Lucent Technologies
Bell Labs Innovations

10 Gb/s Multimode Fiber Standards Update and 850 nm Justification

Paul Kolesar and Keith Goossen
Lucent Technologies

for

IEEE 802.3 HSSG

Montreal, July ‘99

Standards Update

Objectives - Next Generation MMF Cabling

- Support lowest cost/complexity system solution
- Support legacy LAN applications
- Remain friendly for cable manufacturer and installer
- Provide migration path to at least 10 Gbps with achievable technology
- Meet the needs of in-building network applications with a single universal medium

What is Lowest Cost @ 10 Gbps?

- Transceiver
  - Serial Transmission (no WDM)
  - Direct Modulation (no external modulators)
  - Uncooled and unisolated lasers (no extra components)
  - VCSELs (low-cost surface emitting laser)
  - Multimode specific solution (no SMF tolerances)
- Media
  - Multimode Fiber Cable (single universal media)

Proposal to TR42

- Add a new 50 µm performance level in addition to existing 50 µm specification
  - Bandwidth:
    - 500/500 MHz-km at 850/1300 nm with over-filled launch
    - 2200/500 MHz-km at 850/1300 nm with “laser” launch
  - Attenuation: 3.5/1.5 dB/km at 850/1300 nm
- Reduce building backbone distances to 300 m including patch cords

Letter from US TAG to IEC SC86A

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US TAG: IEC SC86A

To: John Siemon, Chair USTAG to ISO/IEC JTC 1/SC 25/WG 3

cc: TIA TR-42.8 Chair: Tony Beam
TIA FO-2.2 Chair: Don Knasel

From: US Technical Advisory Group to IEC SC 86A

Subject: TIA TR42.8 Proposal Regarding Next Generation Optical Fiber

Date: 18-June-99

Dear Sirs:

Thank you for the opportunity to provide comments on the proposal to modify IS 11801. We are generally supportive of the proposals contained in the presentation (by Steve Swanson and Paul Kolesar) you provided. The proposal summary is to add the following performance levels to the 50 µm multimode cabled fiber documentation:

500/500 MHz•km	@ 850/1300 nm	overfilled Bandwidth
2200/500 MHz•km	@ 850/1300 nm	"laser launch" Bandwidth
3.5/1.5 dB/km	@ 850/1300 nm	cabled fiber attenuation

Relative to SC 86A documentation, these proposals would affect three documents: optical fiber specifications (bandwidth requirements), optical fiber cable specifications (attenuation requirements), and optical fiber test methods (laser launch). With the exception of the aspect relating to "laser launch," revisions are in progress to support these proposals. The following ballots and activities pertain to the proposals:

86A/466/CD revision to IEC 60793-2, Optical Fiber Specifications: Simplifies the normative clause for bandwidth by naming ranges of specifiable values. Adds informative annexes to give an indication of the Application Standards and the fiber specifications that support them. This will go forward as a CDV ballot in the the next months, with editorial changes for clarification. Overfilled launch 500/500 @ 850/1300 nm for 50 µm multimode fiber is noted as a specification that supports many Application Standards.

86A/xxx/CD revision to IEC 60794-1-1, Optical Fiber Cable Specifications. This ballot has been agreed by the cable group, 86A/WG3, and is in the process of being issued. It inserts the cabled attenuation performance requirements at the top of the specification hierarchy, in clause 5.1. The maximum values for 50 µm multimode fiber are 3.5/1.5 dB/km @ 850/1300 nm. An informative annex indicating the Application Standards is also proposed.

Note: Revisions to the single-mode fiber attenuation values in the ITU Recommendations are being proposed. We anticipate that when these values are agreed, the IEC values will be aligned.

86A/453/CD, Creation of a new document, IEC 60793-41, Bandwidth measurement method. This is part of a restructuring of the optical fiber test methods into a one document per attribute organization. Although 86A/WG1 recognizes the need for improvements, this will advance to CDV in the next months. The working group has agreed in principle that an improvement project should be initiated in parallel. When the "laser launch" requirements have been defined and agreed within the TIA FO-2.2 task group, we plan to add these aspects to the improvement project.

Formation of a new Task Group, SC86A/WG1/TG3: The purpose of this task group is to modernize the performance requirements of 60793-2, the fiber specifications. Depending on the timing of "laser launch" definitions – and agreement on the 2200/500 proposal, this aspect could be incorporated into the group of changes that are initiated by this task group. The SC86A TAG will wait for agreement and liaison from the JTC1-SC25/WG3 TAG before proceeding with action on this point.

Sincerely

Tom Hanson, Technical Advisor to the US TAG to IEC SC-86A

Letter from TIA FO2.2

To: John Siemon, Chair ISO/IEC JTC1 SC25/WG3 USTAG

From: Don Knasel, Chair TIA FO-2.2

Subject: TIA TR-42.8 Proposal Regarding Next Generation Optical Fiber

Date: June 15, 1999

Dear John:

FO-2.2 recently completed our plenary sessions during the week of June 14 in San Juan. We currently have a development activity aimed at defining transmitter launch conditions and fiber test methods necessary to support enhanced performance on multimode fiber. The current work targets 850nm operation and addresses both 62.5um and 50um fiber. The technical work necessary to support the Next Generation multimode fiber proposal is a logical step in that development process.

A number of activities are in process that are expected to yield the necessary test methods in draft form by the end of 1999. A validation experiment is currently underway. Its purpose is to achieve enhanced system performance by combining restricted launch power distribution from the source and new fiber characterization.

FO-2.2 can continue to provide liaison to the US TAG to SC25/WG-3 on this subject. Paul Kolesar and Steve Swanson, who were both present at the San Juan meeting, can provide further information, if necessary, on your June 21 teleconference.

Sincerely,

Don Knasel, Chair TIA FO-2.2

Letter from ISO/IEC SC25 WG3

REPORT FROM OPTICAL FIBRE AD-HOC GROUP

SUBJECT: Liaison Report to IEEE 802.3

To: IEEE 802.3

From: ISO/IEC JTC1/SC25/WG3

Subject: Next Generation Multimode Optical Fiber

Date: June 30, 1999

ISO/IEC JTC1/SC25/WG3 met during the week of June 28 in Berlin.

Based on a contribution from the US National Committee, ISO/IEC JTC1/SC25/WG3 has established a development activity aimed at defining next generation fibre specifications to support multi-gigabit applications on multimode fiber. The development activity is currently focused on the following:

- 850nm operation
- 50um multimode fiber (but does not rule out 62.5um multimode fiber)
- Support for 10Gbps applications over 300 meters of multimode fiber

ISO/IEC JTC1/SC25/WG3 has also requested the cooperation of IEC SC86A in this activity.

We believe the technical work necessary to support the enhanced multimode fiber specifications is a logical step in the development process for our revision of ISO/IEC 11801. We request your consideration of our work and welcome your input.

Standards Progress Summary

- TIA TR-42 accepted joint Corning / Lucent proposal (TIA 568B premises cabling standard)
- TR-42 recommended proposal to the US TAG to ISO/IEC SC25/WG3 (IS 11801 cabling standard)
- Supported by US TAG to IEC SC86A (fiber/cable)
- In line with TIA FO2.2 work plan (test procedures)
- Accepted by US TAG as US National Contribution to ISO/IEC SC25/WG3 (IS 11801)
- Proposal accepted by ISO/IEC SC25/WG3 as basis for definition of next generation MMF

850 nm Justification

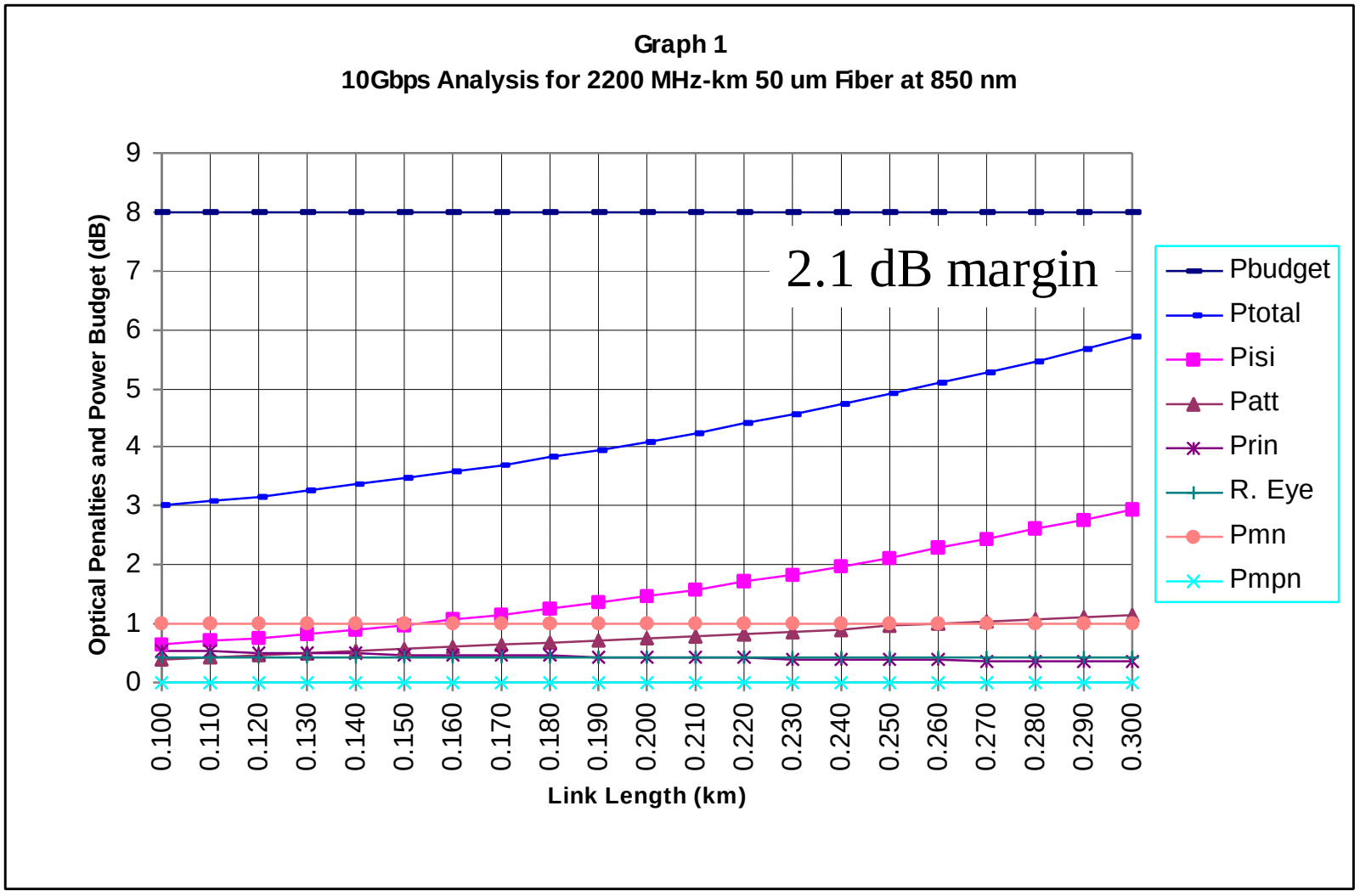
10G 850 nm Power Budget

- Transmitter Average Power Range: -3.7 to -8 dBm
- Receiver Average Eye-Center Sensitivity: -16 dBm
- Optical Power Budget: 8 dB

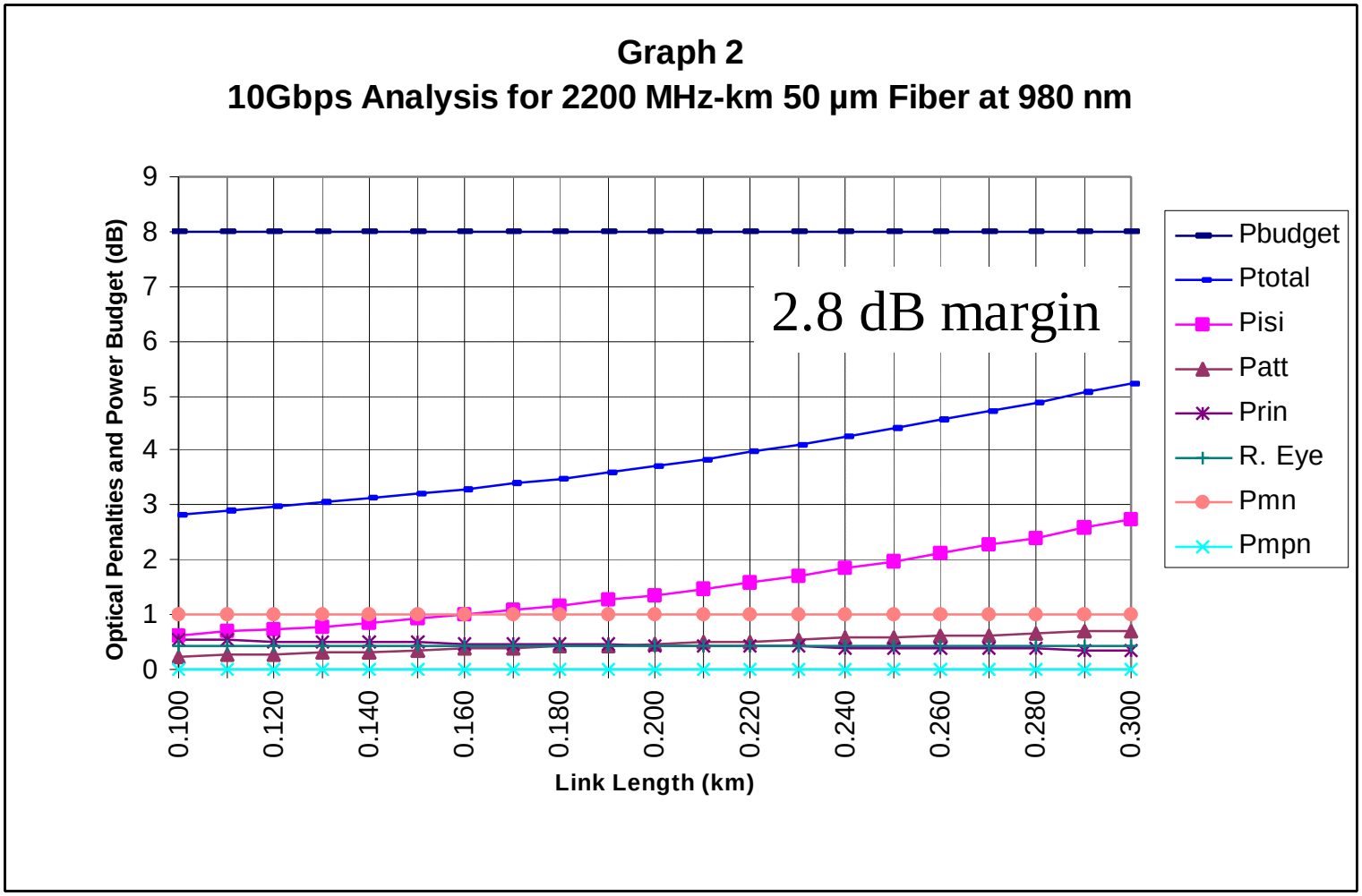
- 4.3 dB Tx power range is only 0.1 dB tighter than the 4.4 dB range of GbE (-5.1 to -9.5 dBm spec for CD lasers)
  - Monitor photodiode commonly used today to stabilize power output
  - Easier to couple 10G (STM) VCSELs than 1G (MTM) VCSELs

- -16 dBm 850 nm receivers are already available
- 10G 850 nm VCSELs demonstrated by at least 3 labs

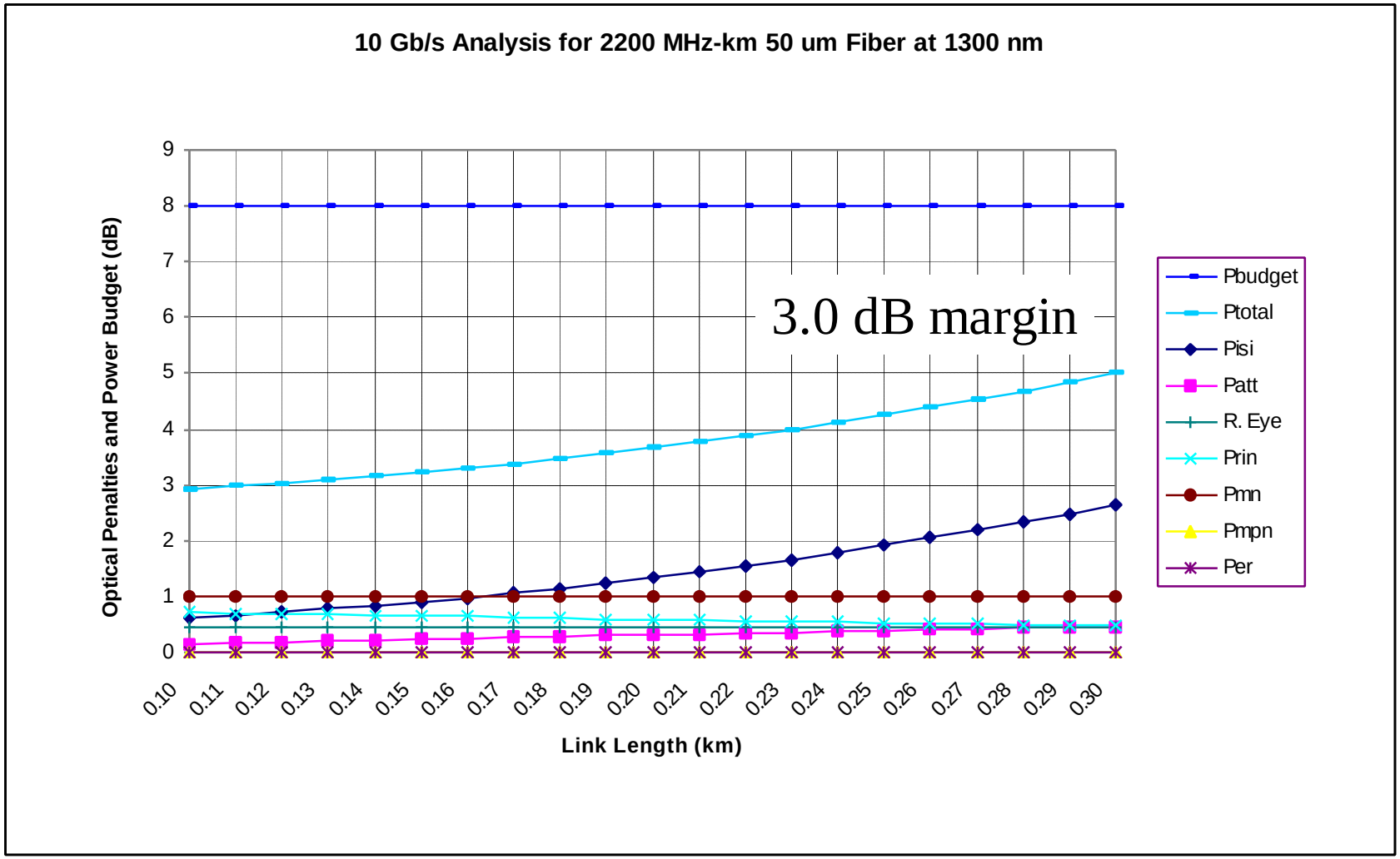
Link Analysis at 850 nm



Link Analysis at 980 nm



Link Analysis at 1300 nm



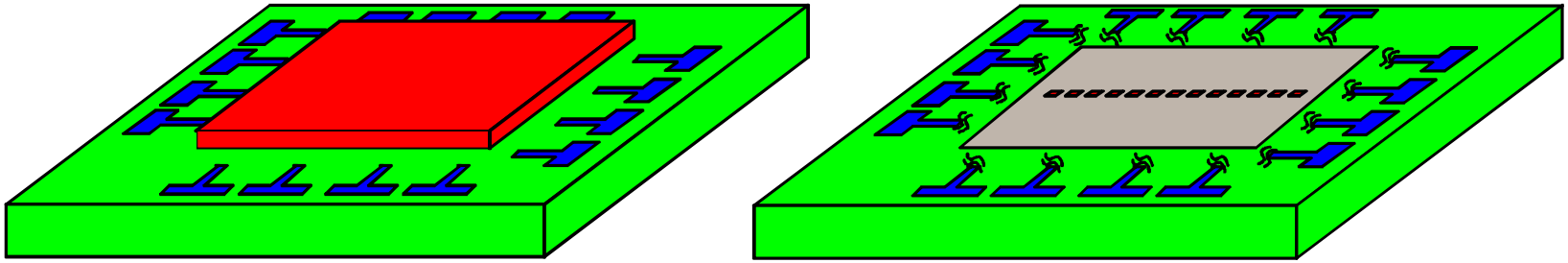
Wavelength Option Analysis

- Technical:
  - Operation at 850 needs 0.7 dB more power than at 980 and 0.9 dB more than at 1300 nm for same margin
  - Eye safety limit is 2.6 dB higher at 980 and 13.2 dB higher at 1300 than at 850 nm
  - IEC eye safety limits may increase 80% (2.5 dB) @ 850
  - Eye safety advantages of 980 and 1300 more important for parallel arrays, not serial transmission on MMF
  - Advanced receivers mitigate the system impact and allow 850 operation with reasonable tolerances
  - 850 nm VCSELs proven reliable in LAN, not 980
  - 850 allows integrated GaAs detectors & preamps, not 980
  - Flip-Chip Bonding not limited by wavelength

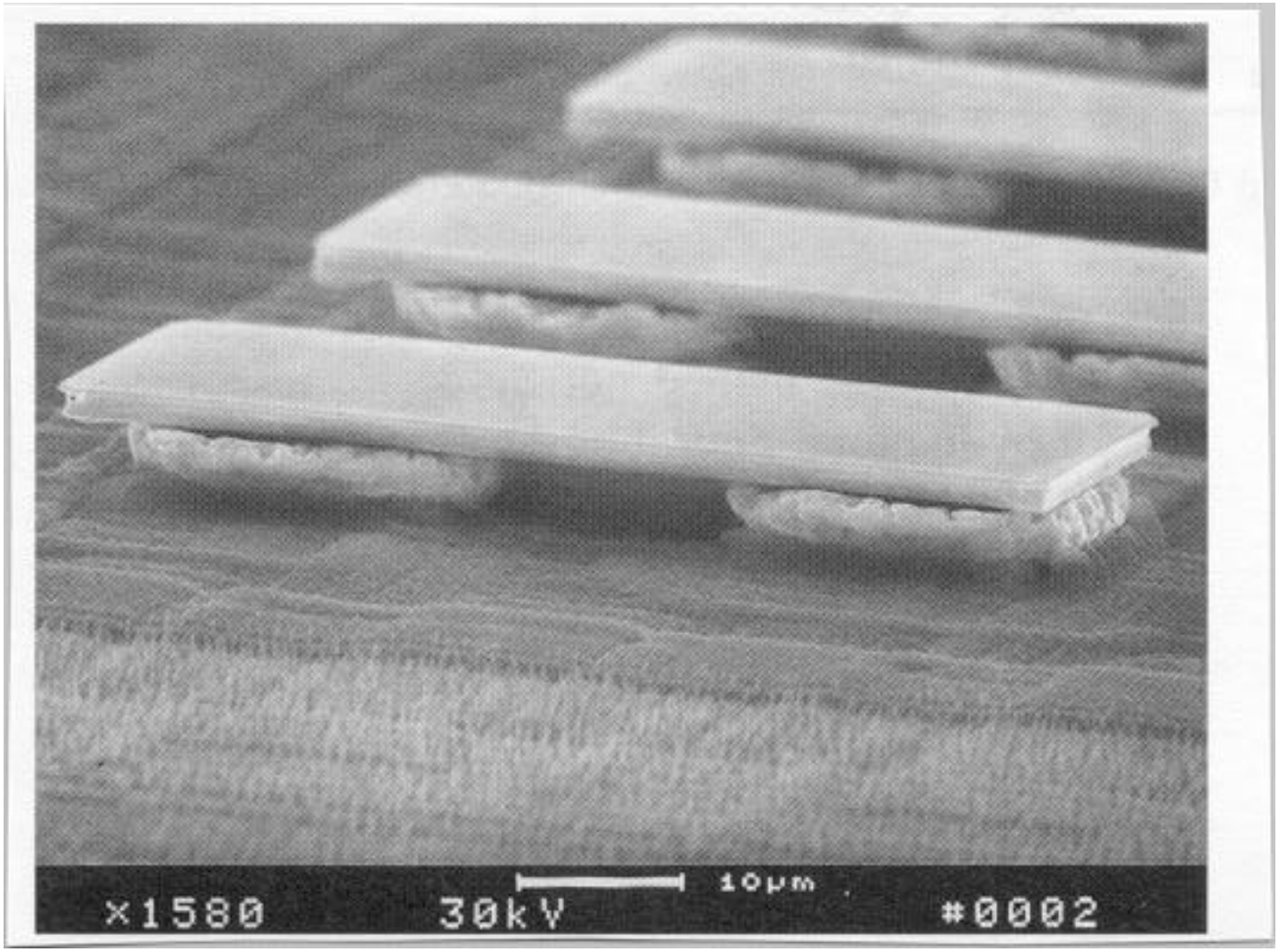
Flip-Chip Bonding
Not Limited by Wavelength Choice

Flip-chip bonded optoelectronics
- GaAs substrate: opaque < 880 nm
- InP substrate: opaque < 960 nm

Substrate removal via chemical mechanical polishing to 100 um followed by etching, which stops on built-in stop etch layer
- Minimal cost
- Allows operation at all wavelengths



GaAs Flip-Chip Bonded Detectors with removed substrates



Wavelength Option Analysis

- Fiber and Cable Manufacturing:
  - Fiber manufacturing test equipment operates at 850, 1300, and 1550 nm
  - Multimode fiber tested at 850 and 1300
  - 980 nm equipment not available
  - Problems are duplicated for Cable Manufacturers
  - Adding 980 requirements adds test-cost and delays products

Wavelength Option Analysis

- Market:
  - 850 and 1300 are accepted MMF operating points
  - 980 must overcome 15 years of inertia
  - 980 requires new test gear for installers (OLTS & OTDR)
  - Field test equipment not available for 980 nm
  - 3rd λ adds 50% more field test measurements
  - Installed base not characterized / specified at 980, limiting CWDM appeal near 980
  - No 980 xcvrs on market vs multiple 850 vendors
  - 1000BASE-SX is ~90% of GbE market
  - 980 barriers limit its market appeal

Wavelength Option Analysis

- Standards:
  - 850 or 1300 allow common xcvr for 1G to 10G apps
    - enables Auto Negotiation
  - 1300 solutions historically required to support SMF
  - 980 may inter-operate with -LX, but is not compliant
  - 980 proposals rejected by ATM Forum
  - 850 and 1300 are defined in MM fiber & cable specs
  - adding 980 requires revising all fiber and cable standards and some application standards

Wavelength Option Analysis

- Conclusions:
  - 980 and 1300 offer some technical advantages over 850 that are mitigated by new receivers
  - Manufacturing and installation test-costs increase and products delayed by adding 980 requirements
  - Market acceptance of a new wavelength is not assured. Must overcome significant barriers that could limit appeal of technology.
  - Standards absent 980 specs, requiring major effort
  - 1300 leads to higher cost due to SM tolerances
  - 850 has greatest potential to meet objectives