Dense Wavelength Division Multiplexing Technologies for Local Access Networks

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presented at the DARPA Workshop on WDM

McLean, VA

April 18-19, 2000

Low-Cost Dense Wavelength Division Multiplexing Technologies for Local Access Networks

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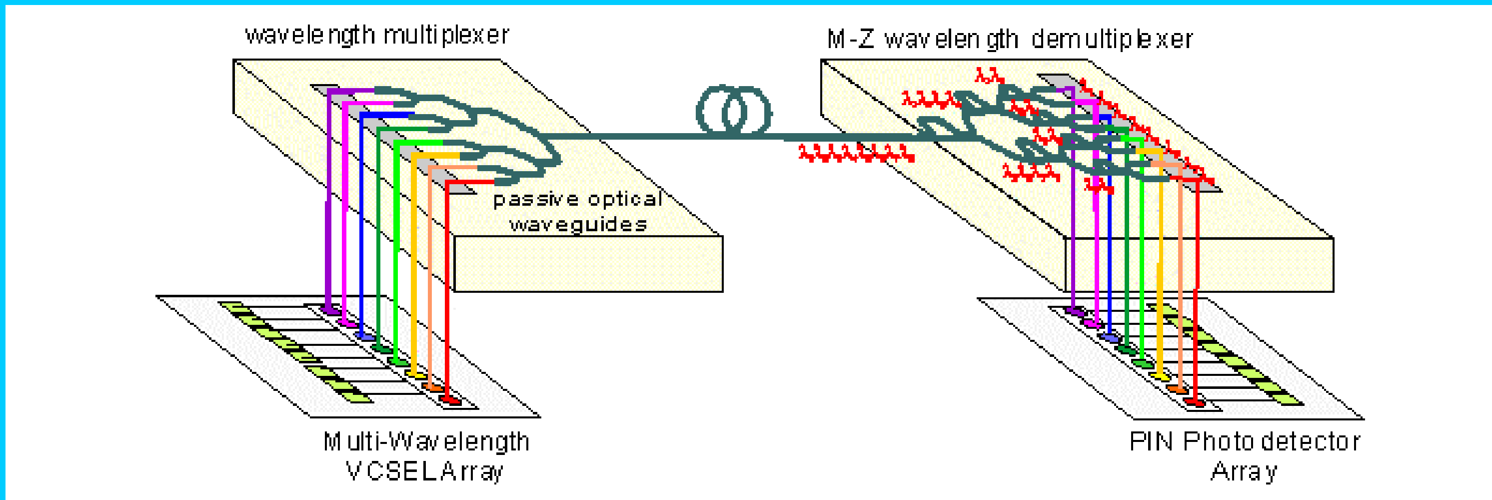
Objective:

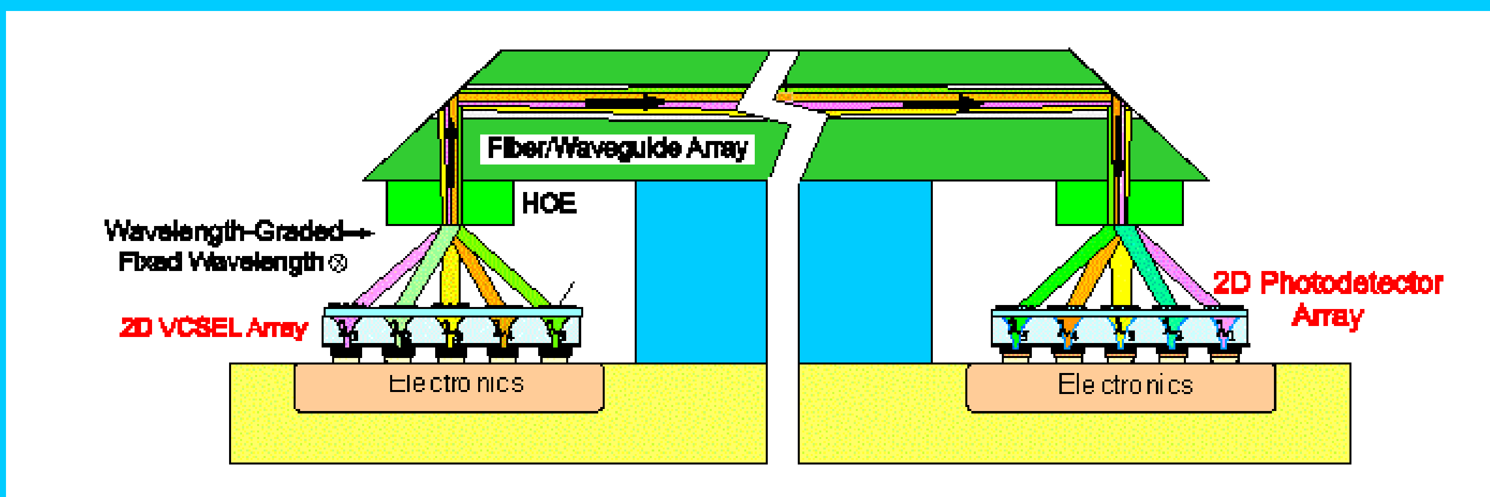
Develop a low-cost, monolithic dense WDM technology for multi-Gb/s LANs consisting of multi-wavelength VCSEL arrays (1x16) with local wavelength regulation, and an add-drop multiplexer technology for wavelength selection.

Approaches and Goals:

- **develop a quasi-planar single-growth technique for achieving multi-wavelength VCSEL and REPD arrays**
- **demonstrate local wavelength tuning to regulate the wavelengths of individual VCSELs**
- **demonstrate multi-channel WDM transmission at >2.5 Gb/s/channel**
- **achieve a 16 channel WDM VCSEL array with a channel spacing of ~2-3 nm (40 Gb/s aggregate throughput)**
- **monolithic ADM technology for wavelength selection**

Wavelength-Multiplexed Parallel Optical Interconnect using Multiple Wavelength VCSEL Arrays and a Passive Demultiplexer





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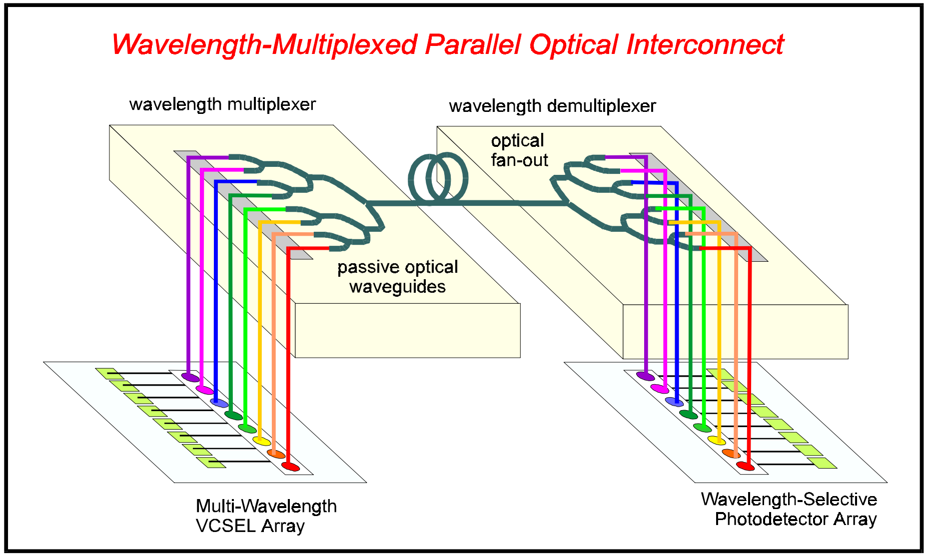
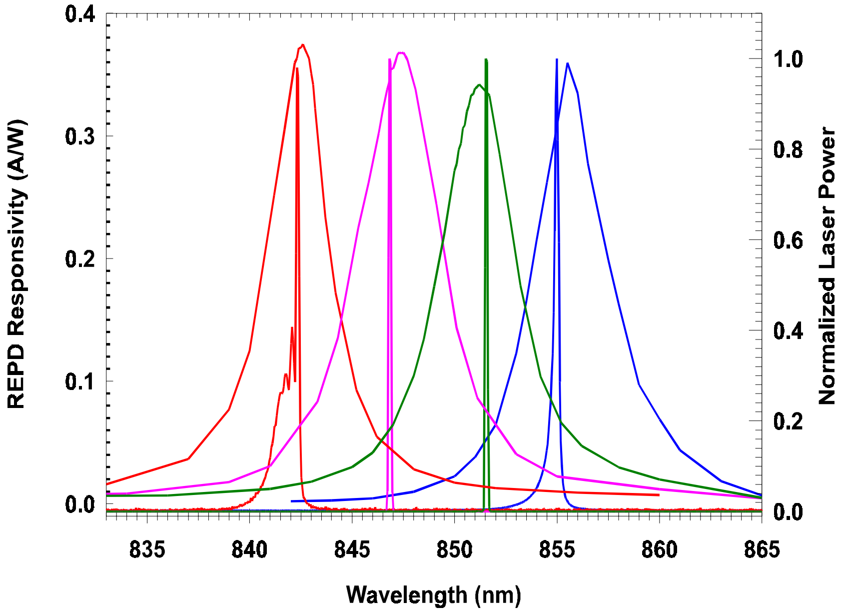
Waveength Division Multiplexing using Monolithic Wavelength-Graded VCSEL and Resonance Enhanced Photodetector Arrays





- **Multiple wavelength channels can be multiplexed together using a wavelength-graded VCSEL array**
- **Data is demultiplexed using wavelength-selective resonance-enhanced photodetectors**
- **Monolithic VCSEL and REPD arrays with matching wavelengths have been achieved**

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Monolithic, Oxide-Confined, Multiple-Wavelength VCSEL Arrays with a 57-nm Wavelength Grading Range

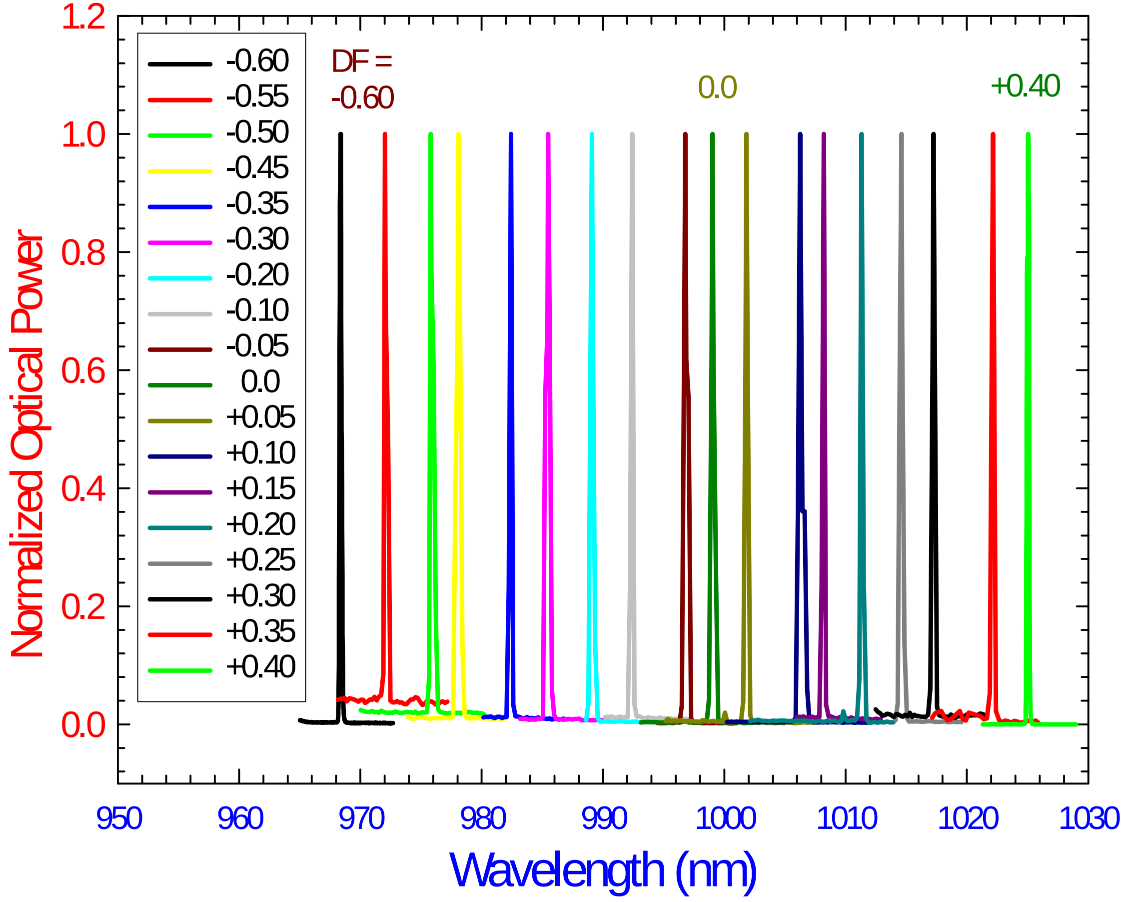
Summary

- **Monolithic, multiple-wavelength, oxide-confined VCSEL arrays with a large periodic wavelength grading span of 57 nm (968 nm to 1025 nm) have been achieved under room temperature, CW lasing operation.**
- **Nearly linear wavelength grading is achieved with even spacing (~3 nm) by using MOCVD growth on a patterned substrate.**
- **An extended wavelength range is achieved by:**

(1) scaling the growth rate of all the epilayers to minimize optical loss dispersion,

(2) using a selectively-oxidized upper DBR mirror with a flattened optical reflectance spectrum

The Normalized Room-Temperature CW Lasing Spectra of a Monolithic, Wavelength-Graded VCSEL Array with a 16μm Oxide Aperture



- **The single-mode cw lasing spectra are almost evenly spaced over a 57 nm wavelength range (968 -1025 nm)**

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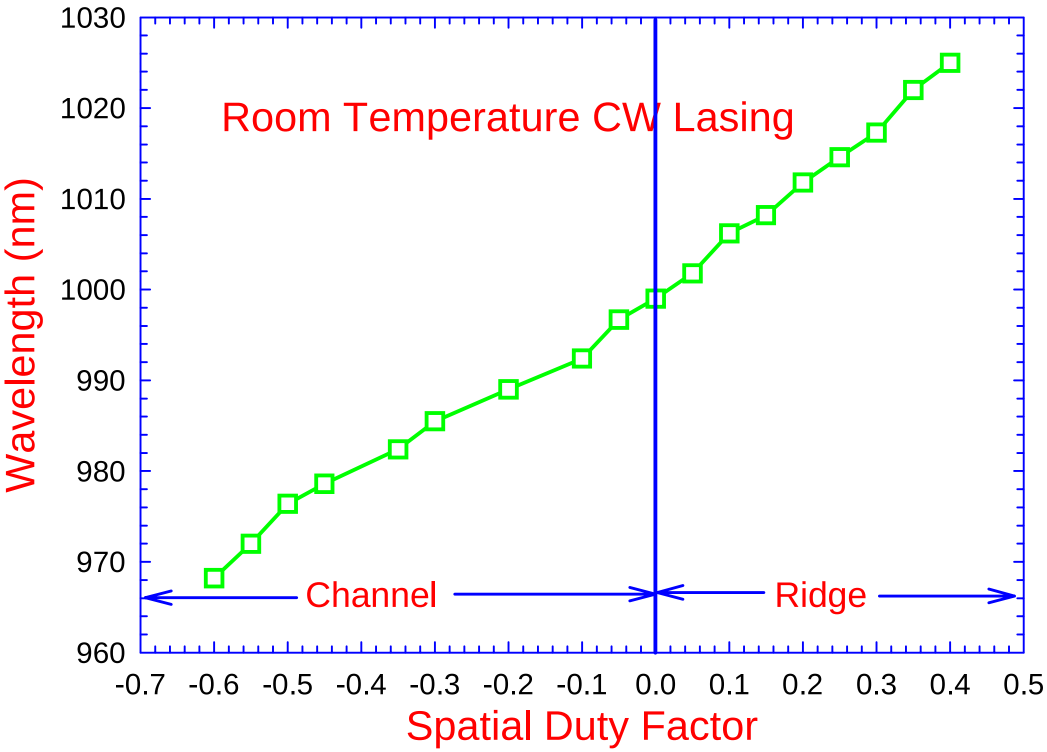
Room-Temperature CW Lasing Wavelength for Individual Elements of a Monolithic Wavelength-Graded VCSEL Array as a Function of the Spatial Duty Factor



- **The spatial duty factor: DF=+/-(1-w/p)**
- **w = width of channel (-) or ridge (+)**
  p=250 μm pitch
- **linear array of VCSEL's each with a 16 μm oxide aperture**
- **room temperature CW lasing operation with a wavelength grading span of 57 nm**

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Monolithic Integration of the VCSEL and the Resonance Enhanced Photodetector on the Same Epilayer Structure for Closer Wavelength Matching

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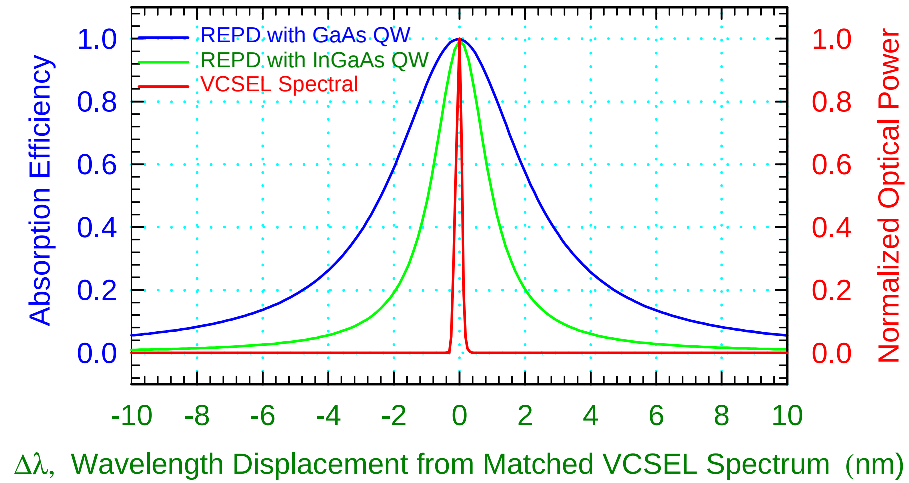
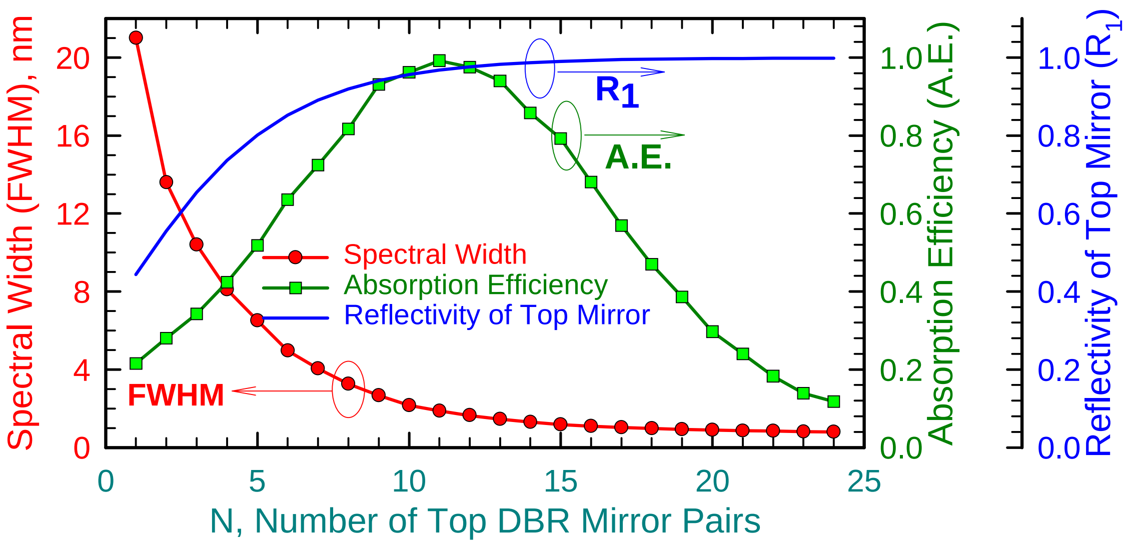
- **The REPD shares the same resonance cavity with the VCSEL, and thus has a xlosely matched resonance wavelength**
- **REPD's are obtained by removing an optimum number of DBR pairs from the upper mirror of the VCSEL**
- **VCSEL and REPD performance are individually optimized**



Advantages of InGaAs MQW's over GaAs MQW's:

- Improved wavelength selectivity (lower optical crosstalk, higher channel density)
- More optimum trade-off between absorption efficiency and wavelength selectivity (more uniform REPD arrays).



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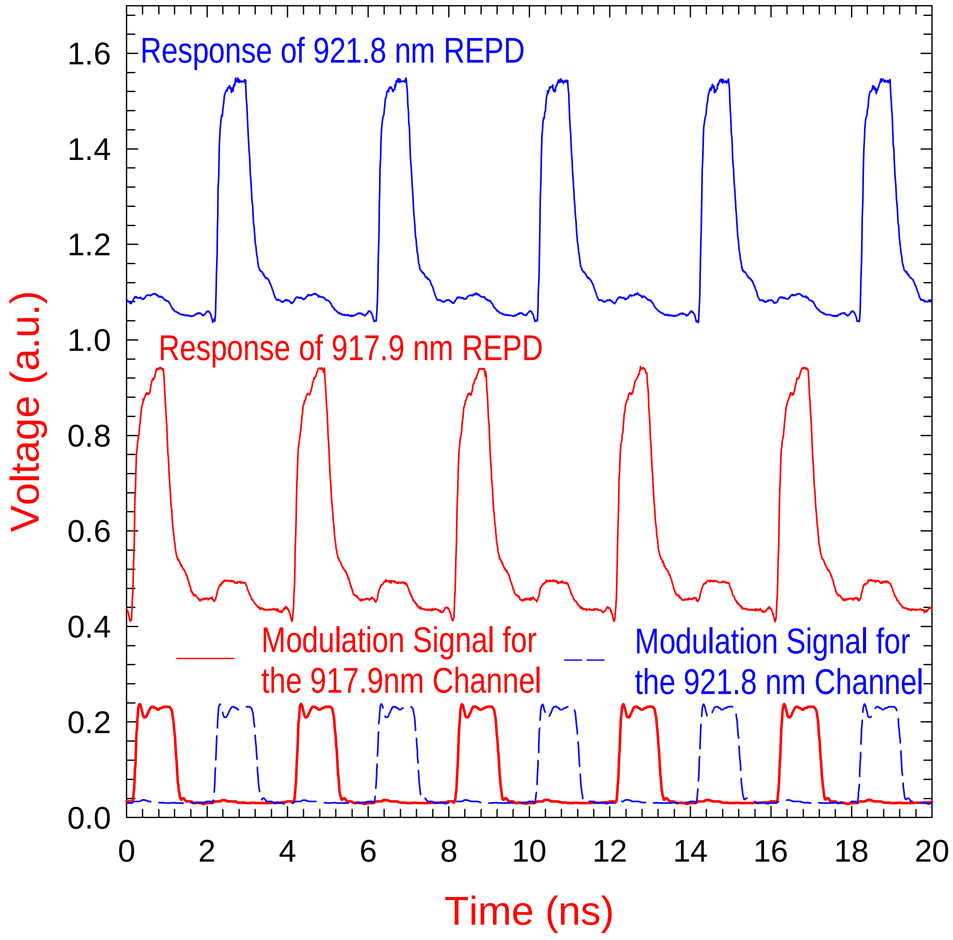
Wavelength Demultiplexing of Two High Speed Modulated Data Channels Using REPD's with a 4 nm Resonance Wavelength Separation



- **Two wavelength multiplexed channels with a 4 nm spacing**
- **Each channel is modulated by 500 Mb/s RZ, 1 ns wide pulses**
- **Demultiplexing is achieved using REPD's, with an ac crosstalk level of ~ -10 dB**

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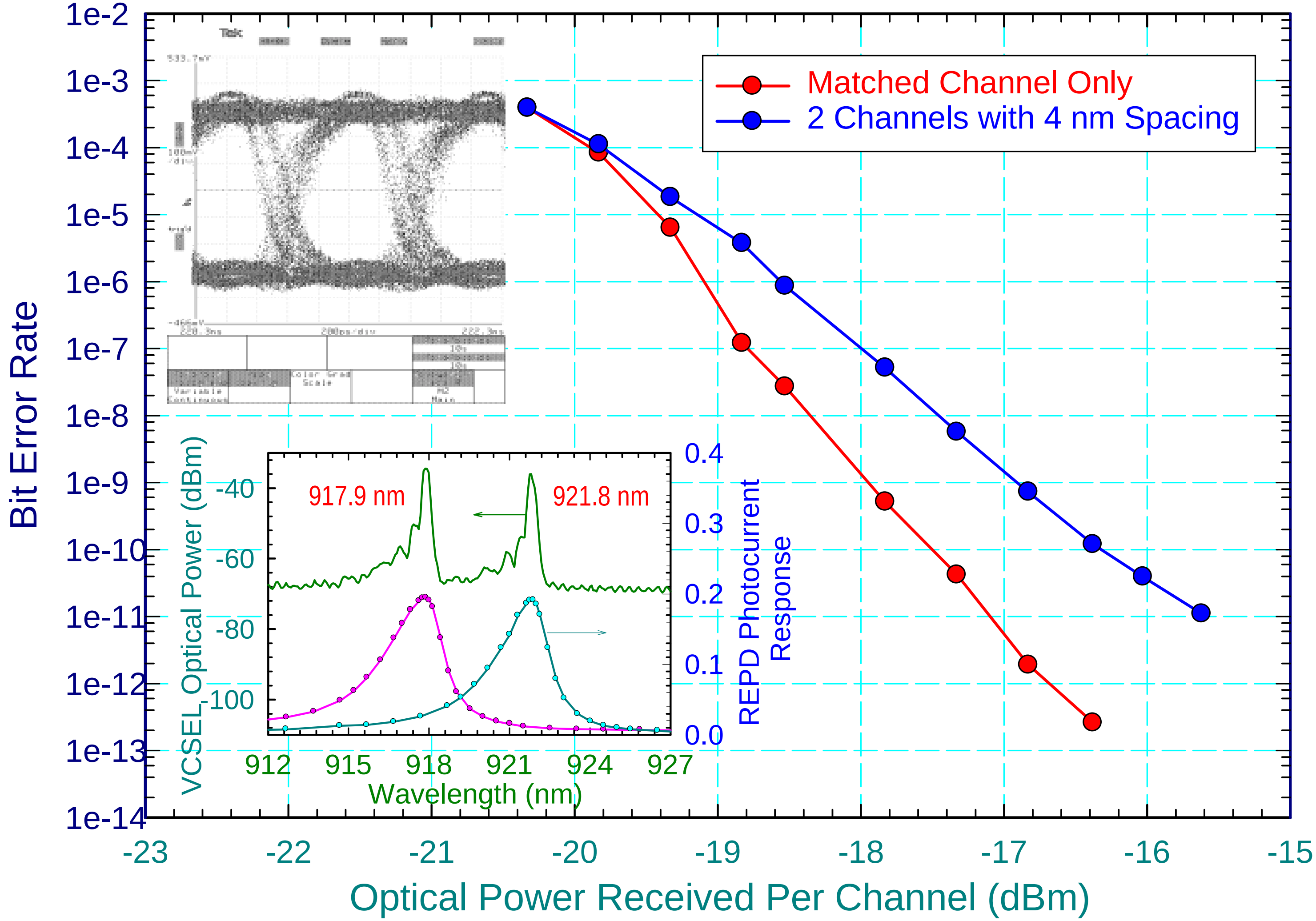
Transmission Performance of a 2-Channel WDM Link with a 4 nm Wavelength Separation at 1 Gb/s per Channel, Showing the Effect of Optical Crosstalk

Upper inset: eye diagram@ BER=10^{-11}

Lower inset: emission spectra of VCSELs and responsivity of REPDs



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