

## **PRINCIPAL RESEARCH**

Prof. Lau has made the following contributions to the presently installed base of fiber-optic networks:

**1.)** Prof. Lau's work formed the basis for all of today's high-speed laser diode design for fiber-optic telecommunications. The development of continuously operating (cw) laser diodes at room temperature (Hall 1962, Hayashi 1971) was key to the realization of fiber-optic communications for which the 2009 Nobel Prize in Physics was awarded. To impress information onto the continuous optical emission from the laser diode, the simplest and most cost-effective means is to directly modulate the electric current through it, as practiced in all metropolitan and local-area networks today. Ever since the realization of cw laser diode at room temperature, intense world-wide efforts have focused on the modulation dynamics of laser diodes, with the goal of realizing high speed laser diodes that can be intensity modulated at 10's of Gbits/s. Yet prior to 1980, laser diode modulation speed was still limited to below ~1Gbit/s. In a series of seminal publications in the 1980s [i – iv] <sup>PRINCIPAL PUBLICATIONS below</sup> Prof. Lau provided the fundamental understanding of dynamics of directly modulated laser diodes, culminating in the first realization of a laser diode with modulation bandwidth of >10GHz [iv.] <sup>PRINCIPAL PUBLICATIONS below</sup> – the figurative equivalence of *4-minute mile* for laser diodes, by reducing the hitherto complex relationship between the laser- modulation bandwidth and numerous intertwined laser parameters to just three fundamental, independent device and material parameters [i – iv] <sup>PRINCIPAL PUBLICATIONS below</sup>, including the differential optical gain of the laser medium as it provides the basis for advanced laser diodes using quantum-well (QW) or strained-layer QW materials. Virtually all high speed fiber-optic transmitters currently deployed in fiber-optic networks today employ direct modulation of laser diodes constructed from these advanced materials. In recognition of these contributions Prof. Lau was awarded the 2008 Nicholas Holonyak Award from the Optical Society of America and the and the 2009 David Sarnoff Award from the IEEE -

[http://www.osa.org/Awards\\_and\\_Grants/Awards/Award\\_Description/nickholonyak/default.aspx](http://www.osa.org/Awards_and_Grants/Awards/Award_Description/nickholonyak/default.aspx) ;  
<http://www.ieee.org/organizations/pubs/newsletters/leos/feb09/2009sarnoffaward.html>

**2.)** In Hybrid Fiber Coax (HFC) networks - the underlying infrastructure supporting cable-modem TV and internet access to the home where highly linear subcarrier-modulated laser-diode transmitters constitute the engine of the majority of fiber links Prof. Lau performed the first experimental investigation and development of an analytic perturbation formulation for predicting the fundamental limits in analog-distortion characteristics of subcarrier directly modulated laser diodes [v, vi] <sup>PRINCIPAL PUBLICATIONS below</sup>. These works established the laser action as the basic origin of distortion generation in directly-modulated laser diodes thus it cannot be eliminated by clever device structure design. This finding provided the impetus for development of the now widely employed pre-distortion linearization techniques, system-level designs, and subsequent field deployment of HFC networks which support present-day ubiquitous cable modem video and internet access to the home. Prof. Lau assumed the role of Chief Scientist at **Ortel** Corp. as a founding member of the company, where he performed the aforementioned fundamental investigations in subcarrier modulation of laser-diode transmitters as well as fiber transmission properties of subcarrier modulated optical signals [vii]. <sup>PRINCIPAL PUBLICATIONS below</sup> **Ortel's** linear CATV fiber-optic transmission subsystem products dominated the industry and paved the way for wide-scale deployment of Hybrid Fiber Coax (HFC) infrastructure on which present-day superior and popular CATV services and cable-modem internet access depend. **Ortel** was acquired by **Lucent** (NYSE:LU) in 2000 -

<http://money.cnn.com/2000/02/07/deals/lucent/index.htm>

**3.)** In enabling mobile voice and data access in urban and campus environments through pioneering and commercialization of wireless signal delivery to distributed antenna systems over linear fiber- optic links for coverage and capacity enhancements in challenging radio environments such as inside concrete buildings and underground structures [viii -xi] <sup>PRINCIPAL PUBLICATIONS below</sup>. Prof. Lau performed the first quantitative modeling of fiber-fed distributed antenna wireless network and development of a measurement-based design methodology for optimal antennas placement in such a system. These work have been commercialized by **LGC Wireless, Inc.** – a successful venture co-founded by Prof. Lau (“L” in “LGC”). To date **LGC Wireless** has shipped and installed >10,000 systems covering convention centers, corporate campuses of **Fortune 500** companies, government building complexes (including the massive 10-story **FCC** headquarter building in Washington D.C.), subways, hospitals, hotels and airports, to > 50 countries around the globe on every continent, its technology thus becomes *de-facto* industrial standard for coverage of high wireless traffic areas such as inside buildings and campuses. **LGC Wireless** was acquired by **ADC Telecom** (NASDAQ:ADCT) in 2007 - <http://www.cellular-news.com/story/26865.php>  
In recognition of **2.)** and **3.)** above Prof. Lau was awarded the 2009 J.J. Thomson Medal from the **IET** of U.K.) - [http://www.theiet.org/about/media-centre/press-releases/20091008\\_3.cfm](http://www.theiet.org/about/media-centre/press-releases/20091008_3.cfm)

## **PRINCIPAL PUBLICATIONS**

[i.] Kam Y. Lau, **Monograph**, “Ultra-high Frequency Linear Fiber Optic Systems”  
**First Edition, Springer** 2009, ISBN: 978-3-540-25350-1, **Second Edition, Springer** 2011, ISBN : 978-3-642-16457-6 – *First comprehensive treatise on Linear Fiber Optic Systems*

<http://www.springer.com/physics/optics+%26+lasers/book/978-3-642-16457-6>

[ii.] Lau, K. Y., Bar-Chaim, N., Ury, I., Harder, C., and Yariv, A., “Direct amplitude modulation of short-cavity GaAs lasers up to X-band frequencies,” Applied Physics Letters, 43 (1), 1-3, 1983 – *First identification of the fundamental laser parameters governing direct modulation bandwidth.*

[http://www.eecs.berkeley.edu/~klau/pubs/PrincpalPubs/Lau\\_Bar\\_Chaim\\_Ury\\_Harder\\_Yariv\\_1983.pdf](http://www.eecs.berkeley.edu/~klau/pubs/PrincpalPubs/Lau_Bar_Chaim_Ury_Harder_Yariv_1983.pdf)

[iii.] Lau, K. Y.; Harder, Ch.; Yariv, A., “Direct modulation of semiconductor lasers at  $f > 10$  GHz by low-temperature operation,” Applied Physics Letters (ISSN 0003-6951), vol. 44, Feb. 1, 1984, p.273-275. – *First definitive experimental verification of the explicit dependence of the modulation bandwidth on differential optical gain (an intrinsic material parameter – basis of quantum well and strained quantum well laser diode designs prevalent in fiber-optic networks today.)*

[http://www.eecs.berkeley.edu/~klau/pubs/PrincpalPubs/Lau\\_Harder\\_Yariv\\_111983.pdf](http://www.eecs.berkeley.edu/~klau/pubs/PrincpalPubs/Lau_Harder_Yariv_111983.pdf)

[iv.] Lau, K. Y.; Bar-Chaim, N.; Ury, I.; Yariv, A.; “11-GHz direct modulation bandwidth GaAlAs window laser on semi-insulating substrate operating at room temperature,” Applied Physics Letters, vol.45, Aug. 15, 1984, pp. 316-318. – *First demonstration of direct modulation bandwidth of laser diodes at  $f > 10$ GHz - figurative equivalence of 4-minute mile for high-speed lasers*

[http://www.eecs.berkeley.edu/~klau/pubs/PrincpalPubs/Lau\\_Bar-Chaim\\_Ury\\_Yariv\\_51984.pdf](http://www.eecs.berkeley.edu/~klau/pubs/PrincpalPubs/Lau_Bar-Chaim_Ury_Yariv_51984.pdf)

[v.] Lau, K. Y.; Yariv, A.; “Intermodulation distortion in a directly modulated semiconductor injection laser,” Applied Physics Letters, vol. 45, Nov. 15, 1984, p. 1034-1036. – *First experimental and analytic studies of third-order intermodulation distortion in directly modulated laser diodes, leading to the understanding of the fundamental nature of the distortion.*

[http://www.eecs.berkeley.edu/~klau/pubs/PrincpalPubs/Lau\\_Yariv\\_1984.pdf](http://www.eecs.berkeley.edu/~klau/pubs/PrincpalPubs/Lau_Yariv_1984.pdf)

[vi.] Lau, K. Y.; Yariv, A., “Nonlinear distortions in the current modulation of non-self-pulsing and weakly self-pulsing GaAs/GaAlAs injection lasers,” Optics Communications, vol. 34, Sept., 1980, pp.424-428. – *Identification of fundamental nature of nonlinear distortions in directly modulated laser diodes and first introduction of perturbation analytic approach for prediction of basic distortion limitations. Provides the basis of subsequent work for Hybrid Fiber Coax (HFC) distribution network designs.*

[http://www.eecs.berkeley.edu/~klau/pubs/PrincpalPubs/Lau\\_Yariv\\_1980.pdf](http://www.eecs.berkeley.edu/~klau/pubs/PrincpalPubs/Lau_Yariv_1980.pdf)

[vii.] Lau, K. Y.; Gee, C.M.; Chen, T.R.; Bar-Chaim, N., Ury, I; “Signal-induced noise in fiber-optic links using directly modulated Fabry-Perot and distributed- feedback laser diodes,”; IEEE Journal of Lightwave Technology, Volume: 11 Issue: 7, July 1993, pp. 1216-1225 – *Discovery and mitigation of a new type of noise of importance in and unique to field- installed linear (subcarrier) lightwave transmission systems.*

[http://www.eecs.berkeley.edu/~klau/pubs/PrincpalPubs/Lau\\_Gee\\_Chen\\_Bar-Chaim\\_Ury\\_1993.pdf](http://www.eecs.berkeley.edu/~klau/pubs/PrincpalPubs/Lau_Gee_Chen_Bar-Chaim_Ury_1993.pdf)

[viii.] Cutrer, D.M.; Georges, J.B.; Le, T.H.; Lau, K.Y.; “Dynamic range requirements for optical transmitters in fiber-fed microcellular networks,” IEEE Photonics Technology Letters, Volume: 7 Issue: 5, May 1995, Page(s): 564-566. – *First quantitative modeling of a fiber-fed cellular network, including RF signal processing algorithms. U.S. Patent 5,765,099 discloses its implementation in multimode fiber links which (together with CAT5 cables) constitute the standard Ethernet cabling infrastructure ubiquitous in all commercial buildings world-wide today. This patent is the key founding patent of LGC Wireless, Inc.*

[http://www.eecs.berkeley.edu/~klau/pubs/PrincpalPubs/Cutrer\\_Georges\\_Le\\_Lau\\_51995.pdf](http://www.eecs.berkeley.edu/~klau/pubs/PrincpalPubs/Cutrer_Georges_Le_Lau_51995.pdf)

<http://www.google.com/patents/about?id=1vAhAAAAEBAJ&dq=5765099><http://www.google.com/patents/about?id=1vAhAAAAEBAJ&dq=5765099>

...to be continued...

[ix.] Schwartz, A., Lau, K.Y.; “Dynamic sectorization in a CDMA cellular System employing Centralized Base Station Architecture,” **U.S. Patent 6,353,600** – *Capacity Enhancement in a Fiber-fed Distributed antenna Cellular Network by Dynamic load balancing.*

<http://www.google.com/patents/about?id=IUoKAAAAEBAJ&dq=6,353,600>

[x.] David M. Cutrer, John B. Georges, Kam Y. Lau, “Measurement-based method of optimizing antennas placement in an RF distribution system” **U.S. Patent 5,668,562** – *A design methodology for optimized placement of repeater or base station antennas in an in-building or urban wireless communication network*

<http://www.google.com/patents/about?id=dWUaAAAAEBAJ&dq=5,668,562>

[xi.] Arredondo, A.; Cutrer, D.M.; Georges, J.B.; Lau, K.Y.; “Techniques for improving in-building radio coverage using fiber-fed distributed antenna networks”, Proceedings of IEEE 46<sup>th</sup>. Vehicular Technology Conference, “Mobile Technology for the Human Race” April, 1996. vol.3.pp. 1540 - 1543 – *Performance and characteristics of an in-building fiber-fed distributed antenna network are addressed by simulation of an indoor radio environment at 900MHz, 1.8 and 1.9GHz*

[http://www.eecs.berkeley.edu/~klau/pubs/PrincpalPubs/Arredondo\\_Cutrer\\_Georges\\_Lau\\_41996.pdf](http://www.eecs.berkeley.edu/~klau/pubs/PrincpalPubs/Arredondo_Cutrer_Georges_Lau_41996.pdf)

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