

# Power Laser Trends

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# Power Laser Trends

- Distinguish between Non-Diode and Diode Laser Market
  - Non-Diode laser market
    - All lasers except direct diodes, i.e. CO<sub>2</sub>, lamp and diode pumped SSL, fiber laser
    - 2.7B\$ in 2008, good profitability, future growth rate of 4% (12% over last 4 years)
      - Enables 56B\$/year systems market
  - Diode laser market
    - Direct Diodes (telecom, consumer, and pump lasers)
    - 3.8b\$ in 2008, poor profitability, long term growth rate of 2%
      - Enables 20B\$/year comm systems, and even larger optical storage, consumer market
- Distinguish between assembly line and fab technology
  - Assembly line technology
    - Classical lasers (CO<sub>2</sub>, SS, Ion, Dye, Excimer) are produced in assembly line
  - Fab technology
    - Diode lasers and fiber lasers are produced in fabs (high fix cost, small variable cost)
  - Hybrid technology
    - Disk, DPSS are assembling fab technology

# Non-Diode and Diode Lasers

- **Non Diode Laser**

- Optical material (Ions in crystal or glass, gas, dye) which lases. Need light (lamp, pump diodes) or discharge to supply energy.
  - Efficiency: low% up to 35% (fiber laser, disk laser)
- Wavelength bands between 0.1 $\mu$ m and 10 $\mu$ m
- High radiance: 10mW..10kW/mode  
== 1MW..10GW..1000GW/cm<sup>2</sup> ster
- Technologies
  - Assembly (Excimer, Ion, CO<sub>2</sub>)
  - Hybrid (Disk, DPSS)
  - Fab (fiber lasers) technology

- **Diode Lasers**

- Photonic material which converts directly current into laser light
  - Efficiency up to 70% (fiber coupled: 50%)
- Wavelengths between 0.4 and 1.5 $\mu$ m ..5 $\mu$ m (green gap)
- Limited radiance: 10mW..1W/mode  
== 1MW..0.1GW/cm<sup>2</sup> ster
- Fab technology

# Total Laser Market Size

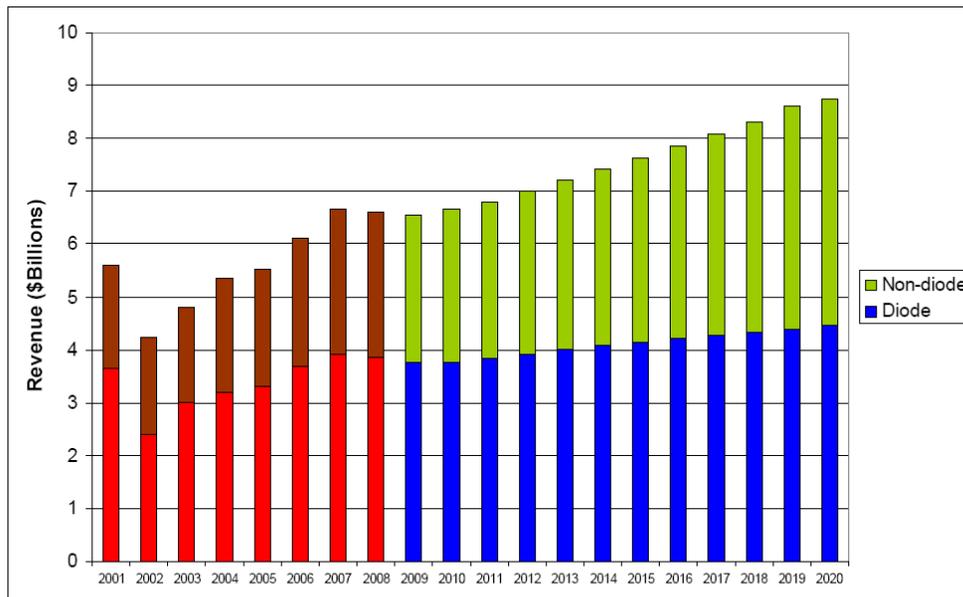


Figure 2.1: Global Commercial Laser Revenue Performance and Forecast, 2001-2020

Sources: IOA, Laser Focus World, OIDA, OIDA members

- **Non-Diode**
    - Moderate growth (4%) expected through adoption of laser processing in new markets
  - **Diode**
    - Slow growth (2%): Competing technologies for laser diode optical storage, sensing erode diode market
- Diode technology („telecom refugees“) penetrate through diode pumped disk, rod and fiber lasers into „non-diode segment“

# Non-Diode: Key Markets Segments

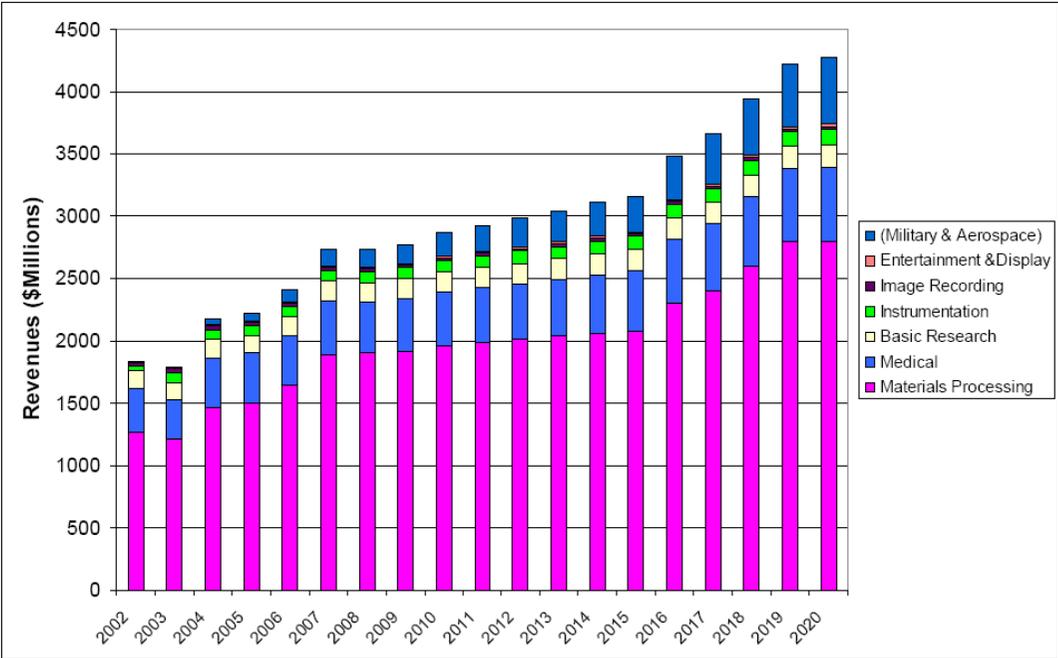


Figure 2.6: Global Nondiode Laser Revenue and Forecast by Key Segment, 2002-2020

Sources: IOA, Laser Focus World, OIDA, OIDA members

- Dominated by material processing, followed by medical
  - Growth in material processing and military (death ray)
- Material processing is Swiss key industry (Laser beam tool)

# Non-Diode: Technologies

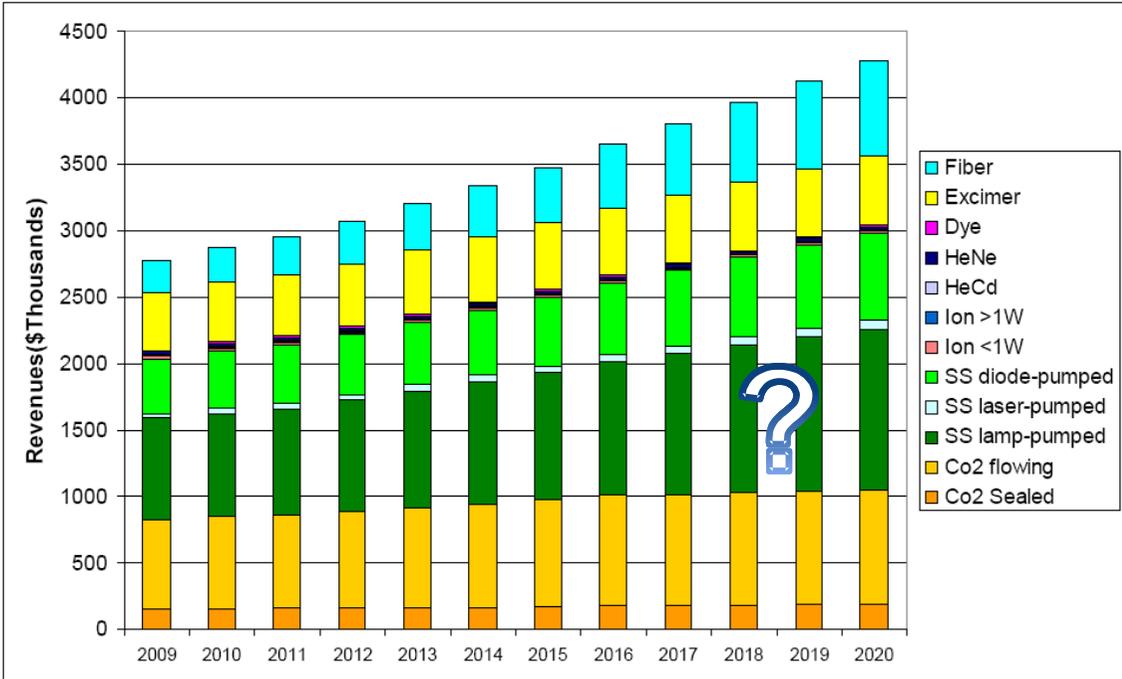


Figure 2.12: Nondiode Laser Revenue Forecast by Type, 2009-2020

Sources: IOA, Laser Focus World, OIDA, OIDA members

- Assembly line vs fab technology: In future
  - CW SS lamp pumped will be replaced by direct diode or fiber laser (power efficiency)
  - Fab technology (direct diode/fiber laser) growing. By 2020 will be >40% share

# Non-Diode: Summary

- CW
  - Efficiency will become more important and favour diode/ fiber laser technology:
    - Excimer: 0.2..2%, CO<sub>2</sub>: 5%..20%, Fiber, disk: ..35%, Direct Diode: ..50+%
  - Assembly vs fab
    - Fab needs high volume. Fab (diode, fiber) will win market share. CO<sub>2</sub> will have
  - Fiber delivery
    - Fiber delivery is important advantage
- Pulsed
  - Moderate pulses can be done by fiber or diode
  - Very high power Q-switching: Territory of lamp pumped SS
- Pico, Femto
  - Domain of hybrid technology. Market will grow with new applications
  - 100W Pico lasers and many femto lasers available. Looking for application development
- CO<sub>2</sub>
  - Coherent shows small 1kW CO<sub>2</sub> laser, mountable on robot arm for 3-d cutting

# Diode Lasers: Key Markets

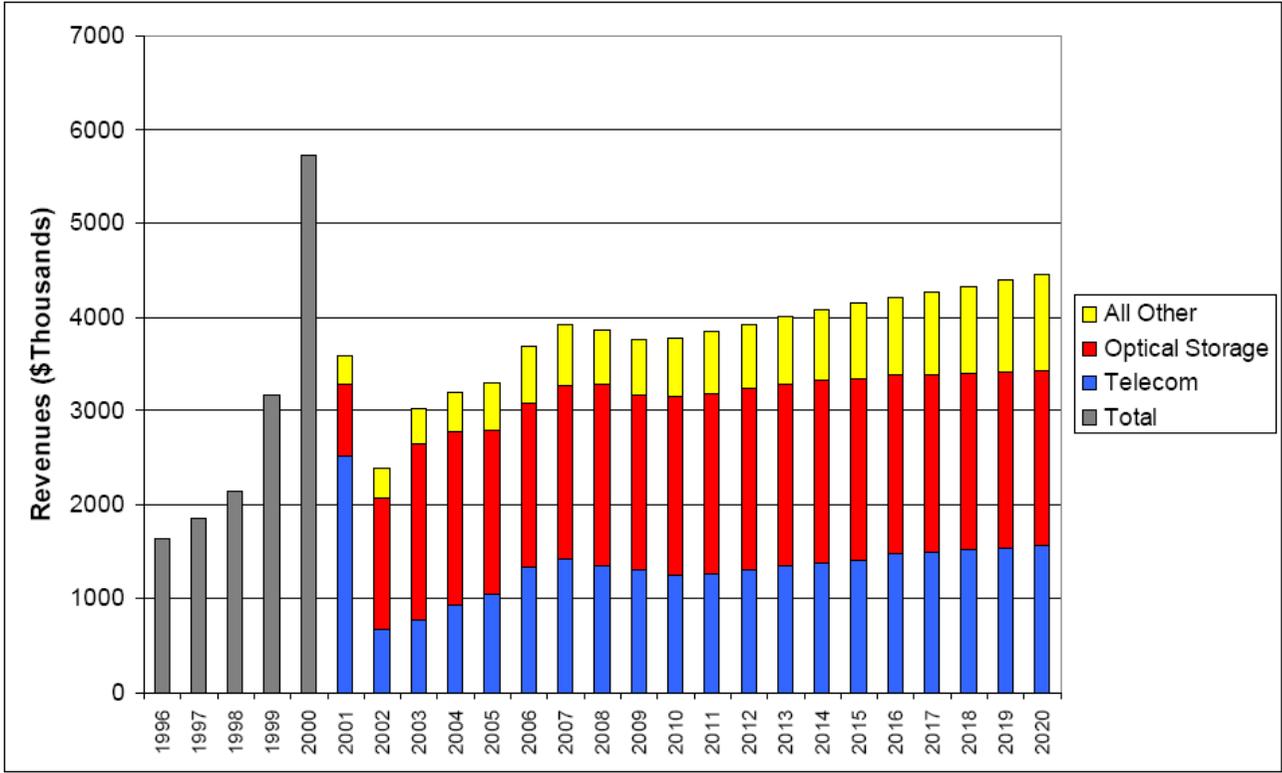


Figure 2.18: Global Laser Diode Market History, 1996-2020

Sources: IOA, Laser Focus World, OIDA, OIDA members, Pennwell

- Dominated by Telecom and Optical storage

# Diode Lasers: Key Markets

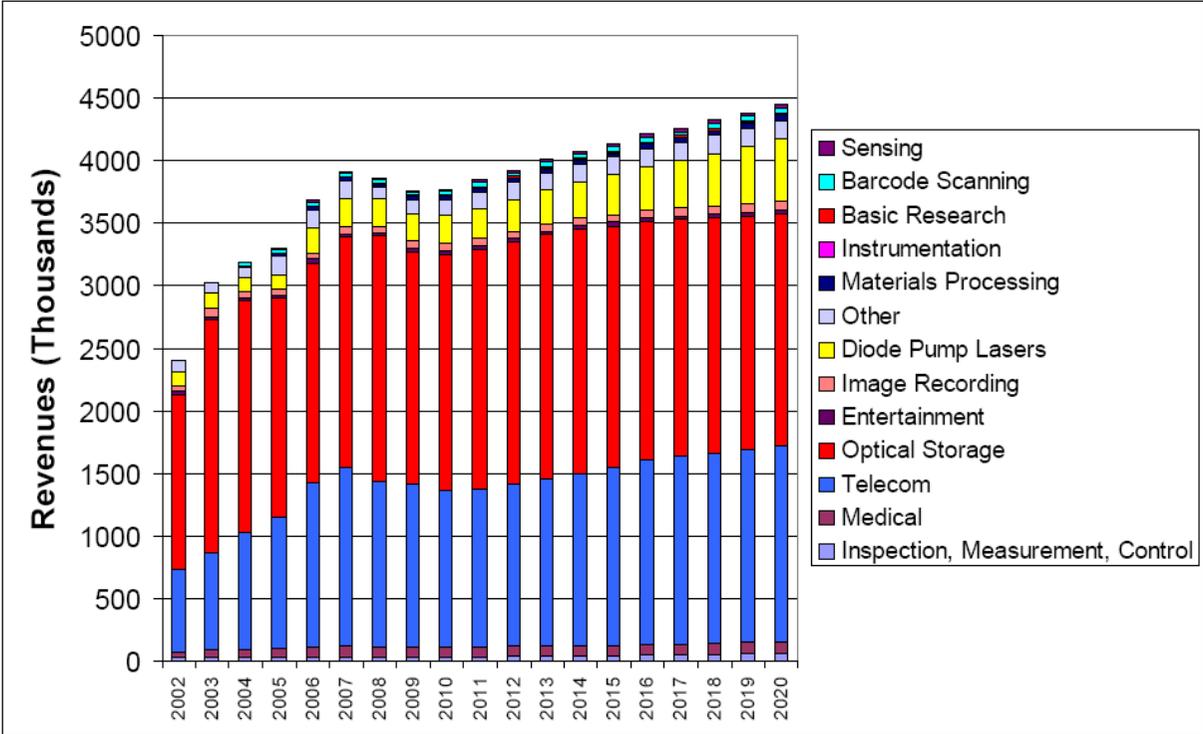


Figure 2.20: Global Laser Diode Revenue and Forecast by Segment, 2002-2020

Sources: IOA, Laser Focus World, OIDA, OIDA members

- Key markets
  - Optical storage, telecom: 80% of total market
  - Diode pumps: 7% growing to 15%

# Diode Lasers: Telecom Group

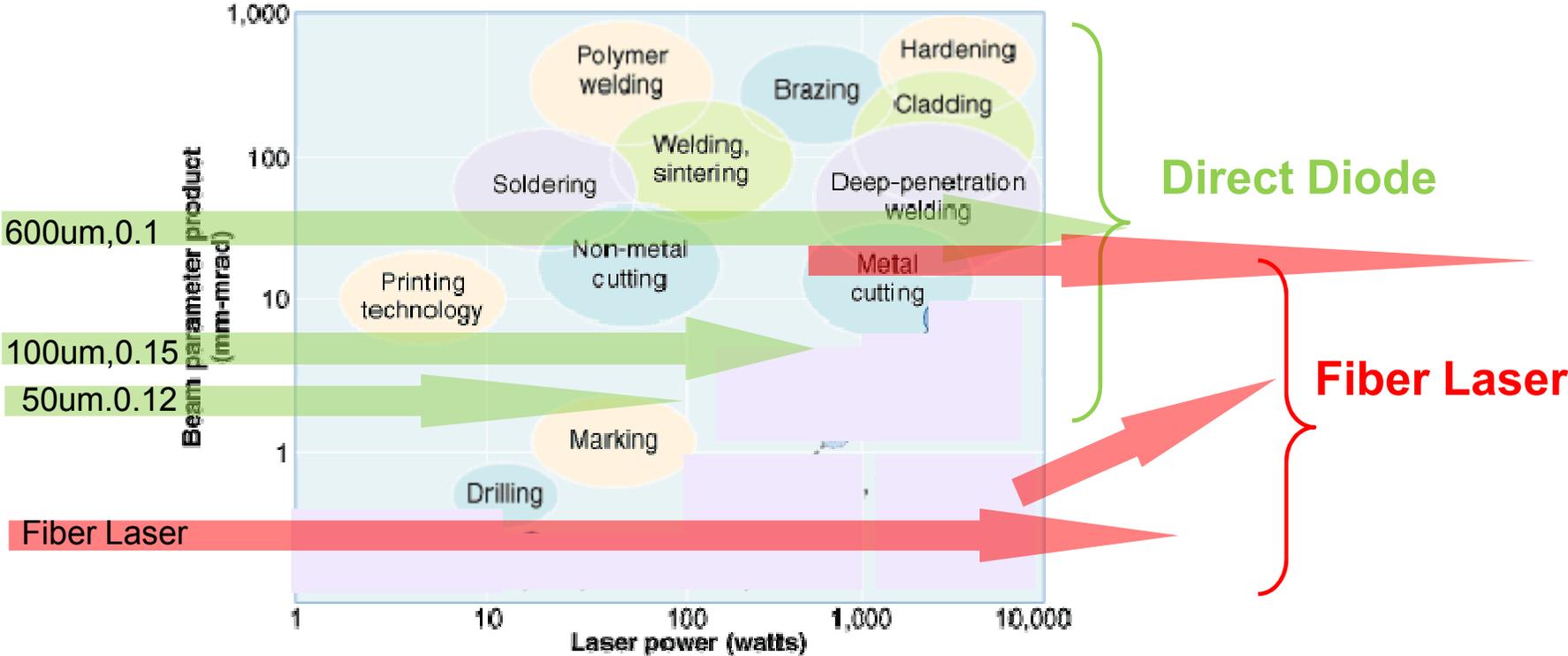


- Group:
  - JDSU (Acterna, Dynatech, Uniphase, E- Tek Dynamics, SDLI); Finisar (Optium); Oclaro (Bookham, New Focus, Avanex); Oplink (OCPI); and Opnext
- Over 12 years:
  - 72B\$ loss on 23B\$ revenue, 1 year (1997) profitable
- Looking aggressively for new markets (> Industrial applications), pushing limits

# Diode Lasers: Industrial Companies

- 2004
  - Fab overcapacity from Telecom group for diodes and fibers
  - Push into new markets to fill capacity („telecom refugees“)
- From 2006
  - Industrial companies are building up own diode fab, aquired fiber fabs and built up fiber laser assembly. Assembly line thinking? Vertical integration?
  - > Adding fix cost to industrial companies, squeezing „telecom refugees“
- 2008: Huge wafer- and fiberfab and fiber laser assembly overcapacity
  - Jenoptik diode labs, Osram, Rofin Sinar, Oclaro, 3S Photonics, Intense, Trumpf Photonics, IPG, Lasertel, Newport, JDSU, Coherent, Nlight, Hamatasu, Sony, ...)
  - IPG, SPI, Rofin, Jena, Newport, Coherent, Trumpf, .....
- 2009: Started consolidation
  - Diode fabs: Newport line to be absorbed by Oclaro, many more to come
  - Fiber laser: SPI aquired by Trumpf (Own fiber laser: Not present in Munich), Jenoptik using SPI engine, ...
- Expensive detour will end in a few years (hopefully)

# Direct Diode and Fiber Laser CW Map:



Direct Diode: Base of arrow: Commercial, Tip of Arrow: Projected for single wavelength, single polarization (at 1W/mode)

Fiber laser: Base of arrow: Commercial, Tip of arrow: projected

# Diode Lasers: Summary

- Direct Diode
  - 30W (105um/0.15): Oclaro, IPG, Limo (0.22).
  - 100W (105um/0.15): Trumpf (bar), Oclaro (multiple SE), Jenoptik (announced), ..
  - 4kW (600um/0.1): Laserline (MCC, free space), Trumpf (100W combined with fiber and WDM).
    - To replace lamp pumped SS lasers
- Fiber laser
  - 4kW (25mm mrad, equiv to 300um/0.15): IPG for 40..50\$/W:
    - Replace lamp pumped SS lasers and direct diodes
  - 10kW SM (IPG prototype) ( $10^{12}$ W/cm<sup>2</sup>ster) for 1000\$/W.
  - kW product from Rofin Sinar
  - Many high power fiber laser companies have stopped effort and use IPG or SPI OEM parts:
    - IPG (Han lasers, .., ..)
    - SPI (Trumpf, Jenoptik, ..)