and capacitance frequency dependence of a-Si:H Schottky solar cells," P. Viktorovitch and G. Moddel, *Bull. Am. Phys. Soc.* 25, 329 (1980).
5. "Comparison of a-Si:H produced by rf sputtering and glow discharge methods," G. Moddel, J. Blake, R.W. Collins, P. Viktorovitch, D.K. Paul, B. von Roedern and W. Paul, in *"Tetrahedrally Bonded Amorphous Semiconductors"*, Carefree, Arizona, AIP Conference Proceedings No. 73, edited by R.A. Street, D.K. Biegelsen, and J.C. Knights (American Institute of Physics, New York, 1981) pp.25-30.
6. "Evidence for an additional conductivity path in P-doped a-Si:H from Schottky barrier height and a photoconductivity temperature measurements," P. Viktorovitch, G. Moddel and W. Paul, *ibid.* pp. 186-191.
7. "Microstructure in a-GaAs:H alloys and its correlation with the electronic properties," D.K. Paul, J. Blake, G. Moddel and W. Paul, *Thin Film Technologies and Special Applications*, SPIE 346, 95-104 (1982).
8. "Photoaddressing of high speed liquid crystal spatial light modulators," G. Moddel, K.M. Johnson and M.A. Handschy, *Proc. SPIE* 754, 207-213 (1987).
9. "Use of semiconductor/oxide multilayer films to determine gap density of states in hydrogenated amorphous silicon," R.B. Jones and G. Moddel, *Industry-University, Advanced Materials Conference*, edited by J.G. Morse (Metallurgical Society, Warrendale, PA, 1987) p. 351.
10. "Optical logic gates using photoaddressed ferroelectric liquid crystals," K.M. Johnson, G. Moddel, S.A. Anderson, and L.A. Pagano-Stauffer, *OSA Tech. Dig.* 22, 55 (1987).
11. "Memory systems for optical computing," R.A. Schmidt and G. Moddel, *AIAA Computers in Aerospace VI Conference* (AIAA, Washington D.C., 1987), pp. 201-206.
12. "Design and performance of high-speed photoaddressed spatial light modulators," W. Li, C.T. Kuo, G. Moddel and K.M. Johnson, *Proc. SPIE* 936, 48-55 (1988).
13. "High speed optically addressed spatial light modulator," W. Li, C.T. Kuo, and G. Moddel, *IEEE Device Research Conf.*, June, 1988, and *IEEE Trans. Electron Devices* 35, 2447-2448 (1988).
14. "Optically addressed ferroelectric liquid crystal spatial light modulator," W. Li, C.T. Kuo, and G. Moddel, *OSA Meeting*, Santa Clara, CA Oct.-Nov. 1988.
15. "Hydrogenated amorphous silicon photosensor for optically addressed high speed spatial light modulators," C.T. Kuo, R.A. Rice, W. Li, and G. Moddel, *Int. Topical Conf. on Hydrogenated Amorphous Silicon Devices and Technology*, RC14189, Jerzy Kanicki, editor (IBM, New York, 1988), pp. 259-262.
16. "Recent advances and applications of ferroelectric liquid crystal spatial light modulators," K.M. Johnson, M.A. Handschy, and G. Moddel, *OSA Topical Mtg. on Spatial Light Modulators*, Lake Tahoe, June 1988, 8 WE2-1, 74 (1988).

17. "Hydrogenated amorphous silicon photosensor for optically-addressed spatial light modulators," R.A. Rice, W. Li, and G. Moddel, Advanced Materials Conference, Denver, March 6 - 9, 1989.
18. "An integrated optically switched directional coupler," P.R. Barbier, G. Moddel, S.T. Vohra, and A.R. Mickelson, Proceedings of the Advanced Materials Conference, Denver, March 6 - 9, 1989, pp. 453-462.
19. "High speed optically addressed spatial light modulator for optical computing," R.A. Rice, W. Li, and G. Moddel, Optical Computing Conference, Salt Lake City, February 27 - March 1, 1989, pp. 64-66.
20. "Advances in optical addressing of chiral smectic liquid crystal spatial light modulators," invited paper, G. Moddel, K.M. Johnson, I. Abdulhalim, and M.A. Handschy, Second International Symposium on Ferroelectric Liquid Crystals, Goteborg, Sweden, June, 1989.
21. "Low-power, high speed phase conjugation using optically addressed ferroelectric liquid crystal spatial light modulators," C.C. Mao, K. Arnett, K.M. Johnson, M.A. Handschy, and G. Moddel, poster, Second International Symposium on Ferroelectric Liquid Crystals, Goteborg, Sweden, June, 1989.
22. "A three-terminal spatial light modulator optically addressed by an a-Si:H photosensor," R.A. Rice, G. Moddel, I. Abdulhalim, and C.M. Walker, International Conference on Amorphous Semiconductor Technology, Raleigh, North Carolina, Aug., 1989.
23. "Optically addressed electroclinic spatial light modulator with an a-Si:H photodiode," I. Abdulhalim, G. Moddel, and K.M. Johnson, International Conference on Amorphous Semiconductor Technology, Raleigh, North Carolina, Aug., 1989.
24. "Joint transform correlator using an a-Si:H/ferroelectric liquid crystal spatial light modulator," D. Jared, K.M. Johnson, and G. Moddel, SPIE conference, San Diego, Aug., 1989.
25. "High speed, high resolution optically addressed spatial light modulator," L.A. Pagano-Stauffer, M.A. Handschy, and G. Moddel, SPIE conference, San Diego, Aug., 1989.
26. "Low-power, high speed optical phase conjugation using optically addressed spatial light modulator," C.C. Mao, K.M. Johnson, K. Arnett, M.A. Handschy, and G. Moddel, SPIE conference, San Diego, Aug., 1989.
27. "Analog response from binary spatial light modulators," B. Landreth and G. Moddel, Proc. SPIE 1296, 64-72 (1990).
28. "Analog optically addressed spatial light modulator with pseudocolor capability using helix distortion of ferroelectric liquid crystal," I. Abdulhalim, B. Landreth, and G. Moddel, Society for Information Display International Symposium, Las Vegas, May 15-17, 1990, *Digest of Technical Papers*, Vol. 21 (SID, California, 1990), p. 330-333.
29. "Optically addressed spatial light modulators for optical neural networks," invited, G. Moddel, Workshop on Optical Neural Networks, Jackson, Wyoming, Feb. 7-10, 1990.
30. "Compensating for light soaking effects in optically addressed spatial light modulators incorporating a-Si:H photodiodes," C.M. Walker, B. Landreth, and G. Moddel, Spring Meeting, Materials Research Society, San Francisco, CA, April 16-21, 1990.
31. "Recent advances in ferroelectric liquid crystal optically addressed spatial light modulators," invited paper, G. Moddel, Intl. Symp. on Application of Ferroelectrics, Am. Ceramic. Soc. Inc., Urbana-Champaign, June 6-8, 1990.
32. "Electrically and optically controlled light modulation and color switching using helix distortion of ferroelectric liquid crystals," I. Abdulhalim, and G. Moddel, 13th Intl. Liq. Cryst. Conf., Vancouver, July 22-27, 1990.

33. "Variable-sensitivity analog response from an optically-addressable spatial light modulator," B. Landreth, and G. Moddel, OSA Tech. Digest *14*, 109-112 (1990).
34. "Suitability of hydrogenated amorphous silicon photosensors for optically addressed spatial light modulators," P.R. Barbier, C.M. Walker, and G. Moddel, OSA Tech. Digest *14*, 47-50 (1990).
35. "Optically addressed spatial light modulators which incorporate an amorphous silicon photosensor," G. Moddel, OCSC Technical Report 90-28, 95 pages (1990).
36. "Custom-designed electro-optic components for optically implemented, multilayer neural networks," M.G. Robinson, K.M. Johnson, D. Jared, D. Doroski, S. Wichart, and G. Moddel, in *Optical Computing, 1991*, Technical Digest Series 6, (Optical Soc. of America, Washington, DC), pp. 84-87 (1991), presented at Optical Computing Conf., Salt Lake City, March 4-6, 1991.
37. "Response time of a-Si:H photosensors in optically addressed spatial light modulators," invited paper, G. Moddel, and P. Barbier, Spring Meeting, Materials Research Society, Anaheim, CA, April 29 - May 3, 1991.
38. "Comparison of optically addressed spatial light modulators incorporating distorted helix and surface stabilized ferroelectric liquid crystals," B. Landreth, C.C. Mao, and G. Moddel, poster, Third International Symposium on Ferroelectric Liquid Crystals, Boulder, June 24-28, 1991.
39. "Tradeoffs in the design and operation of optically addressed spatial light modulators," invited paper, S.H. Perlmutter, D. Doroski, B. Landreth, A.M. Gabor, P.R. Barbier, and G. Moddel, Proc. SPIE *1562* Devices for Optical Processing, 74-84 (1991).
40. "Transient recovery of a-Si:H p-i-n photodiodes," P. Barbier, and G. Moddel, Intl. Conf. on Amorphous Semiconductors, Garmish, Germany, Aug. 19-23, 1991.
41. "Photovoltaic optically addressed spatial light modulator," C.C. Mao, B. Landreth, K.M. Johnson, and G. Moddel, Optical Soc. of Am. Meeting, San Jose, Calif., Nov. 3-8, 1991.
42. "A circuit model for the optical and electric response of an FLC to an arbitrary driving voltage," R.A. Rice, and G. Moddel, Society for Information Display International Symposium, Boston, May 17-22, 1992, *Digest of Technical Papers*, Vol. 23 (SID, California, 1992), pp. 224-227.
43. "A method to obtain asymmetric bistable SSFLC cells," Z. Zou, N.A. Clark, and G. Moddel, 14th Intl. Liquid Crystal Conf., Pisa, Italy, June 21-26, 1992, (Taylor & Francis, London, 1992), p. 256.
44. "Kink-antikink pair production and annihilation in ferroelectric liquid crystals," I. Abdulhalim, G. Moddel, and N.A. Clark, 14th Intl. Liquid Crystal Conf., Pisa, Italy, June 21-26, 1992, (Taylor & Francis, London, 1992), p. 180.
45. "The influence of ion migration in ferroelectric liquid crystal on the performance of optically addressed spatial light modulators," S.H. Perlmutter, D. Doroski, P.R. Barbier, S. Wichart, and G. Moddel, 1992 OSA Annual Meeting, September 20-25, 1992, Albuquerque. OSA Annual Meeting Technical Digest 1992, Vol. 23 of the OSA Technical Digest Series (Optical Society of America, Washington, DC 1992) p. 82.
46. "Bottlenecks in developing optically addressed SLMs with desirable performance," invited paper, G. Burdge, S.H. Perlmutter, P. R. Barbier, D. Doroski, R. A. Rice, S. Wichart, and G. Moddel, Proc. SPIE *1911* (1993), pp. 226-235, SPIE 1993 Int. Symp. on Electronic Imaging: Science & Technology, January 31-February 4, 1993, San Jose, California.
47. "Structures and drive modes for optically addressed ferroelectric liquid crystal SLMs," invited paper, G. Moddel and P. R. Barbier, *Spatial Light Modulators and Applications*, March 15-17, 1993, Palm Springs,

California. Spatial Light Modulators and Applications, 1993 Technical Digest Series, Vol. 6 (OSA, Washington, DC, 1993), pp. 10-13.

48. "An asynchronous image subtracting optically addressed spatial light modulator," P.R. Barbier and G. Moddel, Spring Meeting, Materials Research Society, San Francisco, CA, April 12-16, 1993.
49. "Thin film photosensor design and fabrication for liquid crystal spatial light modulators," invited paper, P. R. Barbier, L. Wang, and G. Moddel, Proc. SPIE 2022, 98-110 (1993), SPIE 1993 Int. Symp. on Optics, Imaging, and Instrumentation, 11-16 July, 1993, San Diego, California.
50. "Ion drift and diffusion in ferroelectric liquid crystal devices," S. Perlmutter, D. Doroski, and G. Moddel, Fourth International Symposium on Ferroelectric Liquid Crystals, Tokyo, Sept. 28 - Oct. 1, 1993.
51. "Ferroelectric liquid crystal spatial light modulators," G. Moddel, OCSC Technical Report 94-07, 124 pages (1994).
52. "Particle image velocimetry fringe processing using an image subtracting, optically-addressed spatial light modulator," P. R. Barbier, J. Sharpe, K. Johnson, and G. Moddel, 1994 OSA Annual Meeting, October 2-7, Dallas. OSA Annual Meeting Technical Digest 1994, p. 124.
53. "Effects of charge spreading on resolution of optically-addressed spatial light modulators," L. Wang, and G. Moddel, 1994 OSA Annual Meeting, October 2-7, Dallas. OSA Annual Meeting Technical Digest 1994, p. 131.
54. "Wedge liquid crystal beam steering device," P. Searcy, T. Hahn, L. Wang, G. Moddel, J. Wootton, G. Waldman, and D. Holder, Spatial Light Modulators and Applications, March 14-17, 1995, Salt Lake City, Utah, Technical Digest Series, Vol. 9 (OSA, Washington, DC, 1995), pp. 93-96.
55. "Surface normal optical modulation in thin film silicon: is it feasible?," M. Estes and G. Moddel, Spatial Light Modulators and Applications, March 14-17, 1995, Salt Lake City, Utah, Technical Digest Series, Vol. 9 (OSA, Washington, DC, 1995), pp. 69-72.
56. "Liquid crystal device performance degradation through selective adsorption of ions by alignment layers," S. H. Perlmutter, D. Doroski, and G. Moddel, Spatial Light Modulators and Applications, March 14-17, 1995, Salt Lake City, Utah, Technical Digest Series, Vol. 9 (OSA, Washington, DC, 1995), pp. 148-151.
57. "MIS model of optically addressed spatial light modulators," L. Wang and G. Moddel, Spatial Light Modulators and Applications, March 14-17, 1995, Salt Lake City, Utah, Technical Digest Series, Vol. 9 (OSA, Washington, DC, 1995), pp. 53-56.
58. "Design of an optically addressed spatial light modulator sensitive to 1.55- μ m write light," L. Wang and G. Moddel, Spatial Light Modulators and Applications, March 14-17, 1995, Salt Lake City, Utah, Technical Digest Series, Vol. 9 (OSA, Washington, DC, 1995), pp. 89-92.
59. "Noise induced switching and stochastic resonance in an optically addressed spatial light modulator," J. P. Sharpe, D. C. O'Brien, and G. Moddel, Spatial Light Modulators and Applications, March 14-17, 1995, Salt Lake City, Utah, Technical Digest Series, Vol. 9 (OSA, Washington, DC, 1995), pp. 65-68.
60. "Ferroelectric liquid-crystal optically addressed spatial light modulators for binary phase holograms," D. C. O'Brien, and G. Moddel, Spatial Light Modulators and Applications, March 14-17, 1995, Salt Lake City, Utah, Technical Digest Series, Vol. 9 (OSA, Washington, DC, 1995), pp. 45-48.
61. "Characterization of the visible photoluminescence from anodized porous a-Si:H and a-Si:C:H thin films," M. J. Estes, L. R. Hirsch, S. Wichart, and G. Moddel, Spring Meeting, Materials Research Society, San Francisco, CA, April 8-12, 1996, paper A15.37.

62. "Reducing the pixel density required for three-dimensional wavefront-modulating and two-dimensional displays," invited paper, G. Moddel, W. T. Cathey, and C. Boggs, SPIE 3015 , 142-149, (1997), Optoelectronics '97, Integrated Devices & Applications, 8-14 February, 1997, San Jose, California.
63. "Spatial light modulators: processing light in real time," P. R. Barbier and G. Moddel, invited paper, Optics & Photonics News 8, 16 - 21 (1997).
64. "Development of an infrared optically addressed spatial light modulator," B. Eliasson, and G. Moddel, Spatial Light Modulators, March 17-21, 1997, Incline Village, Technical Digest (OSA, Washington, DC, 1997), pp.84-86.
65. "Fixed polarizer ellipsometry: a simple, sensitive method for detection of thin films generated by specific molecular interactions," R. Ostroff, G. Bogart, D. Maul, B. Trotter, and G. Moddel, Oak Ridge Conference, Raleigh, North Carolina, April 23-24, 1998.
66. "Optically addressed SLM incorporating a CuInGaSe₂/a-Si:H heterojunction," B. Eliasson, G. Moddel, T. Hughes-Lampros, and W.N. Shafarman, Spatial Light Modulators, April 12 - 14, 1999, Snowmass Village, Technical Digest (OSA, Washington, DC, 1999), pp. 97-99.
67. "Organic photosensors for ferroelectric liquid crystal spatial light modulators," S. Dickey, B. Eliasson, and G. Moddel, Organic Thin Films for Photonics Applications Topical Meeting, Santa Clara, CA, Sept. 24-26, 1999, Technical Digest (OSA, Washington, DC, 1999), pp.147-149.
68. "Retrocausation and entropy," G. Moddel, Annual Meeting of the Society for Scientific Exploration, June 12, 2003, Kalispell, Montana.
69. "Nature's selection principles in subtle interactions: modeling intention," G. Moddel, Annual Meeting of the Society for Scientific Exploration, May 22, 2004, Las Vegas, Nevada.
70. "Detectors at the Intersection of Photons and Electromagnetic Fields or, Where Einstein Meets Maxwell," invited paper, B. Eliasson and G. Moddel, Spring Meeting of the Materials Research Society, San Francisco, March 28-April 1, 2005.
71. "Sizing up psi in a university classroom: exploration, acceptance & skepticism," G. Moddel, Annual Meeting of the Society for Scientific Exploration, May 19-21, 2005, Gainesville, Florida.
72. "Modeling Intention," G. Moddel, late paper, Parapsychological Association Convention 2005, August 11-15, 2005, Institute of Noetic Sciences, Petaluma, California.
73. "Metal-Insulator Electronics for 60 GHz and Beyond," Garret Moddel, Invited Presentation, 41st IEEE802.15 WPAN Meeting, March 5-10, 2006, Denver, Colorado.
74. "Low cost, easily integrated, CMOS-compatible metal-insulator THz systems," Garret Moddel, presented at 4th Annual Terahertz Systems Conference, American Institute of Engineers, May 15-16, 2006, Washington, DC.
75. "Experimenter effect in remote staring," E. Hedman, T. Mangin, and G. Moddel, Annual Meeting of the Society for Scientific Exploration, June 7-10, 2006, Orem, Utah.
76. "Puzzle test of morphic resonance," W. Dowling and G. Moddel, Annual Meeting of the Society for Scientific Exploration, June 7-10, 2006, Orem, Utah.
77. "Effect of subject bias on psi: self-fulfilling prophecies," K. Walsh and G. Moddel, Annual Meeting of the Society for Scientific Exploration, June 7-10, 2006, Orem, Utah.
78. "Constraints on retrocausation due to entropy and information," G. Moddel, Invited talk, Symposium on

Frontiers of Time: Retrocausation: Experiment and Theory, 87th Annual Meeting of American Association for the Advancement of Science, Pacific Division, University of San Diego, San Diego, CA, June 20-22, 2006.

79. "A very simple test for psi: a pilot study," G. Moddel, and K. Walsh, Annual Meeting of the Society for Scientific Exploration, May 31-June 2, 2007, East Lansing, Michigan, 2007.
80. "Metal-insulator high-frequency components for detector focal-plane arrays and wireless communication," G. Moddel, A. Rentschler, B. Eliasson and R. Pauley, Nanoelectronic Devices for Defense & Security Conference, June 18-21, Crystal City, Virginia.
81. "Simple Test for the Effects of Intention on a Random Physical Process at the Quantum Level", G. Moddel, invited talk, Meeting of Minds Conference, University of British Columbia, Vancouver, July 15-July 16, 2007.
82. "Retrocausation: Is it compatible with known physics," G. Moddel, Annual Meeting of the Society for Scientific Exploration, June 25 - 28, 2008, Boulder, Colorado, 2008.
83. "Something from nothing: An evaluation of vacuum Energy extraction methods," G. Moddel, to be presented at the Annual Meeting of the Society for Scientific Exploration, May 28-30, Charlottesville, Virginia, 2009.

U.S. Patents:

1. "Pulse anneal method for solar cell", G. Moddel and J.F. Gibbons, U.S. #4,539,431, issued 1984.
2. "Electrically isolated semiconductor integrated photodiode circuits and method", G. Moddel, L. Christel and J.F. Gibbons, U.S. #4,612,408, issued 1986.
3. "Optically addressed spatial light modulators," G. Moddel, and K.M. Johnson, U.S. #4,941,735, issued 1990.
4. "Self-powered optically addressed spatial light modulator," G. Moddel, U.S. #5,177,628, issued 1993.
5. "Optically addressed spatial light modulator," G. Moddel and M.A. Handschy, U.S. #5,178,445, issued 1993.
6. "Devices for detection of an analyte based upon light interference," G.R. Bogart, G. Moddel, D. M. Maul, and J. B. Etter, U.S. #5,468,606, issued 1995.
7. "Devices and methods for detection of an analyte based upon light interference," G. R. Bogart, G. Moddel, D. M. Maul, and J. B. Etter, U.S. #5,482,830, issued 1996.
8. "Methods for detection of an analyte," G. R. Bogart, G. R. Moddel, D. M. Maul, J. B. Etter, and M. Crosby, U.S. #5,541,057, issued 1996.
9. "Silicon quantum dot laser," J.I. Pankove, G. Moddel, and K. Douglas, U.S. #5,559,822, issued 1996.
10. "Electro-optic wedge structure for beam steering and method of manufacture," G. Moddel, J. R. Wootton, G. Waldman, and D. L. Holder, U.S. #5,615,029, issued 1997.
11. "Silicon quantum dot laser," J.I. Pankove, G. Moddel, and K. Douglas, and U.S. #5,703,896, issued 1997.
12. "Methods for detection of gram negative bacteria," G.R. Bogart, G. Moddel, D. M. Maul, J. B. Etter, M. Crosby, U.S. #5,869,272, issued 1999.
13. "Liquid crystal eyewear with two identical guest host subcells and tilted homeotropic alignment," G. Moddel and D. Doroski, U.S. #5,943,104, issued 1999.

14. "Display having gradient response pixels," G. Moddel, U.S. #5,952,988, issued 1999.
15. "Metal-oxide electron tunneling device for solar energy conversion," B. J. Eliasson, and G. Moddel, U.S. #6,534,784, issued 2003.
16. "High speed electron tunneling device and applications," G. Moddel, and B. J. Eliasson, U.S. # 6,563,185, issued 2003.
17. "Device integrated antenna for use in resonant and non-resonant modes and method," M. D. Weiss, B. J. Eliasson, and G. Moddel, U.S. #6,664,562, issued 2003.
18. "High speed electron tunneling device and applications," G. Moddel, and B. J. Eliasson, U.S. #6,756,649, issued 2004.
19. "Light modulating eyewear assembly," G. Moddel, and S. C. Shear, U.S. #6,760,080, issued 2004.
20. "Method for fabricating a metal-oxide electron tunneling device for solar energy conversion," B. J. Eliasson, and G. Moddel, U.S. #6, 762,071, issued 2004.
21. "Terahertz device integrated antenna for use in resonant and non-resonant modes and method," Manoja D. Weiss, Blake J. Eliasson, and Garret Moddel, U.S. patent #6,835,949, issued 2004.
22. "Terahertz interconnect system and applications," Michael J. Estes, and Garret Moddel, U.S. patent #6,967,347, issued 2005.
23. "Surface plasmon devices," Michael J. Estes, and Garret Moddel, U.S. patent #7,010,183, issued 2006.
24. "High speed electron tunneling devices," G. Moddel, and B. J. Eliasson, U.S. #7,105,852, issued 2006.
25. "Interconnected high speed electron tunneling devices," M. Estes, and G. Moddel, U.S. #7,126,151, issued 2006.
26. "Surface plasmon devices," Michael J. Estes and Garret Moddel, U.S. Patent No. 7,177,515, issued 2007.
27. "Quantum vacuum energy extraction ," Bernard Haisch and Garret Moddel, U.S. Patent No. 7,379,286, issued 2008.
28. "Surface plasmon devices," Michael J. Estes and Garret Moddel, U.S. Patent No. 7,418,179, issued 2008.

Plus many foreign patents.