Exponent®
Engineering & Scientific Consulting

Erwin Lau, Ph.D., P.E., CLSO

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Professional Profile

Dr. Lau's expertise covers a wide range of technologies, including optics, optical devices, consumer electronics, medical devices, and prototyping. At Exponent, Dr. Lau assists clients with resolving complex issues relating to due diligence, failure analysis, intellectual property, and product design, safety, and risk assessment.

Dr. Lau has over 25 years of experience in the design, characterization, modeling and simulation of electronic, optoelectronic devices, and optical systems.

Dr. Lau has led complex investigations in the following technology areas:

- Virtual reality/augmented reality (VR/AR) headsets
- Solid-state (LED) lighting
- Laser/LED-based medical devices
- LiDAR
- Wearable/mobile devices
- Autonomous vehicles
- Battery and energy storage systems
- IoT appliances

At Exponent, Dr. Lau assists clients with product design, risk analysis, and failure analysis of solid-state lighting, liquid-crystal displays (LCDs), light-emitting diodes (LEDs), lasers, ocular biomedical devices, optical lens, and multi-layer transmissive optical systems. He has extensive experience in optical metrology, colorimetry, luminance, reflectance, quantification of visual defects, and cosmetic appearance of surfaces of all types. Dr. Lau has performed laser and LED radiation safety analysis for numerous consumer electronics and medical products. Dr. Lau has extensive experience in designing and modeling of optical and electromagnetic systems, including raytrace modeling of compound optical systems, and has performed finite element analysis of electro-magnetic systems, including high voltage arcing, and magnetic resonance imaging (MRI) systems.

Dr. Lau has extensive experience in prototyping of consumer and medical products, custom analysis fixtures, including design and construction of a ruggedized single-molecule fluorometer system, a laser-based surface particle scatterometer, a micron-scale optical 3-D profilometer, and high-speed transient metrology. He has experience in delivery of robust test fixtures to clients with rapid needs.

Dr. Lau has extensive experience in consumer electronic failure analysis. Some of his notable investigations include solid-state lighting reliability and failure; virtual reality (VR) headset failure; flex cable failures; PCB failures due to component failure: FOD, tin whiskers, solder joints; laser failures; and adhesive and conductive epoxy failure. He has extensive experience with switching-mode power converter, especially electrolytic capacitor and PWM failure.

Dr. Lau has supported several litigation matters as an expert witness, including laser medical and consumer product injury and breach-of-warrantee, LED billboard display failure, insurance loss, and accident reconstruction.

Dr. Lau currently serves as a member on various ANSI Z136 and TC76 laser safety standard development committees and currently serves as Exponent's laser safety officer. He has developed and taught university courses on electronic circuits and microelectronics.

Academic Credentials & Professional Honors

Ph.D., Electrical Engineering and Computer Sciences, University of California, Berkeley, 2006

M.Eng., Electrical Engineering and Computer Sciences, Massachusetts Institute of Technology (MIT), 2001

S.B., Electrical Engineering and Computer Sciences, Massachusetts Institute of Technology (MIT), 2000

IEEE Japan Best Paper Award, 2008

Hertz Fellowship Finalist, 2002-2003

University of California, Los Angeles Dean's Fellowship, 2000

Beneficial Presidential Scholarship, 1995

IEEE International Symposium on Product Compliance Engineering (ISPCE) Best Paper Award, 2019

Licenses and Certifications

Professional Engineer Electrical, California, #20518

Certified Laser Safety Officer (CLSO)

Prior Experience

Postdoctoral Researcher, University of California, Berkeley, 2007-2010

Student Researcher, IBM T. J. Watson Researcher Center, 2004

Teaching Assistant, Massachusetts Institute of Technology, 1999-2000

Student Researcher, IBM Tokyo Research Laboratory, 1998

Professional Affiliations

Institute of Electrical and Electronics Engineers (IEEE), Member

Optical Society of America (OSA), Member

Accredited Standards Committee (ASC) Z136 for the Safe Use of Lasers, Voting Member

ANSI Z136 SSC-2: Safe Use of Optical Fiber Communications Systems Utilizing Laser Diode and LED Sources, Committee Member

ANSI Z136 TSC-1: Laser Bioeffects and Medical Surveillance, Committee Member

ANSI Z136 TSC-7: Analysis and Applications, Vice-Chair, Committee Member

IEC TC 76: Optical Radiation Safety and Laser Equipment, Committee Member

ANSI Z136 SSC-6: Safe Use of Lasers Outdoors, Committee Member

Patents

Zhao X, Lau EK, Wu MC, Chang-Hasnain CJ, Sung HK, and Parekh D. High-Speed Optical Transmitters Using Cascaded Optically Injection-Locked Lasers. 2008.

Agarwal D, Aydeiette PF, Brennan JF, Pooley MA, Lau EK. Automated Control and Inspection System for Manufacture and Measurement of Apparel. 2020. (Provisional)

Publications

Books and Book Chapters

Lau E. High-Speed Modulation of Semiconductor Lasers by Optical Injection Locking: From Basics to Modern Advances. VDM Verlag, 2008.

Lau EK, Sung HK, Wu MC. Direct modulation of injection-locked semiconductor lasers. In: Microwave Photonics, Lee CY (ed), Boca Raton, FL: CRC Press, pp. 77-110, 2007.

Presentations

Lau EK. Wearable Product Laser Safety. Smart Wearable Device Asia Pacific Summit 2020 (SWAP), Shenzhen, China, Jan. 13-14, 2020.

Lau EK, Fei E. Safe design of laser consumer products. 2019 International Laser Safety Conference (ILSC), pp. 274-279, Kissimmee, FL, 2019.

Horton NG, Pollock KL, Fei ET, Lau EK. Retinal hazard analysis for laser and LED illumination for close-in long duration exposure. 2019 International Laser Safety Conference (ILSC), pp. 294-301, Kissimmee, FL, 2019.

Pollock KL, Horton NG, Lau EK, Fei ET. The effect of liquid droplets on laser safety for consumer products: A numerical model. 2019 International Laser Safety Conference (ILSC), pp. 304-310, Kissimmee, FL, 2019.

Lau EK, Fei E. Safe design of laser consumer products. 2019 IEEE Symposium on Product Compliance Engineering (ISPCE), San Jose, CA, 2019.

Fei E, Piper J, Lau, EK, Brennan, JF. Optical hazards posed by high-intensity LED flashlights. 2017 International Laser Safety Conference (ILSC), Atlanta, GA, 2017.

Lau EK. Understanding radiation safety of high-intensity light-emitting diodes. 2013 IEEE Symposium on Product Compliance Engineering (ISPCE), Austin, TX, 2013.

Lakhani A, Kim MK, Lau EK, Wu MC. Lasing in a one-dimensional photonic crystal. IEEE International Semiconductor Laser Conference, Kyoto, Japan, 2010.

Lau EK, Tucker RS, Wu MC. Enhanced modulation bandwidth of nanocavity light emitting devices. International Nano-Optoelectronics Workshop (iNOW), Stockholm, Sweden and Berlin, Germany, 2009.

Wu MC, Chang-Hasnain, Lau EK, Zhao X. High-speed modulation of optical injection-locked semiconductor lasers. Optics Fiber Communications Conference, pp. 1-3.San Diego, CA, 2008.

Wu MC, Chang-Hasnain CJ, Lau EK, Zhao X. High-speed modulation of semiconductor lasers. International Nano-Optoelectronics Workshop (iNOW), Tokyo, Japan, 2008.

Lau EK, Zhao X, Chang-Hasnain CJ, Wu MC. 80-GHz intrinsic bandwidth of directly modulated semiconductor lasers by optical injection locking. Semiconductor Laser Workshop, San Jose, CA, 2008.

Lau EK, Tucker RS, Wu MC. Modulation bandwidth of purcell-enhanced nanocavity light emitters. Semiconductor Laser Workshop, San Jose, CA, 2008.

Lau EK, Tucker RS, Wu MC. Small-signal modulation bandwidth of purcell-enhanced nanocavity light emitters. International Nano-Optoelectronics Workshop (iNOW), Tokyo, Japan, 2008.

Lau EK, Zhao X, Chang-Hasnain CJ, Wu MC. 80-GHz bandwidth enhancement of directly modulated semiconductor lasers under optical injection locking. International Semiconductor Laser Conference (ISLC), 2008.

Lau EK, Tucker RS, Wu MC. Effect of damping and gain compression in Purcell-enhanced nanocavity lasers. OSA Conference on Lasers and Electro-Optics San Jose, CA, 2008.

Zhao X, Lau EK, Parekh D, Sung HK, W. Hofmann, MC Amann, Wu MC, Chang-Hasnain CJ. 107-GHz resonance frequency of 1.55-mm VCSELs under ultra-high optical injection locking. Conference on Lasers and Electro-Optics, San Jose, CA, 2008.

Tucker RS, Lau EK, and Wu MC. Small-signal modulation bandwidth of Purcell-enhanced nanocavity light emitters. International Semiconductor Laser Conference (ISLC), 2008.

Lau EK, Sung HK, Zhao X, Parekh D, Chang-Hasnain CJ, Wu MC. Bandwidth enhancement by optical amplitude and phase modulation of injection-locked semiconductor lasers. Proceedings, IEEE International Top. Meeting Microw. Photon, pp. 241244, Victoria, BC, Canada, 2007.

Lau EK, Sung HK, Zhao X, Parekh D, Chang-Hasnain CJ, Wu MC. Bandwidth Enhancement of electro-absorption modulated lasers by optical injection locking. Annual Meeting IEEE Lasers and Electro-Optics Society, pp. 188-189, Lake Buena Vista, FL, 2007.

Lau EK, Sung HK, Zhao X, Parekh D, Chang-Hasnain CJ, Wu MC. Bandwidth enhancement by optical modulation of injection-locked semiconductor lasers. OSA Frontiers in Optics, San Jose, CA, 2007.

Zhao X, Parekh D, Lau EK, Sung HK, Wu MC, Chang-Hasnain CJ. Optoelectronic oscillator using injection-locked VCSELs. IEEE Annual Meeting, Lasers and Electro-Optics Society, pp. 190-191, Lake Buena Vista, FL, 2007.

Zhao X, Parekh D, Lau EK, Sung HK, Wu MC, Chang-Hasnain CJ. Cascaded injection-locked 1.55-μm VCSELs for high-speed transmission. OSA Conference on Lasers and Electro-Optics, Baltimore, MD, 2007.

Sung HK, Lau EK, Zhao X, Parekh D, Chang-Hasnain CJ, Wu MC. Optically injection-locked optoelectronic oscillators with low RF threshold gain. Conference on Lasers and Electro-Optics, pp. 1-2, Baltimore, MD, 2007.

Lau EK, Sung HK, Wu MC. Ultra-high, 72 GHz resonance frequency and 44 GHz bandwidth of injection-locked 1.55-mm DFB lasers. Optic Fiber Communications Conference, pp. 1-3, Anaheim, CA, 2006.

Sung HK, Lau EK, Wu MC. Near-single sideband modulation in strong optical injection locked semiconductor lasers. Optic Fiber Communications Conference, Anaheim, CA, 2006.

Sung HK, Lau EK, Wu MC, Tishinin D, Liou KY, Tsang WT. Large-signal analog modulation response of monolithic optical injection-locked DFB lasers. Conference on Lasers and Electro-Optics, pp. 1025-1027, 2005.

Lau EK, Wu MC. Amplitude and frequency modulation of the master laser in injection-locked laser systems. Proceedings, IEEE International Topics Meeting, pp. 142-145, Microw. Photon., Ogunquit, ME, 2004.

Schultz JF, Taubman MS, Harper WW, Williams RM, Myers TL, Cannon BD, Sheen DM, Anheier, Jr. NC, Allen PJ, Sundaram SK, Johnson BR, Aker PM, Wu MC, Lau EK. Quantum cascade transmitters for ultra-sensitive chemical agent and explosives detection. SPIE-International Society Optics Engineering, Proceedings of the SPIE - The International Society for Optical Engineering, Vol.4999, No.1, 2003, pp. 1-18, 2003.

Lee MCM, Hah D, Lau EK, Wu MC, Toshiyoshi H. Nano-electro-mechanical photonic crystal switch. Optic Fiber Communications Conference, pp. 94-95, 2002.

Patterson SG, Lau E, Pipe KP, Petrich GS, Ram RJ, Kolodziejski LA. High temperature properties of bipolar cascade lasers. Conference on Lasers and Electro-Optics, pp. 268-269, 2000.

Publications

Lau EK, Fei ET. How to design safe laser consumer products. The Laser Institute (LIA), 27(4), pp. 26-28, 2019. (invited article)

Beiker S, Lau EK, et al. (contributors). Unsettled topics concerning sensors for automated road vehicles. SAE Edge Research Report, SAE International, USA, 2018.

Lau EK, Wong LJ, Wu MC. Enhanced modulation characteristics of optical injection-locked lasers: A tutorial. IEEE Journal of Selected Topics in Quantum Electronics 2009 May/June; 15:618-633.

Lau EK, Lakhani A, Tucker RS, Wu MC. Enhanced modulation bandwidth of nanocavity light emitting devices. Optics Express 2009; 17:7790-7799.

Sung HK, Zhao X, Lau EK, Parekh D, Chang-Hasnain CJ, Wu MC. Optoelectronic oscillators using direct-modulated semiconductor lasers under strong optical injection. IEEE Journal of Selected Topics in Quantum Electronics 2009 May/Jun; 15:572-577.

Lau EK, Zhao X, Sung HK, Parekh D, Chang-Hasnain CJ, Wu MC. Strong optical injection-locked semiconductor lasers demonstrating > 100-GHz resonance frequencies and 80-GHz intrinsic bandwidths. Optics Express 2008; 16:6609-6618.

Lau EK, Wong LJ, Zhao X, Chen YK, Chang-Hasnain CJ, Wu MC. Bandwidth enhancement by master modulation of optical injection-locked lasers. Journal of Lightwave Technology 2008 Aug; 26:2584-2593.

Lau EK, Sung HK, Wu MC. Frequency response enhancement of optical injection-locked lasers. IEEE Journal of Quantum Electronics 2008 Jan; 44:90-99.

Zhao X, Parekh D, Lau EK, Sung HK, Wu MC, Chang-Hasnain CJ. Novel cascaded injection-locked 1.55-μm VCSELs with 66 GHz modulation bandwidth. Optics Express 2007; 15:14810-14816.

Sung HK, Lau EK, Wu MC. Optical properties and modulation characteristics of ultra-strong injection-locked distributed feedback lasers. IEEE Journal of Selected Topics in Quantum Electronics 2007

Sept/Oct; 13:1215-1221.

Sung HK, Lau EK, Wu MC. Optical single sideband modulation using strong optical injection-locked semiconductor lasers. IEEE Photonics Technology Letters 2007 Jul; 19:1005-1007.

Lau EK, Sung HK, Wu MC. Scaling of resonance frequency for strong injection-locked lasers. Optics Letters 2007; 32:3373-3375.

Lee MCM, Hah D, Lau EK, Toshiyoshi H, Wu MC. MEMS-actuated photonic crystal switches. IEEE Photonics Technology Letters 2006 Jan; 18:358-360.

Nguyen HD, Dooyoung H, Patterson PR, Rumin C, Piyawattanametha W, Lau EK, Wu MC. Angular vertical comb-driven tunable capacitor with high-tuning capabilities. Journal of Microelectromechanical Systems 2004 Jun; 13:406-413.

Patterson SG, Lau EK, Pipe KP, Ram RJ. Temperature characteristics of bipolar cascade lasers. Applied Physics Letters 2000; 77:172-174.

Lau EK. Wearable Product Laser Safety. Smart Wearable Device Asia Pacific Summit 2020 (SWAP), Shenzhen, China, Jan. 13-14, 2020.

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Beiker S, Lau EK, et al. (contributors). Unsettled topics concerning sensors for automated road vehicles. SAE Edge Research Report, SAE International, USA, 2018.

Project Experience

Prototyping and Manufacturing

- International arbitration dispute on optoelectronic weapon system manufacture
- Single-molecule fluorometer
- Micro-scale 3-D profilometer
- Light-pipe design for status indicator
- Laser beam expander spot generator
- Surface particle scatterometer for surface cleanliness

Laser and LED Safety and Failure

- Radiation safety failure of lasers
- Near-infrared light detection and ranging (LIDAR) systems
- Medical devices using optical radiation treatment
- Risk assessment of laser- and light-based medical devices and consumer products
- Laser medical and consumer product reliability, failure, and personal injury
- Large-format LED display failure
- Insurance flood loss medical laser property damage

Night-time Lighting Scene Reconstruction

- Night-time quantitative lighting accident scene reconstruction
- Parking lot lighting accident scene reconstruction
- Train lighting accident scene reconstruction

Optical Characterization and Metrology

- Accelerated lifetime testing (ALT) via UV exposure
- High-speed phenomenon, i.e. impact visualization, transient effects
- Scratch and abrasion quantification and comparison
- Quantification and comparative cosmetic analysis on materials for ALT
- Microcolorimetry

Reverse Engineering

- Fluorescence authentication system
- White light emitting diode (LED) technology

Electronic Components

- Failure analysis of electrolytic capacitors
- Flex cable reliability testing and failure
- Conductive epoxy and adhesive failure
- Anisotropic conductive film (ACF) and anisotropic conductive paste (ACP) failure

Electronic Systems

- Switching mode power converters
- AC/DC power adapters
- Electostatic discharge (ESD) testing
- Touchscreens, capacitive arrays
- Battery management units

Peer Reviews

Optics Express

Optics Letters

IEEE Photonic Technology Letters

Journal of Lightwave Technology

IEEE Photonics Journal

Applied Optics