Semiconductor Optical Communication Components and Devices

Lecture 1: Introduction 1 (History & trend)

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Semiconductor Optical Communication Components and Devices

Semiconductor Devices, such and sources and detectors, are the mainstay of Optical Communications, as we know it in the present day. It has become an integral part of any future development in this area. The course would include:

1. Introduction: (2Lectures)
2. Review of Semiconductors: (5 Lectures)
3. Epitaxial Growth of Semiconductors: (3 Lectures)
4. Semiconductor Optical Waveguides: (4 Lectures)
5. LED: (3 Lectures)
6. Diode Lasers: (8 Lectures)
7. Packaging: (1 Lecture)
8. Single mode Laser diodes+Reliability: (4 Lectures)
9. Photo-Detectors: (8 Lectures)
10. External Modulators: (1 Lecture)
11. Photonic Integrated Circuits: (2 Lecture)

Semiconductor Optical Communication Components and Devices :

Recommended Books - I

(1) Optical Fiber Communications:J. M. SENIOR, Prentice

(2) Optical Fiber Communication Systems: W.B. JONES, HRW

(3) Optoelectronics: An Introduction: J. GOWAR, Prentice Hall

(4) Guided Wave Photonics: A. B. BUCKMAN, H BJ/Saunders

(5) Guided Wave Optoelectronics: Ed. T. TAMIR, Springer V26.

(6) Integrated Optics:R. G. HUNSPERGER, Springer Verlag.

(7) Modular Series on Solid State Devices, Vol. VI, Ed:G. W. Neudek& R. F. Pierret: R. F. PIERRET, Addision-Wesley.

Semiconductor Optical Communication Components and Devices :

Recommended Books - II

(8) Semiconductor Optoelectronic Devices:P. K. BHATTACHARYA, Prentice Hall.

(9) Semiconductor Optoelectronic Devices: J. PIPREK, Elsevier

(10) Elements of Optoelectronics and Fiber Optics: C.-L. CHEN, Irwin

(11) Optical Electronics in Modern Communication: A. YARIV, Oxford University Press

(12) Integrated Photonics: G. LIFANTE, J. Wiley

(13) Handbook of Semiconductor Lasers and Photonic Integrated Circuits: Y. SUEMATSU & A. R. ADAMS, Chapman &Hall.

(14) Semiconductor Devices for High-Speed Optoelectronics: GIOVANNI GHIONE, Cambridge Univ. Press.

History of Long Distance Communications

776 BC : First recorded use of homing pigeons used to send message.

490 BC : Phidippides, legend goes, ran 36.2 km from Marathon to Athens to warn of an approaching Persian army.

200 -100 BC: Human messengers on foot or horseback (Egypt & China) with messenger relay stations.

4th Century AD onwards:

- **Relay of messages by drums in deep jungles of Africa.**
- **Greek Torch telegraphs.**
- **Native American Smoke signals.**
- **French semaphore towers for optical relays.**

Read more at:"All That Is Past Is Prelude…A Brief History of Communications". Communications News. Find Articles.com. 01Feb, 2012, COPYRIGHT 1984 Nelson Publishing, COPYRIGHT 2004 Gale Group.

Optical communication prevails when Bandwidth x Distance >100 Gbps.m

Outlines of Optical Communications (contd.)

Circa **2500 B.C.**: Earliest known glass.

Roman Times: Glass is drawn into fibers.

1841: Daniel Colladon demonstrates light guiding in jet of water, Geneva.

1880: Alexander Graham Bell invents Photophone, Washington.

1895: Jagadish Chandra Bose 1st demonstrated in Presidency College, Calcutta, India, transmission and reception of mm-waves at 60GHz, over 23m, through two intervening walls by remotely ringing a bell and detonating some gunpowder.

June 1953: Van Heel publishes first report of clad fiber in Dutch-language weekly De Ingeneur.

Jan 1954: **Hopkins and Kapany and van Heel publish separate papers on cladded optical fibers in Nature**

1959: Hicks, American Optical, Elias Snitzer : fibers so fine such that they act as single-mode waveguides.

May 1960: Theodore Maiman demonstrates first laser at Hughes Research Laboratories in Malibu.

Dec 1960: Ali Javan makes first helium-neon laser at Bell Labs.

1962: Four groups make first semiconductor diode lasers at the same time.

1963: Karbowiak proposes flexible thin-film waveguide.

Jan 1966: Kao tells Inst. of EE in London that fiber loss could be reduced below 20 dB/Km for inter-office communications.

Start of Transmission & evolution of Standard

The one-way transmission on Aug. 10 1876-Alexander Graham Bell able to transmit voice signals only between rooms in a building. True telephony, with two-way voice transmission came a few months later.

Basic Transmission UNIT is :

VOICE CIRCUIT-CAPACITY TO TRANSMIT VOICE

Bell System Standard done in 1980.

FOR DIGITIZED VOICE CIRCUIT 56 kbits/s

24 individual phone lines=A DS (1.5 Mbps signal) = A T1 line,

4Tl lines = A DS2 line (6.3 Mbps signal) = A T2 line

7T2 lines = A DS3 line (45 Mbitls signal) = A T3 line

9T3 lines = 405 Mbps.

USUALLY 28 DS1 lines are merged into a DS3 signal directly.

Theses are done by TDM (time division multiplexing).

International Telecommunication Union (ITU) Standard Rates (Europe & Asia)

Basic Transmission Standard - I

Rate Name	Data Rate (Mbit/s)	Voice Circuit #	Nominal Rate	
STS-l/OC-1	51. 84	672		
STS-3/OC-3 (STM-1)	155.52	2,016		India Starts
STS-12/0C12 (STM-4)	622.08	8,064		
STS-48IOC-48 (STM-16)	2,488.32	32,256	2.5 Gbits/s	Intl. 1996
STS-96IOC-96 (STM-32)	4.976.64	64,512	5 Gbits/s	Intl. 1998
STS-192/OC-192 (STM-64),	9,953.28	129,024	10 Gbits/s	Intl. 2000, India 2002
OC-768 (STM-256)	39,800		40 Gbits/s	Etectr.Lett. vol 35,
			60Km, TDM	12047(1999)
			60Gbits/s	Lab.

In 2009 a 112 Gbit/s field trial over an existing, heavy loaded real-traffic fiber link of Telefonica's network during which live traffic at 40GBps and 10GBps transmitted over 1,088 km between four cities, in Spain.

http://www.lucent.com/wps/portal

160 GBits/s Lab.

Basic Transmission Standard - II

N. American and ITU have two standards which are identical for most practical purposes:

SONET (Synchronous Optical Network)

and

SDH (Synchronous Digital Hierarchy).

STM-1& up used *for* Fiber Optic Networks.

[51.84=DS3(45)+Overhead Bits]

Overhead Bits: Monitor transmission quality and verify system operation

WDM = Wavelength Division Multiplexing,

DWDM = Dense WDM,

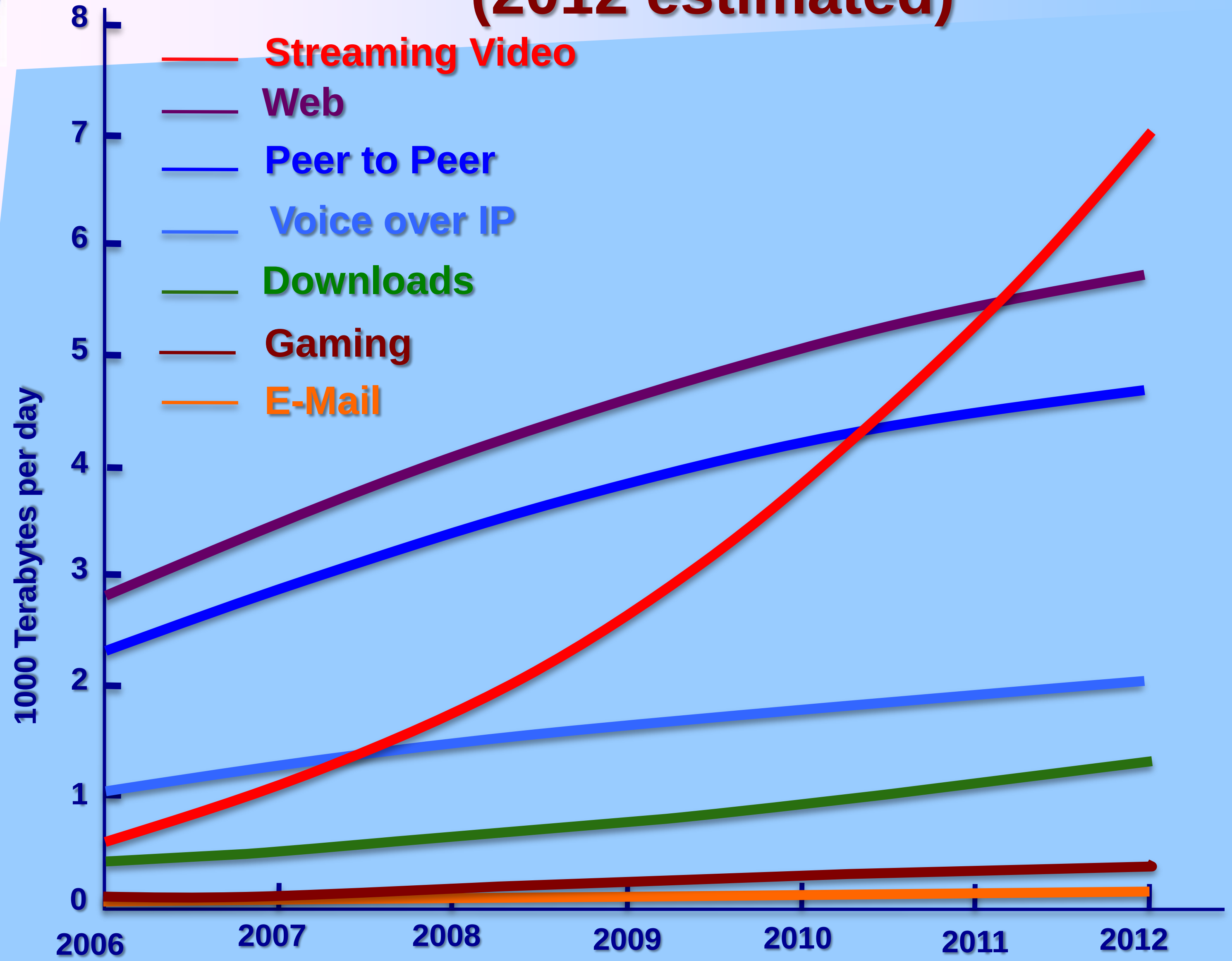
CWDM = Coarse WDM,

ATM = Asynchronous Transfer Mode

Routing : Routing is distinct from Switching,

IP = Internet Protocol

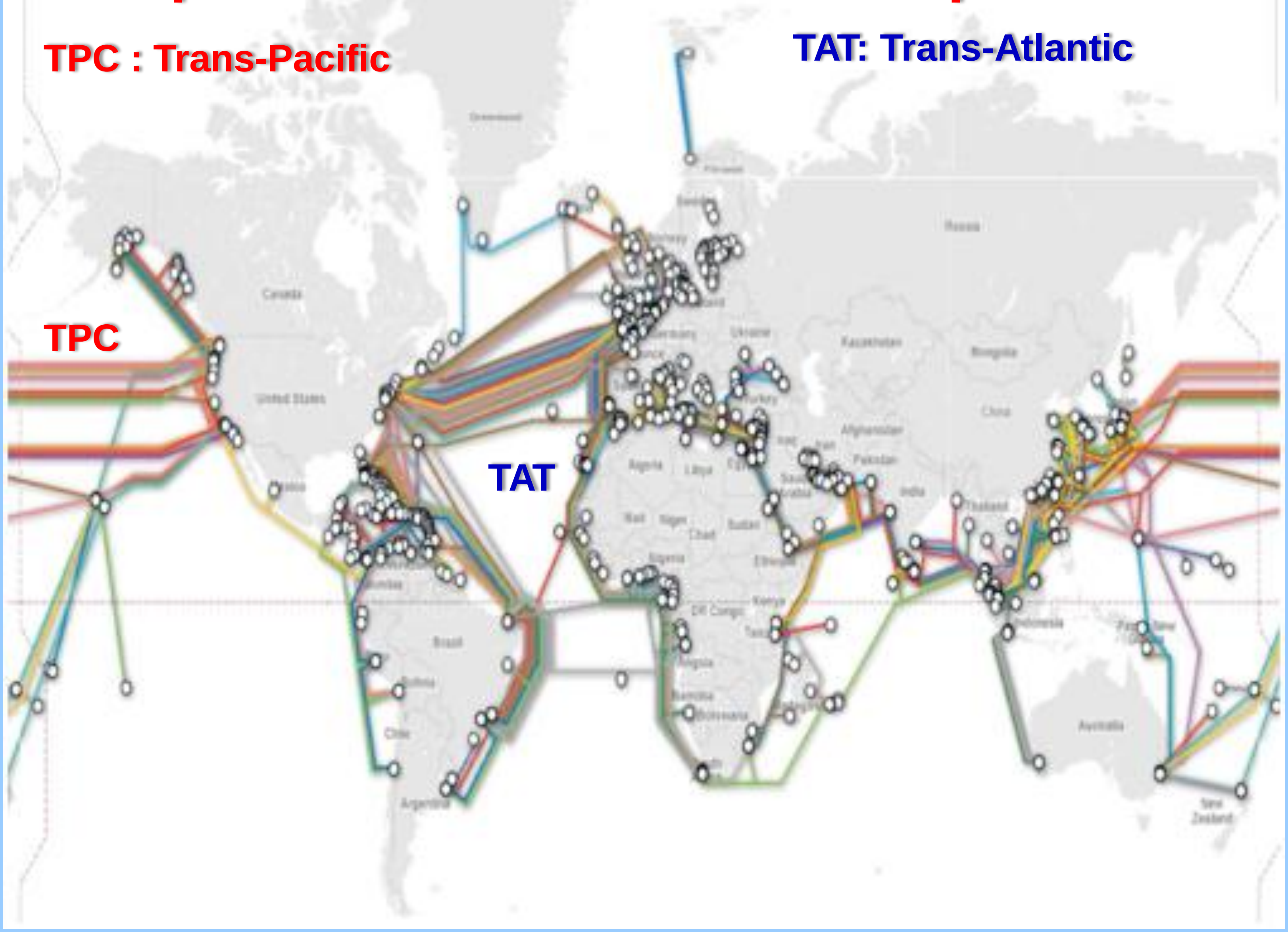
Trends of Internet usage over the recent years (2012 estimated)



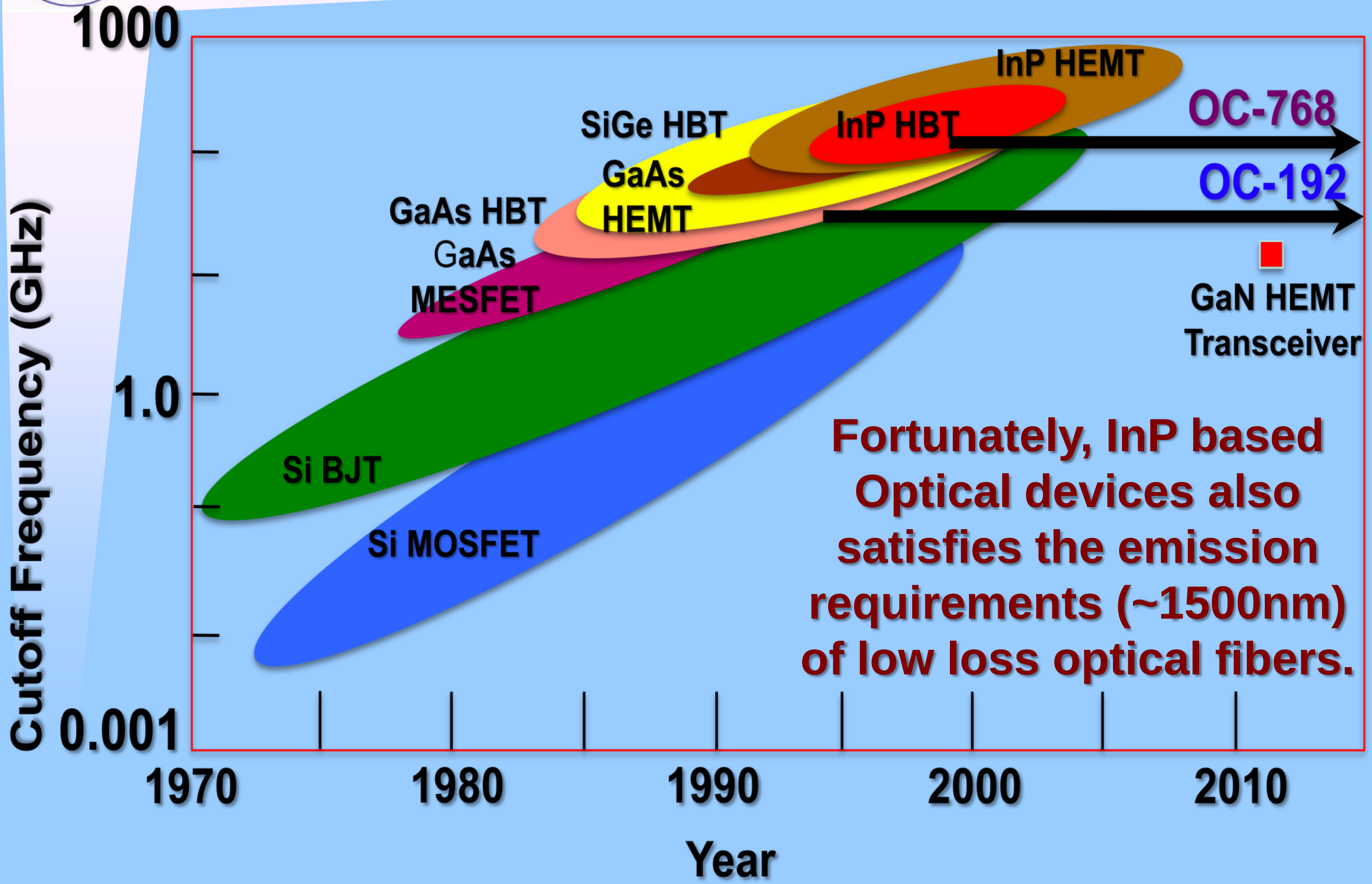
IDC Report on U.S. Consumer Internet 2007-2011: Forecast, June 2007

Undersea Fiber-optic cables around the world 2012

http://www.submarinecablemap.com/

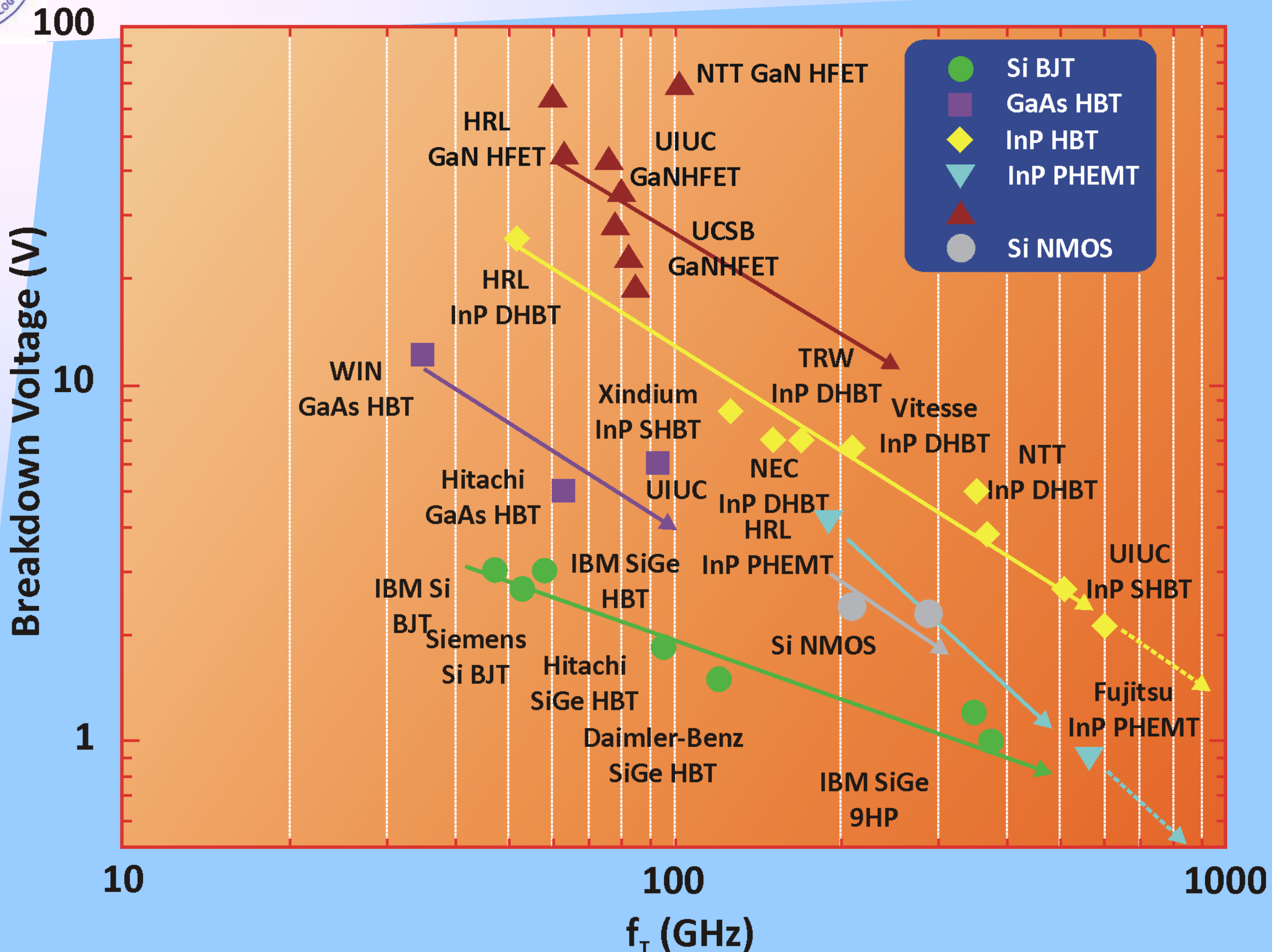


Competing Technologies for implementation of Optical communication Integrated Circuits



Fortunately, InP based Optical devices also satisfies the emission requirements (~1500nm) of low loss optical fibers.

Overview of the competing technologies

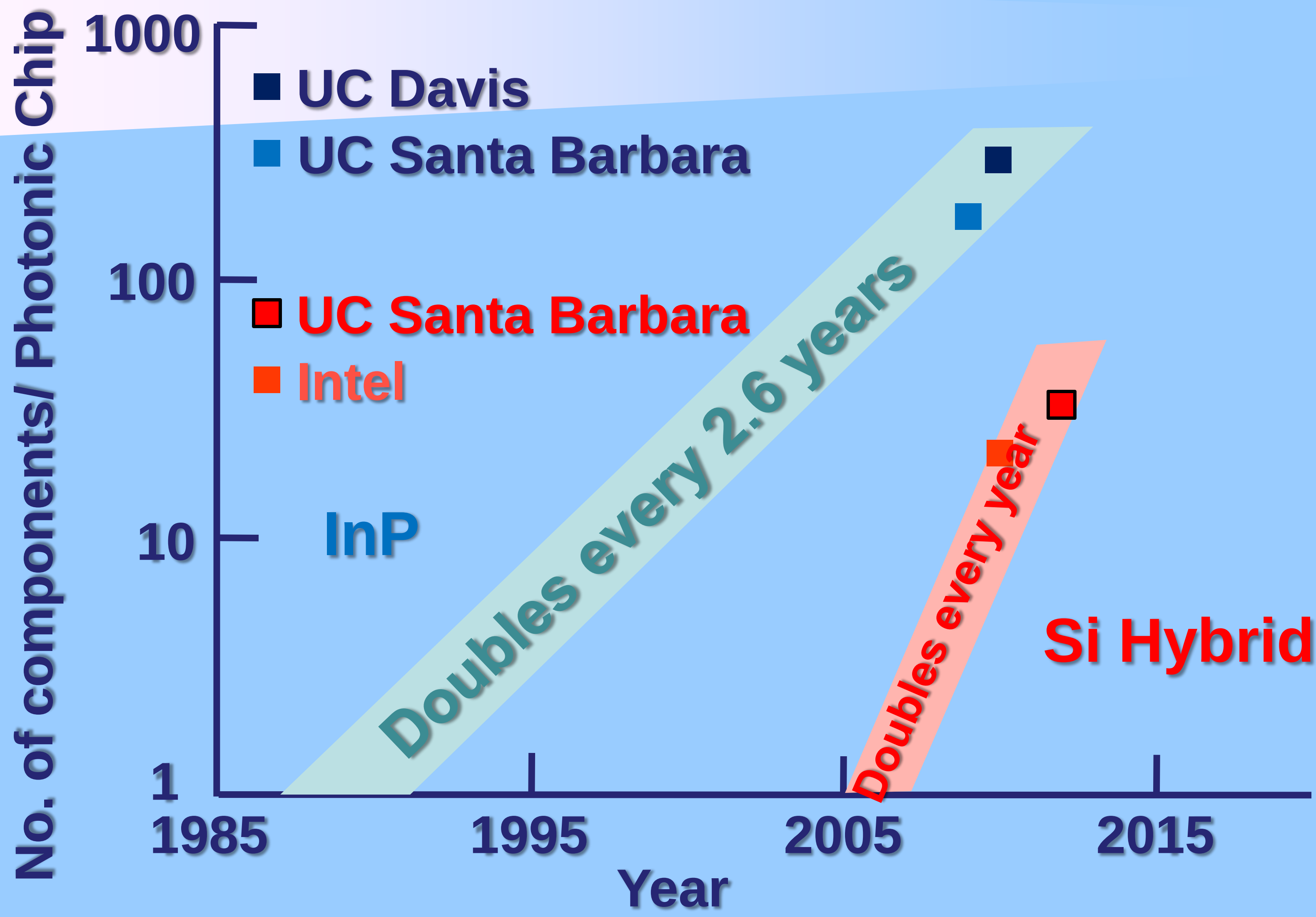


Competing Technologies for implementation of Optical communication Integrated Circuits –Contd.

Optical: 10-40Gbit/s the chromatic (16X) & polarization-mode dispersion (2-4X), respectively, while 40 Gbit/components are not yet qualified in volumes.

Electronics: Indium Phosphide (InP) or Silicon-Germanium (SiGe) - is still very expensive. CMOS at 40Gbit/s, is also expensive. Most of the cost of the electronics is in the testing, so CMOS doesn't offer advantage at high data rates.

Silicon Hybrid: InP based sources coupled to Silicon-on-Insulator based waveguides, electro-optic ring modulators, and Silicon Avalanche Photodiodes are playing catch up.



JSTQE-INV-SL-04600-2012, M. J. R. Heck, J. F. Bauters, M. L. Davenport, J. K. Doylend, S. Jain, G. Kurczveil, S. Srinivasan, Y. Tang, and J. E. Bowers.

Laser Photonics Rev., M. Smit, J. van derTol, and M. Hil, Vol 6, No.1 (2012)