

YUZURU TAKASHIMA Ph.D.

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EDUCATION

Ph.D., Electrical Engineering, Stanford University, Stanford, CA. 04/2007
▪ Dissertation: Optical system designs for page-based and bit-based holographic data storage systems.
M.S., Electrical Engineering, Stanford University, Stanford, CA. 04/2003
B.S., Physics, Kyoto University, Kyoto, Japan. 03/1990

MAJOR RESEARCH FIELDS

- **Lidar:**
 - Laser beam steering device, MEMS-LiDAR, Automotive LiDAR, Single-chip LiDAR
- **AR Display:**
 - Image steering and Foveation, Giga-pixel display, Multiplexed Display, Near-to-eye display, Multi-perspective 3D display, On-chip 3D display, Holographic Display
- **Information optics:**
 - Optical and holographic data storage
- **Optical system design engineering:**
 - THz space optics, Camera optics
- **Optical engineering in general:**
 - Digital Micromirror Device, MEMS phase light modulators, Computer Generated Holograms, Metrology, Photonics device design and modeling

EMPLOYMENT

Professor, University of Arizona, Tucson, AZ 2022-Current
Associate Professor, University of Arizona, Tucson, AZ 2011-2022
Visiting Professor, Utsunomiya University, Utsunomiya, Japan 11/2014-03/2015
Engineering Research Associate, Stanford University, Stanford, CA 2010
Postdoctoral Scholar, Stanford University, Stanford, CA 2007-2010
Optical Engineer, Solyndra Inc., Santa Clara, CA 2006
Research Assistant, Stanford University, Stanford, CA 2000-2007
Research Specialist, Toshiba Manufacturing Engineering Research Center, Yokohama, JAPAN 1990-2000

AWARDS

Certificate of Achievement, The Center for Biomedical Imaging at Stanford April 22, 2010

PROFESSIONAL AFFILIATIONS:

Senior Member, SPIE
Senior Member, OSA
Member of Optical Design Group/JSAP

SERVICE / OUTREACH

Professional Societies

- Optical Society of America (OSA): **Senior Member**, 2017-
- SPIE: **Senior Member**, 2017-
- Optical Design Group Japan (Japanese Society of Applied Physics): Member

National / International Outreach

- NSF Center for Integrated Access Network, Pre-college Director 2013
- Program Manager: 2012, 2014, 2016, 2017 Optical Design and Measurement Tokyo Short Course Program in Japan

2012-Current

University Committee: N/A

Departmental Committee:

- College of Engineering Advisory Committee

2018-Current

College Committee

- Member: Optical Engineering Faculty Search Committee 2021
- Member: Undergraduate Curriculum Committee 2017-20, 2014, 2022
- Member: T&P Review Committee 2020
- Member: Academic Program Review Committee 2017, 2013
- Member: Graduation Admission Committee 2016
- Member: Prelim Committee 2016
- Chair: Scholarship Committee 2015
- Member: Colloquium Committee 2013
- Member: Prelim Committee 2012
- Member: Academic Program Review Committee 2017, 2012

1. **Local Organizing Committee Chair:** ODF 2024: International Conference on Optics-photonics Design and Fabrication 2024, ODF 2024, (2022-2024).
2. Program Committee, International Workshop on Holography and Related Technologies, IWH2022, (2022)
3. Member of selection committee, The best optics paper award 2022, Optical Society of Japan (2022)
4. **Subcommittee Chair of FiO 1** Fabrication, Design and Instrumentation of the OSA Frontiers in Optics (FiO) 2022 meeting (2022)
5. **Guest Editor**, Special issue “MEMS lidar”, Journal of Optical Microsystems, SPIE, (2021-2022)
6. **General Co-Chair**, Optical Data Storage (ODS), Industrial Optical Devices and Systems (iODS) 2012, 2017-Current
7. Member of Technical Program Committee, OSA Frontiers in Optics (2021)
8. Member of Technical Program Committee, International Conference on Optoelectronic and Microelectronic Technology and Application (OMTA 2020)
9. Member of Program Committee, Optics-photonics Design and Fabrication (ODF) Japan 2014-Current.
10. Member of Program Committee, Current Development in Lens Design and Optical Engineering, SPIE Optics and Photonics 2010-Current.
11. Member of Program Committee, Optical Memories for Big Data Storage, The International Symposium on Optoelectronic Technology and Application (OTA 2016) 2016-2019.
12. Member of Program Committee, Optical Data Storage (ODS) 2014-2017
13. **General Co-Chair**, OSA Topical Meeting on Optical Data Storage 2012 (Tucson AZ, USA).
14. Session Chair, OSA Topical Meeting on Optical Data Storage 2011 (Kauai HI, USA).
15. Member of Program Committee, OSA Topical Meeting on Optical Data Storage 2011.
16. Early Career Observer in Planning Committee Meeting for Optomechanics; Optical Design; Optical Manufacturing and Testing; Advanced Metrology; Optical Systems Engineering, SPIE Optics and Photonics 2009.
17. Member of Committee, Research Group on Next Generation Image Media in Optoelectronic Industry and Technology Development Association Japan (1999-2000)
18. Reviewer, Optical Society of America: Applied Optics, Journal of Optical Society of America and Optics Express.
19. Stanford Freshman and Undergraduate Advising as a Pre-major Advisor (2009-2011).

PUBLICATIONS

Refereed Journals:

In preparation

- Wavelength multiplexed AR display engine
- VHG FOV demultiplexer for wavelength multiplexed AR display engine
- Diffractive FOV expansion and image steering for AR optical engine
- Fabrication of prism array for diffractive FOV expansion and image steering for AR optical engine
- Optical design of diffractive FOV expansion and image steering for AR optical engine

- Sub wavelength equivalent and side-lobe free PLM-DMD hybrid beam steering (Optics Express)
- Diffractive expansion of FOV for DMD-MPPC lidar
- Temperature dependence of DMD (OSA Continuum)
- Environmental effect and slowing down DMD (OSA Continuum)

In internal revision

1. QIAN HUANG, ZHIPENG DONG, YUZURU TAKASHIMA, TIMOTHY, J. SCHULZ AND DAVID J. BRADY1,*Scatter Ptycography, Submitted to Optica. (2022)

Submitted

In revision

Accepted

Published

2. Tang, Chin-I, Xianyue Deng, and Yuzuru Takashima. 2022. "Real-Time CGH Generation by CUDA-OpenGL Interoperability for Adaptive Beam Steering with a MEMS Phase SLM" *Micromachines* 13, no. 9: 1527. <https://doi.org/10.3390/mi13091527> (2022).
3. Eunmo Kang, Heejoo Choi, Brandon Hellman, Joshua Rodriguez, Braden Smith, Xianyue Deng, Parker Liu, Ted Liang-Tai Lee, Eric Evans, Yifan Hong, Jiafan Guan, Chuan Luo, Yuzuru Takashima, "Solid-state lidar by hybrid optical architecture with Digital Micromirror Devices and a 2D-MEMS mirror", *Micromachines* (2022).
4. Siddhartha Sirsi, Henry Quach, Hyukmo Kang, Pete Morken, Art Palisoc, Yuzuru Takashima, Christian d'Aubigny, Aman Chandra, Marcos Esparza, Karlene Karrfalt, Heejoo Choi, Christopher Walker, Daewook Kim, "Methodology of testing and modeling for unprecedented large scale inflatable optics: primary antenna for Orbiting Astronomical Satellite for Investigating Stellar Systems (OASIS)" *Optics Express* (2022).
5. Jiafan Guan, Zhipeng Dong, Xianyue Deng, and Yuzuru Takashima, "Optical enhancement of diffraction efficiency of Texas Instruments Phase Light Modulator for beam steering in near infrared", *Micromachines* 2022, 13(9), 1393; <https://doi.org/10.3390/mi13091393> (registering DOI) - 26 Aug 2022 (2022). https://www.mdpi.com/journal/micromachines/special_issues/Beam_Steering_Arrays
6. Siddhartha Sirsi, Yuzuru Takashima, Arthur Palisoc, Heejoo Choi, Jonathan W. Arenberg, Daewook Kim, Christopher Walker, "Optical design of the Orbiting Astronomical Satellite for Investigating Stellar Systems," *J. Astron. Telesc. Instrum. Syst.* 8(3), 034002 (2022), doi: 10.1117/1.JATIS.8.3.034002.
7. Xianyue Deng, Chin-I Tang, Chuan Luo, Yuzuru Takashima, "Diffraction efficiency of MEMS phase light modulator, TI-PLM, for quasi continuous and multi-point beam steering" *Micromachines*, June 14 2022 (2022) <https://www.mdpi.com/2072-666X/13/6/966>, https://www.mdpi.com/journal/micromachines/special_issues/Beam_Steering_Arrays
8. Yuzuru Takashima "Special Section Guest Editorial: MEMS Lidar," *Journal of Optical Microsystems* 2(1), 011001 (16 March 2022). <https://doi.org/10.1117/1.JOM.2.1.011001> (2022)
9. Wang, Chengyu, Minghao Hu, Yuzuru Takashima, Timothy J Schulz, and David J Brady. "Snapshot Ptycography on Array Cameras." *Optics Express* 30.2 (2022): 2585-598. Web.

10. Quach, H.; Kang, H.; Sirsi, S.; Chandra, A.; Choi, H.; Esparza, M.; Karrfalt, K.; Berkson, J.; Takashima, Y.; Palisoc, A.; Arenberg, J.W.; Walker, C.; d'Aubigny, C.D.; Kim, D. Surface Measurement of a Large Inflatable Reflector in Cryogenic Vacuum. *Photonics* (2022), 9, 1. <https://doi.org/10.3390/photonics9010001>
11. Yuzuru Takashima and Brandon Hellman, "Review paper: imaging Lidar by Digital Micromirror Device", Special Section: *Invited Review Paper*, Optical Review (Sep. 6, 2020). DOI: 10.1007/s10043-020-00620-w, [Review paper: imaging lidar by digital micromirror device | SpringerLink](#)
12. B. Hellman, Ted Lee, Y. Takashima, "Gigapixel and 1440-perspective extended-angle display by megapixel MEMS-SLM", *Optics Letter* (July 22, 2020).
13. Joshua Rodriguez, Braden Smith, Brandon Hellman, and Yuzuru Takashima, "Fast laser beam steering into multiple diffraction orders with a single digital micromirror device for time-of-flight lidar," *Appl. Opt.* 59, G239-G248 (2020). <https://opg.optica.org/ao/fulltext.cfm?uri=ao-59-22-G239&id=433575>
14. Brandon Hellman, Chuan Luo, Guanghao Chen, Joshua Rodriguez, Charles Perkins, Jae-Hyeung Park, and Yuzuru Takashima, "Single-chip holographic beam steering for lidar by a digital micromirror device with angular and spatial hybrid multiplexing," *Opt. Express* 28, 21993-22011 (2020), <https://opg.optica.org/oe/fulltext.cfm?uri=oe-28-15-21993&id=433368>
15. Yeon-Gyeong Ju, Myeong-Ho Choi, Pengyu Liu, Brandon Hellman, Ted L. Lee, Yuzuru Takashima, and Jae-Hyeung Park, "Occlusion-capable optical-see-through near-eye display using a single digital micromirror device," *Opt. Lett.* 45, 3361-3364 (2020)
16. Yoshitaka Takekawa, Yuzuru Takashima, and Yasuhiro Takaki, "Holographic display having a wide viewing zone using a MEMS SLM without pixel pitch reduction," *Opt. Express* 28, 7392-7407 (2020). <https://doi.org/10.1364/OE.385645>
17. Brandon Hellman, Adley Gin, Braden Smith, Young-Sik Kim, Guanghao Chen, Paul Winkler, Phillip McCann, and Yuzuru Takashima, "Wide-angle MEMS-based imaging lidar by decoupled scan axes," *Appl. Opt.* 59, 28-37 (2020), <https://opg.optica.org/ao/fulltext.cfm?uri=ao-59-1-28&id=424679>
18. Brandon Hellman and Yuzuru Takashima, "Angular and spatial light modulation by single digital micromirror device for multi-image output and nearly-doubled étendue," *Opt. Express* 27, 21477-21496 (2019).
19. T. Nakamura and Y. Takashima, "Design of discretely depth-varying holographic grating for image guide based see-through and near-to-eye displays," *Opt. Express* 26, 26520-26533 (2018). <https://doi.org/10.1364/OE.26.026520>
20. A. Özdemir, N. Yılmaz, S. Alboon, Y. Takashima, and H. Kurt, "Analysis of the focusing crosstalk effects of broadband all-dielectric planar metasurface microlens arrays for ultra-compact optical device applications," *OSA Continuum* 1, 506-520 (2018). <https://doi.org/10.1364/OSAC.1.000506>
21. Kazuyoshi Yamazaki and Yuzuru Takashima, "Time Differential Phase Detection Method for Robust Industrial Non-destructive Inspections" *Japanese Journal of Applied Physics* (2018) <https://doi.org/10.7567/JJAP.57.09SB04>
22. Sungwon Choi, Yuzuru Takashima, and Sung-Wook Min, "Improvement of fill factor in pinhole-type integral imaging display using a retroreflector," *Opt. Express* 25, 33078-33087 (2017).
23. Y. Nakamura, T. Hoshizawa, and Y. Takashima, "Coherent Scattering Noise Reduction Method with Wavelength Diversity Detection for Holographic Data Storage System", *Jpn. J. Appl. Phys.* 56 09NA08 (2017), <http://iopscience.iop.org/article/10.7567/JJAP.56.09NA08/meta>
24. Chris Summitt, Sunglin Wang, Soha Namnabat, Lee Johnson, Tom Milster, and Yuzuru Takashima, "Fast fabrication of polymer out-of-plane optical coupler by gray-scale lithography," *Opt. Express* 25, 17960-17970 (2017) <https://doi.org/10.1364/OE.25.017960>
25. Braden Smith, Brandon Hellman, Adley Gin, Alonzo Espinoza and Yuzuru Takashima, "Single Chip Lidar with Discrete Beam Steering by Digital Micromirror Device", *Optics Express*, Vol. 25, Issue 13, pp. 14732-14745 (2017) <https://doi.org/10.1364/OE.25.014732>, <https://opg.optica.org/oe/fulltext.cfm?uri=oe-25-13-14732&id=368161>
26. Aytekin Ozdemir, Zeki Hayran, Yuzuru Takashima, and Hamza Kurt, "Polarization independent high transmission large numerical aperture laser beam focusing and deflection by dielectric Huygens' metasurfaces", *Optics Communications*, Volume 401, 15 October 2017, Pages 46-53 (<https://doi.org/10.1016/j.optcom.2017.05.031>)

27. J. Wilde, J. Goodman, Y. Eldar, and Y. Takashima, "Coherent super resolution imaging via grating-based illumination" Appl. Opt. Vol 56, Issue 1, pp. A79-A88 (<https://doi.org/10.1364/AO.56.000A79>) (2017).
28. B. Miller and Y. Takashima, "Cavity-enhanced eigenmode and angular hybrid multiplexing in holographic data storage systems," Opt. Express 24 (26), 29465-29476 (2016). <https://doi.org/10.1364/OE.24.029465>
29. Toshiki Ishii, Ken-ichi Shimada, Taku Hoshizawa and Yuzuru Takashima, "Modeling and analysis of vibration effects on signal quality for angular multiplexed holographic data storage" ", Jpn. J. Appl. Phys. 55, Number 9S, <http://iopscience.iop.org/issue/1347-4065/55/9S> Special Issue on Optical Memories (2016).
30. B. Miller and Y. Takashima, "Cavity techniques for holographic data storage recording," Opt. Express 24, 6300-6317 (2016).
31. Toshiki Ishii, Ken-ichi Shimada, Taku Hoshizawa, and Yuzuru Takashima, "Analysis of vibration effects on holographic data storage system", Jpn. J. Appl. Phys. 54 09MA04 doi:10.7567/JJAP.54.09MA04 Special Issue on Optical Memories (2015).
32. Ken-ichi Shimada, Toshiki Ishii, Taku Hoshizawa, and Yuzuru Takashima, " New optical modeling and optical compensation for mechanical instabilities on holographic data storage system using time averaged holography", Jpn. J. Appl. Phys. 54 09MA01 doi:10.7567/JJAP.54.09MA01 Special Issue on Optical Memories (2015).
33. Ming Li, Milorad Cvijetic, Yuzuru Takashima, Xiaole Sun, and Zhongyuan Yu, "Evaluation of channel capacities of OAM-based FSO link with real-time wavefront correction by adaptive optics" Optics Express, Vol. 22, Issue 25, pp. 31337-31346 (2014).
34. Y. Takashima. "Optical design in high density and high capacity multi-layer data storage system" Front. Optoelectron. 7, Issue 4, pp 425-436 (2014).
35. Y. Cheng, Y. Takashima, P. Hansen, J. B. Leen, Y. Yuen, and L. Hesselink. "Resonant C-shaped Aperture Nano-tip". Optics Express, 19: 5077-5085 (2011).
36. X. Shi, V. Ostroverkhov, B. Lawrence, E. Boden, Z. Ren, Y. Takashima, F. Ross. "Micro-Holographic Data Storage: Materials and Systems," Review of Laser Engineering, 38: 349-355, (2010).
37. *Y. Takashima and L. Hesselink. "Design and tolerance of NA 0.8 objective lenses for page-based holographic data storage systems". Jap. J. Appl. Phys., 48:03A004-1, (2009).
38. *Y. Takashima and L. Hesselink. "Media tilt tolerance of bit-based and page-based holographic storage systems". Opt. Lett., 31:1513-1515, (2006).
39. *S. S. Orlov, W. Phillips, E. Bjornson, Y. Takashima, P. Sundaram, L. Hesselink, R. Okas, D. Kwan, R. Snyder. "High-transfer-rate high-capacity holographic disk data-storage system," Appl. Opt., 43:4902, (2004).

Invited Articles

1. Yuzuru Takashima, "Preface: Enablers for DX (Digital Transformation), can AR display and automotive lidar be next optical data storage industry?," the 71st symposium of Optical Design Research group, Optical Society of Japan (Oct 15, 2021).

Conference Proceeding Articles

Invited and Awarded Articles:

2. Yuzuru Takashima, "AR and Lidar Applications Enabled by Beam and Image Steering by MEMS SLM" *Invited* for SPIE Photonics West 2023 Practical Holography XXXVII (2023)
3. Yuzuru Takashima, "Unlocking the potential of TI-DMD for AR display and lidar engine: Image and beam steering by MEMS SLMs" *Invited* for ICO-OWLS-2022 (2022)
4. Yuzuru Takashima, "Beam and Image Steering for Mobility Photonics Application of MEMS SLM for solid-state lidar and AR display" " *Invited* for the 2nd Mobility Photonics Research Meeting, Optoelectronics Industry and Technology Development Association (OITDA) Japan, July 20, 2022. (<http://www.oitda.or.jp/main/study/am/22AM-2/22am-2-prg.pdf>)
5. Yuzuru Takashima, "Angular and Spatial Light Modulation for Lidar and AR display", *invited for* ISOM 2022 (Sapporo Japan, 2022) [CLEO-PR 2022 / ISOM'22 / ODF'22 \(cleopr2022.org\)](https://www.cleo-pr2022.org/)

6. Daewook Kim, Jonathan W. Arenberg, Yuzuru Takashima, Art Palisoc, Christopher Walker, "SALTUS Probe Class Space Mission: Enabled by 20-m Inflatable Mirror", *invited for CLEO (2022)*.
7. Zhipeng Dong, Eunmo Kang, Jiafan Guan, Xianyue Deng, Chuan Luo, and Yuzuru Takashima "Optical enhancement of diffraction efficiency of Texas Instrument Phase Light Modulator by Talbot imaging-based pixel matching for infrared lidar beam steering", **Best Student Paper Award**, SPIE Photonics West Emerging Digital Micromirror Device Based Systems and Applications XIV (2022). <https://www.spiedigitallibrary.org/conference-proceedings-of-spie/12014/120140A/Optical-enhancement-of-diffraction-efficiency-of-Texas-Instruments-phase-light/10.1117/12.2610490.full>
8. Daewook Kim, Yuzuru Takashima, Jonathan W. Arenberg, Arthur L. Palisoc, Marcos Esparza, Henry Quach, Hyukmo Kang, Siddhartha Sirsi, Aman Chandra, Karlene Karfalt, Pete Morken, Heejoo Choi, Christian Drouet d'Aubigny, and Christopher Walker, "Inflatable Space Terahertz Optics Technology", *Invited for XLIV OSI Symposium on Frontiers in Optics and Photonics 2021 (FOP21)* Indian Institute of Technology, Optical Society of India. September 24-27 (2021)
9. Y. Takashima, "Time multiplexed high throughput display with Digital Micromirror Device", *Invited for SPIE Photonics West OPTO 2021, OE702 Advances in Display Technologies XI*, San Francisco, CA (2021).
10. B. Miller, G. Chen, Y. Nakamura, K. Yamazaki, T. Ishii, K. Shimada, and Y. Takashima, "Phase, Wavelength, and Cavity Techniques for Holographic Data Storage Systems", *Invited for Optoelectronic and Microelectronic Technology and Application (OMTA2020)*. <https://b2b.csoe.org.cn/meeting/OMTA2020.html>.
11. Dae Wook Kim, Christopher K. Walker, Dániel Apai, Tom D. Milster, Yuzuru Takashima, Glenn Schneider, Rongguang Liang, Young-sik Kim, Chuck Fellows, Yingying Zhang, Andras Gasper, I. Steve Smith, Devon Crowe, Alex Bixel, Stefan O'Dougherty, Siddhartha Sirsi, Aman Chandra, Andy Phan, Zichan Wang, Kira Purvin, Henry Quach, Marcos Esparza, Joel Berkson, Oliver Spires, Heejoo Choi, Geon Hee Kim, and Jonathan Arenberg, "Disruptive space telescope concepts, designs, and developments: OASIS and Nautilus", *Invited for European Optical Society Annual Meeting 2020*.
12. Y. Takashima, B. Hellman, J. Rodriguez, C. Luo, I. B. Donnelly, T. L. Lee, X. Deng, Y. Kim, H. Choi, E. Evans, E. Kang, and D. Kim, "MEMS Imaging Lidar" *Invited for ICO-OWLS-2020 (www.ico25.org)* Meeting postponed due to the COVID19 travel restriction.
13. Y. Takashima, Chuan Luo, B. Hellman, Ted Lee, Xianyue Deng, Jiafan Guan, Heejoo Choi "Emerging Technologies for Optics in Future: from AR Displays to Lidar", *Specially invited paper and panel discussion for The 56th Annual Meeting of the Japanese Society of Ophthalmological Optics (Focus 2020)* in Yokohama, Japan. (<https://www.56jsoo.com/program>)
14. Y. Takashima, B. Hellman, C. Luo" Lidar and AR Displays by MEMS-based Angular and Spatial Light Modulation", *Invited for 12th International Conference on Optics-photonics Design and Fabrication (ODF 2020)* in Taoyuan, Taiwan. Meeting postponed to June, 2021 due to COVID19 travel restriction.
15. B. Hellman, Y. Takashima," Angular and spatial light modulation by single digital micromirror device for beam and pattern steering" **Best Student Paper Award** SPIE Photonics West (SPIE OPTO-PW200) (2020).
16. Y. Takekawa, Y. Nagahama, Y. Takashima, and Y. Takaki, "Electronic Holographic Display Using MEMS-SLM with 40 Degree Viewing Zone" **Outstanding Poster Paper Award**, The 26th International Display Workshops, Sapporo, Japan, November 27-29 (2019)
17. T. Nakamura and Y. Takashima, "Design of discretely depth-varying holographic grating for image guide based see-through and near-to-eye displays," *Invited for Imaging Sensing and Optical Memory (ISOM 2019)*.
18. Y. Takashima, B. Hellman, J. Rodriguez, C. Luo, I. B. Donnelly, T. L. Lee, X. Deng, Y. Kim, H. Choi, E. Evans, and D. Kim, "Imaging LIDARs by Digital Micromirror Device" **Specially Invited Paper** for Imaging Sensing and Optical Memory (ISOM 2019).

19. Yuzuru Takashima, Brandon Hellman, Joshua Rodriguez, Guanghao Chen, Braden Smith, Adley Gin, Alonzo Espinoza, Paul Winkler, Cameron Perl, Chuan Luo, Eunmo Kang, Youngsik Kim, Heejoo Choi, and Daewook Kim, “MEMS-based Imaging LIDAR” *Invited* for OSA E2 conference in Singapore (2018).
20. Toshiki Ishii, Kenichi Shimada, Taku Hoshizawa, Yuzuru Takashima, “Pre-Write Operation and Post Optical Compensation for Robust Holographic Data Storage System (**Invited Paper**)” International Symposium on Optical Memory (ISOM 2015).
21. Kenichi Shimada, Toshiki Ishii, Taku Hoshizawa, Yuzuru Takashima, “Modeling and measures against the effect of mechanical instabilities on holographic data storage system (**Invited Paper**)” SPIE Optics and Photonics, Optical Data Storage (ODS 2015).
22. Yuzuru Takashima, “Recent progress towards practical holographic digital data storage system (**Invited Paper**)” SPIE Optics and Photonics, Optical Data Storage (ODS 2015).

Contributed Articles:

Submitted:

23. Field of View Expansion via Diffractive Image Steering and Prism Array SPIE AR/VR/MR #1 (**2023**)
24. Evaluation of pulsed laser sources for a solid-state diffractive image steering and foveation by Texas Instruments Digital Micromirror Device SPIE AR/VR/MR #2 (**2023**)
25. Wide Field of View Real-time flash DMD-Lidar with 2D Multi-Pixel Photon Counter, Submitted to SPIE Photonics West (**2023**)
26. Beam tracking and image steering by TI PLM based on camera input for lidar and AR applications, Submitted to SPIE Photonics West (**2023**)
27. Ching-Wen Chan, Xianyu Deng, Ted Lee and Yuzuru Takashima, “Wide Field of View Lidar with 2D Multi-Pixel Photon Counter and Digital Micromirror Device”, Submitted to IEEE Sensors Conference (**2022**).

Accepted:

Published:

28. Viveka Bhupasamudram Raghu, Xianyu Deng, Eunmo Kang, Chin-I Tang, and Yuzuru Takashima, “Large Etendue laser beam steering by 2D MEMS resonant mirror and Digital Micromirror Device for time-of-flight lidar and AR display”, Industrial Optical Devices and Systems (ODS) SPIE Optics and Photonics, (**2022**). <https://spie.org/optics-photonics/presentation/Large-etendue-laser-beam-steering-by-2D-MEMS-resonant-mirror/12231-15>
29. Jeff Ching-wen Chan, Chin-I Tang, Xianyu Deng, and Yuzuru Takashima, “DMD-based diffractive FOV expansion for real-time flash lidar with 2D multi-pixel photon counter”, Industrial Optical Devices and Systems (ODS) SPIE Optics and Photonics, (**2022**), <https://spie.org/optics-photonics/presentation/DMD-based-diffractive-FOV-expansion-for-real-time-flash-lidar/12231-16>
30. Orbiting Astronomical Satellite for Investigating Stellar Systems (OASIS): A Paradigm Shift in Realizing Large Space Apertures, submitted to SPIE Space Telescopes and Instrumentation 2022: Optical, Infrared, and Millimeter Wave, SPIE Astronomical Telescopes + Instrumentation (**2022**).
31. Pengyu Liu, Ted Liang-Tai Lee, Chuan Luo, Brandon Hellman, Zhipeng Dong, and Yuzuru Takashima, “Volume holographic grating for wavelength multiplexed field-of-view expansion”, Optical Architectures for Displays and Sensing in Augmented, Virtual, and Mixed Reality (AR, VR, MR) III, SPIE AR/VR/MR (**2022**).
32. Ted Liang-Tai Lee, Pengyu Liu, Chuan Luo, Brandon Hellman, and Yuzuru Takashima, “Wavelength multiplexed field of view expansion for high-resolution near-to-eye displays”, Optical Architectures for Displays and Sensing in Augmented, Virtual, and Mixed Reality (AR, VR, MR) III, SPIE AR/VR/MR (**2022**).

33. Eunmo Kang, Heejoo Choi, Brandon Hellman, Joshua Rodriguez, Braden Smith, Xianyue Deng, Parker Lieu, Ted Lian-Tai Lee, Eric Evans, Chuan Luo, Yifan Hong, Jiafan Guan, and Yuzuru Takashima, “Large Etendue solid-state-lidar with MEMS-resonant mirror assisted diffractive beam steering by Digital Micro Mirror devices”, SPIE Photonics West Emerging Digital Micromirror Device Based Systems and Applications XIV (2022). <https://www.spiedigitallibrary.org/conference-proceedings-of-spie/12014/1201407/Large-etendue-solid-state-lidar-with-MEMS-resonant-mirror-assisted/10.1117/12.2608501.full?SSO=1>
34. Xianyue Deng, Jiafan Guan, Chuan Luo, Ted Lee, Parker Liu, and Yuzuru Takashima, “Diffraction efficiency of MEMS Phase Light Modulator for quasi continuous beam steering”, SPIE Photonics West Emerging Digital Micromirror Device Based Systems and Applications XIV (2022).
35. Chin-I Tang, Xianyue Deng, and Yuzuru Takashima, “CUDA-OpenGL GPU-based real time beam tracking by MEMS phase SLM”, SPIE Photonics West Emerging Digital Micromirror Device Based Systems and Applications XIV (2022). <https://www.spiedigitallibrary.org/conference-proceedings-of-spie/12014/1201408/CUDA-OpenGL-GPU-based-real-time-beam-tracking-by-MEMS/10.1117/12.2608031.full>
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Invited Conference Presentations

Invited Talks and Lectures:

1. Yuzuru Takashima, Chuan Luo, Ted Lee. Brandon Hellman, Parker Liu, “Unlocking the potential of Digital Micromirror Device for AR display systems”, *invited by* Meta (Facebook) Reality Labs Jun. 28, **2022**.
2. Yuzuru Takashima, “Optical Engineering: A Key Enabler for Technology in Daily Life”, Optical Science Winter School (Jan. 5, **2022**) , [Winter School 2022 Videos | \(arizona.edu\)](#)
3. Yuzuru Takashima, “Beam- and Image-Steering for Lidar and Augmented Reality Applications with MEMS Spatial Light Modulators”, *invited for* Photonics Spectra Conferences **2022**, (Jan. 11, 2022) [Beam- and Image-Steering for Lidar and Augmented Reality Applications with MEMS Spatial Light Modulators | Photonics Spectra Conference 2022](#)
4. Yuzuru Takashima, “Made it happen: A pathway towards advanced lidar and all-day AR display”, *invited by* Tech Launch Arizona (TLA) April 21, **2021**
5. Yuzuru Takashima, Chuan Luo, Ted Lee. Brandon Hellman, Parker Liu, “Unlocking the potential of Digital Micromirror Device for AR display systems”, *invited by* Facebook Reality Labs Oct. 6, 2020.
6. Y. Takashima, B. Smith, B. Hellman, A. Gin, G. Chen, P. Winkler, Y. Kim, “Imaging Lidar (**Invited Talk**)”, OSA Imaging Congress 2017.
7. Nicholas Mennona, Chuan Luo, Guang-hao Chen, Sunghin Wang, Chris Summitt, and Yuzuru Takashima “Interactive Graphical User Interface for Ray Aberration Generator 3.0 (**Invited Talk**)” presented at Research Experience for Undergraduates Symposium October 22-23 2017, (http://www.cur.org/conferences_and_events/student_events/reu/)
8. Yuzuru Takashima and Bo Miller “Recent Progress towards Practical Holographic Digital Data Storage System (**Invited Talk**)”, in Optical Memories for Big Data Storage, The International Symposium on Optoelectronic Technology and Application (OTA 2016) Beijing, China, 9-11 May, (2016)
9. Y. Takashima, “Optical Compensation and Enhancement Techniques for Holographic Digital Data Storage System” (**Invited Talk**), SPIE Optics and Photonics, Optical Data Storage 2014.
10. Y. Takashima, L. Hesselink “Design and Implementation of Wearable Head-up Display for Mobile Phone Applications” (**Invited Talk**) , CC3DR, Seoul Korea, (2012).
11. Y. Takashima, L. Hesselink “Wearable Head-up Display for Augmenting Visual Imagery” (**Invited Talk**) OSA Topical Meeting in Digital Holography and Three dimensional Imaging, Tokyo Japan, (2011).

Contributed Conference Presentations

12. Z. Dong, E. Kang, J. Guan, X. Deng, C. Luo, Y. Takashima, “Infrared Light Modulation with MEMS Phase Light Modulator” TxACE Annual Review Meeting, October 20, **2021**

13. Xianyue Deng, Jiafan Guan, Chuan Luo, Ted Lee, Parker Liu, and Yuzuru Takashima, "Diffraction efficiency of Texas Instruments Phase Light Modulator for quasi continuous laser beam steering", TxACE Annual Review Meeting, October 20, 2021
14. Chin-I Tang, Xianyue Deng, and Yuzuru Takashima, "Real time beam tracking by Texas Instruments Phase Light Modulator", TxACE Annual Review Meeting, October 20, 2021
15. Z. Dong, E. Kang, J. Guan, X. Deng, C. Luo, Y. Takashima, "Infrared Light Modulation with MEMS Phase Light Modulator" Annual TxACE Symposium, October 18, 2021 (<https://txace.utdallas.edu/txace-2021-symposium/>)
16. Xianyue Deng, Jiafan Guan, Chuan Luo, Ted Lee, Parker Liu, and Yuzuru Takashima, "Diffraction efficiency of Texas Instruments Phase Light Modulator for quasi continuous laser beam steering", Annual TxACE Symposium, October 18, 2021 (<https://txace.utdallas.edu/txace-2021-symposium/>)
17. Chin-I Tang, Xianyue Deng, and Yuzuru Takashima, "Real time beam tracking by Texas Instruments Phase Light Modulator", Annual TxACE Symposium, October 18, 2021 (<https://txace.utdallas.edu/txace-2021-symposium/>)
18. P. Cameron, B. Hellman, J. Rodriguez, and Y. Takashima, "MEMS Based Beam Steering for Holographic LIDAR Systems," Council on Undergraduate Research, Research Experiences for Undergraduates Symposium, October 28-29, 2018.
19. Yuzuru Takashima, Young-Sik Kim, Chris Summitt, Sunghin Wang, "Fast and End-to-end X-ray Differential Phase Contrast Imaging Simulator" SPIE Optical Design and Engineering V, Friedrich-Schiller-University, Jena, Germany, 7 - 10 September (2015)
20. Yuzuru Takashima, Young-Sik Kim, Chris Summitt, Sunghin Wang, "Design and Optimization of Single Grating X-ray Differential Phase Contrast Imaging System with Free-form and Micro-optics-channeled Detector Array" SPIE Optical Design and Engineering V, Friedrich-Schiller-University, Jena, Germany, 7 - 10 September (2015)
21. Yuzuru Takashima, Young-Sik Kim, Chris Summitt, Sunghin Wang, "Design of Photonic-channeled X-ray Detector Array for Single Grating X-ray Differential Phase Contrast Imaging System", SPIE Optics and Photonics, Radiation Detectors: Systems and Applications XVI (2015)
22. Yuzuru Takashima, Young-Sik Kim, Jihun Kim, "Title: Design of X-ray Differential Phase Contrast Imaging System for High Energy and Incoherent X-ray Sources", SPIE Optics and Photonics, Radiation Detectors: Systems and Applications XVI (2015)
23. Young-Sik Kim, Chris Summitt, Sunghin Wang, Max Yuen, Charles Qi, Lambertus Hesselink, Yuzuru Takashima, "Virtual X-ray Differential Phase Contrast Imaging System Simulator", SPIE Optics and Photonics, Advances in X-Ray/EUV Optics and Components X (2015)

2011 and Before

24. Y. Cheng, Y. Takashima, J. R. Maldonado, D. Ferranti, W. Thompson, L. Hesselink and R.F. Pease "Crisp, high aspect-ratio, C-shaped nanoapertures fabricated in evaporated aluminum using focused helium ions", The 55th International Conference on Electron, Ion, and Photon Beam Technology and Nanofabrication, Las Vegas, Nevada (2011)
25. R. Dinyari, Y. Takashima and P. Peumans, "A Curvable Silicon Retinal Implant", In Poster Session of Stanford Center for Integrated Systems, Fall Advisory Committee Meetings, Stanford CA, (2010)
26. Y. Takashima, Y. Cheng, P. Hansen, Y. Yuen, L. Hesselink, R. F. Pease, J. R. Maldonado and P. A. Pianetta. "Demonstration of $\lambda/50$ optical spot using a C-Aperture Nano Tip for Electron Photo-emitter applications". **Invited Talk** in *Annual Symposium of Stanford Photonics Research Center*, Stanford CA, (2010)

27. Y. Takashima and L. Hesselink, "Design and implementation of recording and readout system for micro holographic optical data storage". In *Current Developments in Lens Design and Optical Engineering XI*, San Diego, California (2010).
28. Y. Takashima. "A Systematic Comparison of Bit-based and Page-based Holographic Storage Systems". **Invited Talk** in *Optical Data Storage Topical Meeting*, Colorado, (2010).
29. Y. Takashima, Y. Cheng, P. Hansen, Y. Yuen, B. Leen and L. Hesselink."Experimental Demonstration of a Spot Size of $\lambda/50$ by Novel NSOM Probe: C-Aperture Nano-Tip". In *2nd Annual Center for Biomedical Imaging at Stanford Symposium*, (2010).
30. A. Koc, Y. Takashima and L. Hesselink. "Systematic analysis of the validity regions of scalar diffraction integral and angular spectrum method". In *Digital Holography and Three-Dimensional Imaging*, Florida, (2010).
31. L. B. Rad, Y. Takashima, P. Pianetta, J. Miao and F. Pease. "Iterative Phase Recovery Using Wavelet Domain Constraints". In *The 53rd International Conference on electron, ion and photon beam technology and nanofabrication*, (2009).
32. L. B. Rad, Y. Takashima, P. Pianetta, J. Miao and F. Pease. "Iterative Phase Recovery Using Wavelet Domain Constraints". In *Bernard M. Gordon Center for Subsurface Sensing and Imaging Systems (Gordon-CenSSIS), Research and Industry Collaboration Conference*, (2009)
33. Y. Takashima and L. Hesselink. "Design and tolerance of two-element NA 0.8 objective lenses for page-based holographic data storage systems". In *SPIE Optics and Photonics*, (2009).
34. Y. Takashima and L. Hesselink. "Design and tolerance of two-element NA 0.8 objective lenses for page-based holographic data storage systems". In *International Society of Optical Memory /Optical Data Storage*, (2008).
35. L. Hesselink and Y. Takashima. "Holographic data storage systems". **Invited talk** in *60th Technical Association of Graphical Art Annual Technical Conference*, (2008).
36. Y. Takashima and L. Hesselink. "Ultra High NA Fourier Transform Lenses for Optical Data Storages". In *Stanford Photonics Research Center Annual Meeting*, (2007).
37. Y. Takashima and L. Hesselink. "Holographic data storage (HDS): Comparison of two approaches: page-based and bit-based HDS". **Invited talk** in *MEDIA-TECH showcase and conference* (2006).
38. Y. Takashima and L. Hesselink. "Optical design for bit-based and page-based holographic data storage systems". In *Stanford Photonics Research Center Annual Meeting*, (2006).
39. Y. Takashima, S. S. Orlov and L. Hesselink, "Optical design for holographic data storage system". In *Stanford Photonics Research Center Annual Meeting*, (2004).
40. Y. Takashima, S. S. Orlov, R. Snyder and L. Hesselink. "Large field and low aberration Fourier transform lens system for photo-polymer disk-based HDS". **Invited talk** in *International Workshop on Holographic Data Storage*, (1999).
41. Y. Takashima, S. S. Orlov, and L. Hesselink. "Large field and low aberration Fourier transform lens system for photo-polymer disk-based HDS". in *National Storage Industry Consortium PRISM/HDSS Quarterly Meeting*, (1999).
42. Y. Takashima, S. S. Orlov, R. Snyder and L. Hesselink. "Large field and low aberration Fourier transform lens system for photo-polymer disk-based HDS (2)". in *National Storage Industry Consortium PRISM/HDSS Quarterly Meeting*, (1999).

Invited Lectures

1. Yuzuru Takashima "Recent Trend in Plastic Optics", **Mitsi Chemical, March 8 (2019)**
1. Yuzuru Takashima "3D Imaging and LIDAR (**Invited Lecture**)", O-film Corporation, May 26, (2017).

2. Yuzuru Takashima “Optics in Future, Robotics, Artificial and Virtual Reality (**Invited Lecture**)”, O-film Corporation, Nov 17, (2016).
3. Yuzuru Takashima “ Introduction to Optical Design (**Invited Lecture**)”, Utsunomiya University, Japan December, (2015).
4. Young-Sik Kim, Chris Summitt, Sunghin Wang, Max Yuen, Charles Qi, Lambertus Hesselink, Yuzuru Takashima.” Young-Sik Kim, Chris Summitt, Sunghin Wang, Max Yuen, Charles Qi, Lambertus Hesselink, Yuzuru Takashima. “Novel 3D Differential Phase Contrast Imaging System (**Invited Lecture**)”, Korea Basic Science Institute, June 18 (2015).
5. Yuzuru Takashima,” Nano-photonic Devices beyond Near-field Applications (**Invited Lecture**)” Utsunomiya University, Japan December, (2012).

Review Articles

1. Y. Takashima, A. Amano and M. Kitamura, “Ultra precision Machining for Optical Elements (In Japanese)”. *Toshiba Review*, vol. 52 no. 7, 55-58 (1997).
2. “Holographic Optical Elements (In Japanese)”. *Toshiba Review*, vol. 52 no. 3, (1997).
3. Y. Honguh, H. Mihara and Y. Takashima, “Illumination Optics for Liquid Crystal Projectors (In Japanese)”. *Toshiba Review*, vol. 53 no. 8, 39-42 (1998).

Patents and disclosures:

1. 10795161 Pseudo phase conjugate image transfer device (Jul. 8, 2016)
2. 9772407 Photonic-channeled X-ray detector array (Sep. 26, 2017)
3. 10859517 Single X-ray grating X-ray differential phase contrast imaging system (Jun. 30, 2017)
4. 9997187 Optical information recording apparatus and method (Jun. 12, 2018)
5. 9977402 Optical information recording/reproducing apparatus, optical information recording/reproducing method (May 22, 2018).
6. 9869861 Glass implemented display (Jan. 16, 2018)
7. 10281262 Range-finder apparatus, methods, and applications (May 7 2019)
8. 10877275 Imageguide for head mounted display (Dec. 29,2020)

Patent disclosures (*Granted):

1. UA23-033: Seeing through fog
2. UA23-016: Flash lidar with FOV expansion
3. UA22-138: Real time CGH calculation and beam tracking
4. UA22-139: Wavelength and Diffractive Multiplexed Expansion of Field of View for Display Devices
5. UA21-201: Optical enhancement of phase modulation depth for a phase light modulator
6. UA21-200: MEMS based beam steering with DC and side lobe suppression
7. UA20-103: Retinal Resolution and Single-Chip Multiplexed Image Transfer for AR Near-to-Eye Displays
8. UA20-053: Digital illumination assisted gaze tracking
9. UA20-020: ASLM Headset Display by Stacked Waveguides
10. UA20-013: Waveguide for Angular Space Light Modulator Display
11. UA19-113: ASLM Multi-Display
12. UA19-013: MEMS-based Hybrid Beam Steering for LIDAR
13. UA18-207: Rotationally Shift Invariant and Shell Structured Optical System
14. UA18-192: Rotationally Shift Invariant And Multi-Layered Microlens Array
15. UA18-077: Single-Chip ASLM
16. UA18-078: Field Steering ASLM
17. UA18-076: *Imageguide For Head Mounted Display
18. UA18-004: Fast and Scalable Fabrication of Microscopic Optical Surfaces and its Application for Optical Interconnect Devices
19. UA17-178: Single-Chip Streak Camera
20. UA17-157: Digital micromirror device based beam steering
21. UA17-156: Angular Spatial Light Modulator (ASLM)
22. UA17-052: *Single Grating X-Ray Differential Phase Contrast Imaging System

23. UA16-029: Wavelength Diversity Detection for Holographic Data Storage System
24. UA16-014: *Photonic-channeled X-ray Detector Array
25. UA16-003: *DMD-based Optical Scanning Device
26. UA15-010: *Pseudo Phase Conjugate Image Transfer Device for Head Worn Display
27. UA15-007: *Recording Mode Control Depending on Vibration for Holographic Data Storage System
28. UA14-029: Optical Compensation of Mechanical Effects for Holographic Digital Data Storage System
29. UA13-027: *Glass Implemented Display

Patent Applications (All at U of A)

30. Single-chip ASLM (UA18-007)
31. Fast and Scalable Fabrication of Microoptic Optical Surfaces and its Application for Optical Interconnect Devices (UA18-004, Provisional Application 62/530,017)
32. Single-Chip Streak Camera (UA17-158) PCT application filed on April 14, 2017
33. DMD-Based Beam Steering (UA17-157) PCT application filed on April 14, 2017
34. Angular Spatial Light Modulation Device (UA17-156) PCT application filed on April 14, 2017
35. Optical Information Recording/Reproducing Apparatus, Optical Information Recording/Reproducing Method (PCT/US2014/041438).
36. Optical Information Processing Apparatus and Method (PCT/US2014/051233).
37. Single Grating X-ray Differential Phase Contrast Imaging System, (US62324326).
38. Eye-glass Mounted Display (US20130009853)
39. Range-finder Apparatus, Methods, and Applications, (PCT/US16/47767)
40. Pseudo Phase Conjugate Image Transfer Device, (PCT/US2016/041599)
41. Wavelength Diversity Detection for Holographic Data Storage System, The University of Arizona Disclosure: UA16-029. Filing scheduled on Sept 30, 2016.

Japanese Patent (Granted Patents)

Patent #

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|--|---|
| <ol style="list-style-type: none"> 1. 3792883 2. JP3333679B2 3. JP2994229B2 4. JP2974644B2 5. JP2854781B2 | <p>Lighting System and Projection Display Device By Using It
Groove Cutting Method
Endoscope
Reflecting and Refracting Optical Lens and Its Manufacture
Optical Equipment</p> |
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Japanese Patent Applications (25 Applications)

Publication #

- | | |
|--|--|
| <ol style="list-style-type: none"> 6. 2002-247453 7. 2001-242377 8. 2001-183601 9. 2000-275547 10. 11-282073, (1999) 11. 11-183794, (1999) 12. 11-183706, (1999) 13. 11-025705, (1999) 14. 10-321027, (1998) 15. 10-321004, (1998) 16. 10-206621, (1998) 17. 10-206618, (1998) 18. 10-197948, (1998) 19. 10-186301, (1998) 20. 10-083448, (1998) 21. 10-062715, (1998) 22. 06-347699, (1994) 23. 06-273678, (1994) | <p>Image Pickup Device and Portable Phone
Lens and Camera Module
Picture Projector
Endoscope and Its Manufacture
Card Type Camera
Optical Lens
Highly Integrated Optical Element and Its Production
Projection Apparatus and Prism Body
Polarized Light Optical Element, Polarized Light Optical System, and Projection Device
Polarization Optical Element, Polarization Optical System, and Projection Device
Manufacture of Holographic Optical Element
Processing Method of Blazed Diffraction Grating
Projection Device
Liquid Crystal Projection Device
Optical Device
Liquid Crystal Projection Device
Optical Element and Optical Device
Diffusing and Illuminating Optical System For Endoscope</p> |
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24. 06-027389, (1994) Optical Observation Device
25. 06-027371, (1994) Optical Observation Device
26. 06-011637, (1994) Optical Device
27. 06-011603, (1994) Optical Parts and Their Production
28. 05-288908, (1993) Optical System
29. 05-151502, (1993) Rotary Scan Type Magnetic Recording and Reproducing Device
30. 05-072477, (1993) Afocal Optical Device

Grants and Contracts: At the University of Arizona, 2011~2016

Funded (Federal, and state)

1. Co-PI: Multiscale Phase Retrieval, DARPA, \$204,050, (2021)
2. PI: Tech Launch Arizona: DMD Imaging LIDAR (PI, 5%), State Funding, \$80,162, (2018)
3. PI: Demonstration of the 1T pixel-angle/sec Bandwidth Angular Spatial Light Modulator (ASLM) for Wide Field of View Optical Surveillance and Situation Awareness TRIF LINK Award, State Funding \$7673.27, (2017)

Funded (Industry)

4. Co-PI: (50%): Phase Light Modulator for LIDAR and Head Up Display Applications, Semiconductor Research Corporation, \$420,000 (2020)
5. PI: 3D LiDAR System with a Laser Scanning Method Using DMD Devices, Mitsubishi Electric, \$28,572 (2019)
6. PI: Angular Spatial Light Modulator for AR/VR, Facebook Inc. \$319,684 (2019)
7. PI: Gift fund, Texas Instruments, \$5,000 (2018)
8. Co-PI: Large Inflatable Apertures, Freefall Aerospace, \$150,000 (2017)

Submitted

9. PI: Vergence-Accommodation Conflict Free Near Field Holographic Image Beaming for Headset-less AR/VR/MR Interaction, Sony Corporation of America, \$99,930, (2021)

Unfunded

10. Co-PI: QuIC - TAQS: Quantum Interconnects Enabling Quantum Internet, NSF, \$2,498,654, (2021)
11. PI: Digital Illumination Assisted Gaze Tracking for Augmented Reality Near to Eye Displays, Sony Corporation of America, \$100,000 (2020)
12. Co-PI: High-Efficiency Laser Power Beaming System for the Exploration of Moon, University of Virginia, 212,000 (2020)
13. Co-PI: CNS Core: Large: On-Demand Composable High Performance Data Centers, NSF, \$3,000,000 (2019)
14. PI: Digital Illumination Assisted Gaze Tracking for Augmented Reality Near to Eye Displays, Sony Corporation of America, \$100,000 (2019)
15. Co-PI: TIPTOP: Testbed for Information and Power Transport by Optical Propagation, Air Force Office of Scientific Research, \$266,123 (2018)
16. PI: Angular Spatial Light Modulator and Spherical Gabor Super Lens for Fully Spherical 4-pi Field Situation Awareness, NSF, \$339,983 (2017)

List of collaborators

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