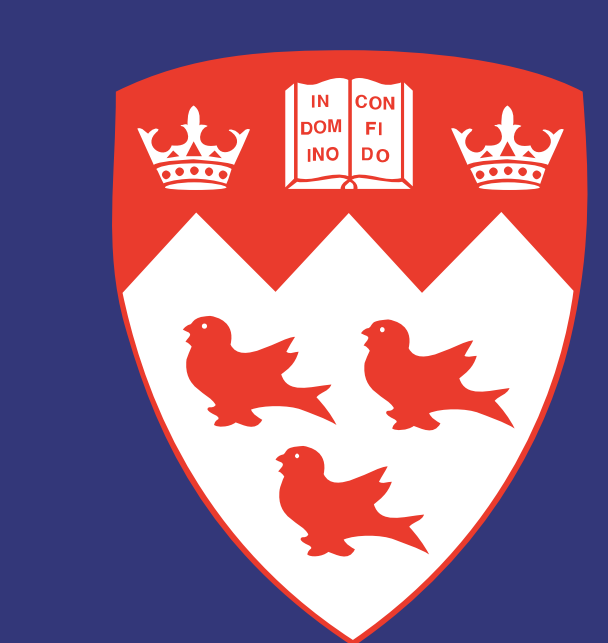




McGill

Photonic Systems Group

Department of Electrical and Computer Engineering
Montréal, Québec, Canada (www.photonics.ece.mcgill.ca)

Research Activities in the McGill University Photonic Systems Group



David V. Plant, Andrew G. Kirk, Lawrence R. Chen and Martin Rochette

Photonic Systems Group

People

4 Professors
7 B.Eng (honours thesis)
8 M.Eng, 17 PhD
5 PDF, other: 7.

Research facilities

- Class 10,000 clean room and free-space optics lab featuring nanopositioning equipment and microscopes.
- Packaging lab complete with wire bonder and interometric profiling microscopes.
- Fiber optics and high-speed electronics lab featuring: 10 Gbps BERT, digital sampling oscilloscopes,

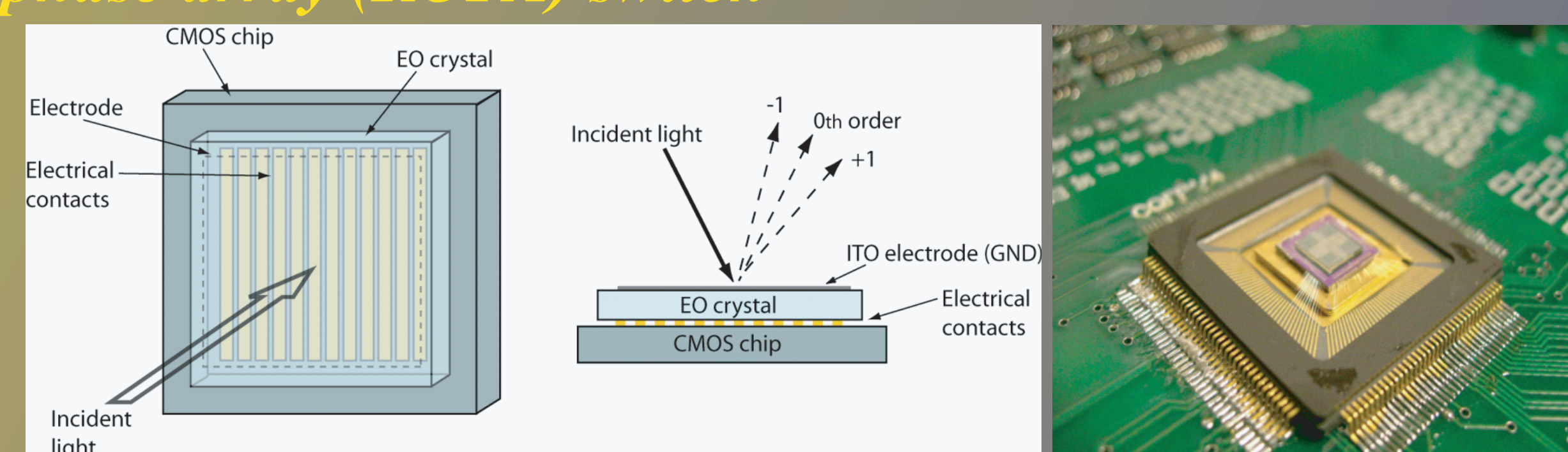
with 30 GHz optical and 50 GHz electrical sampling modules, 0.3-20 GHz lightwave component analyzer, 50 GHz low phase noise synthesizer, OSAs, DFB WDM sources, tunable lasers, passive and active optical components, ...
- Software packages (Cadence, Verilog, Code V, Optiwave, ...)

Optoelectronics, burst mode receivers and agile optical networks

Reprogrammable optical phase array (ROPA) switch

Switching achieved through a voltage controlled phase array.

Characteristics: fast (16.2 μ s), low-voltage (<300 V), 1x6 optical switch.



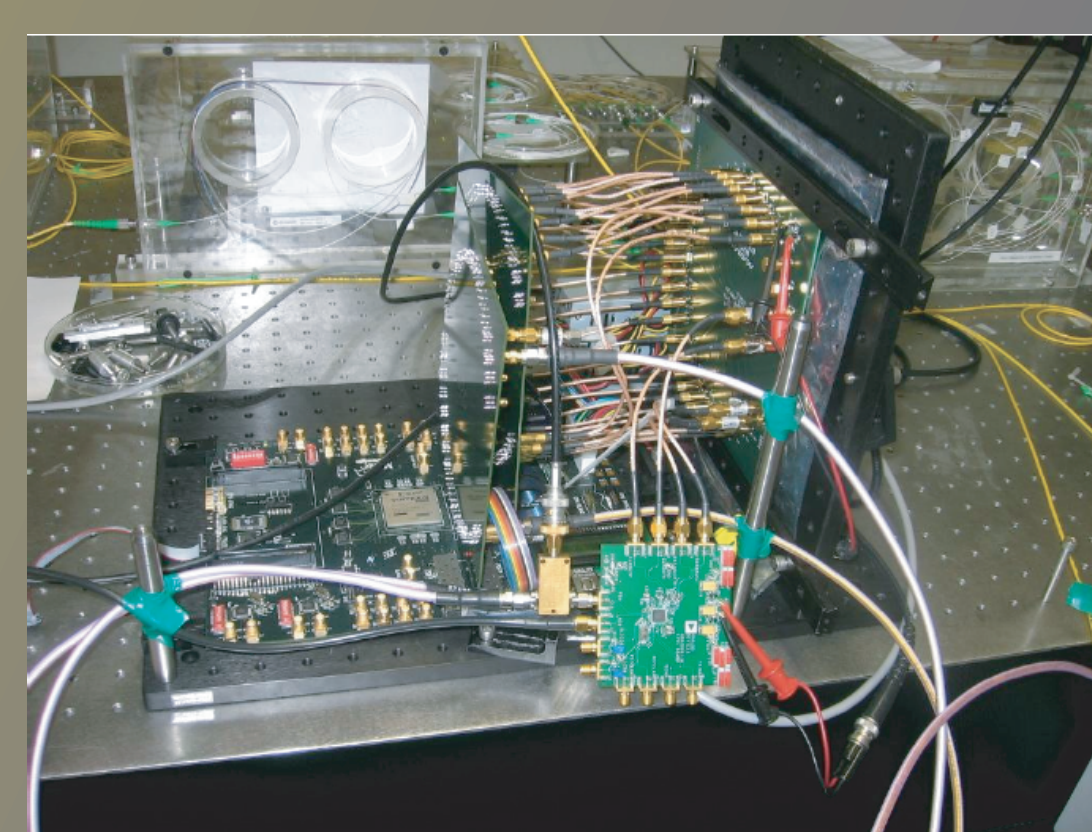
ROPA free-space switch.

Packaged ROPA device.

Burst-mode receiver

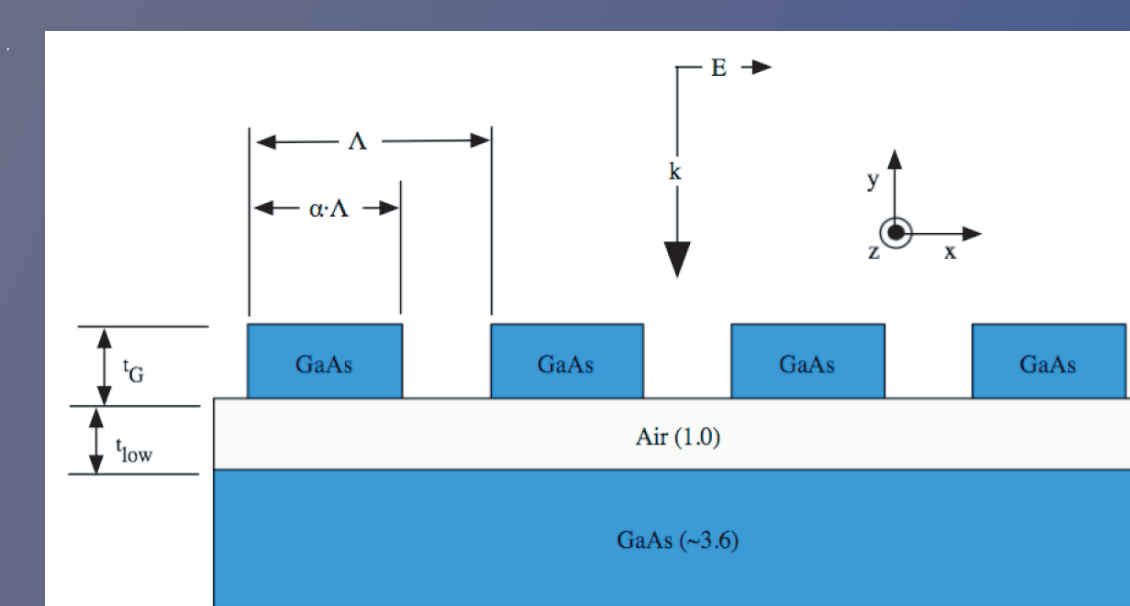
The world's first 622/1244 Mbps burst-mode receiver for GPON OLT applications that achieves instantaneous (0 bit) phase acquisition for any phase step ($\pm 2\pi$ rad) and a BER < 10^{-10} .

Burst-mode receiver experimental setup.

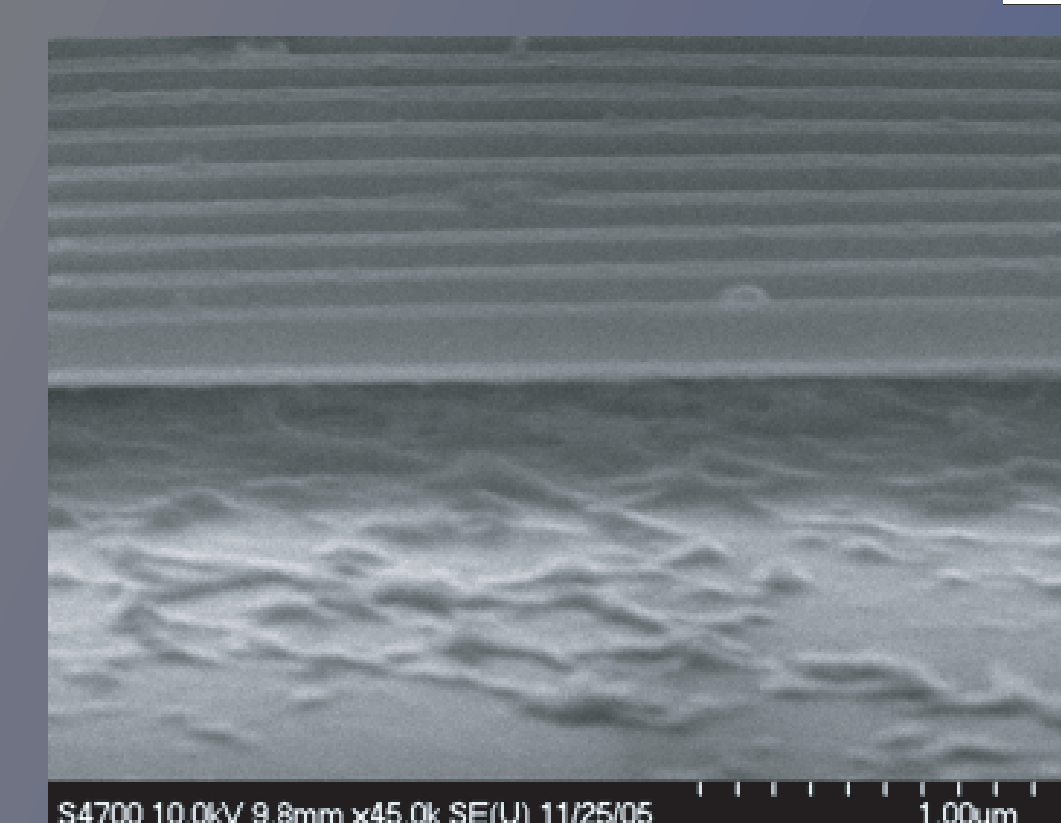


Subwavelength grating (SWG) reflector

A SWG reflector is used as the top mirror of a Fabry-Perot cavity to build a monolithically integrated multiwavelength array of resonant cavity vertical devices.

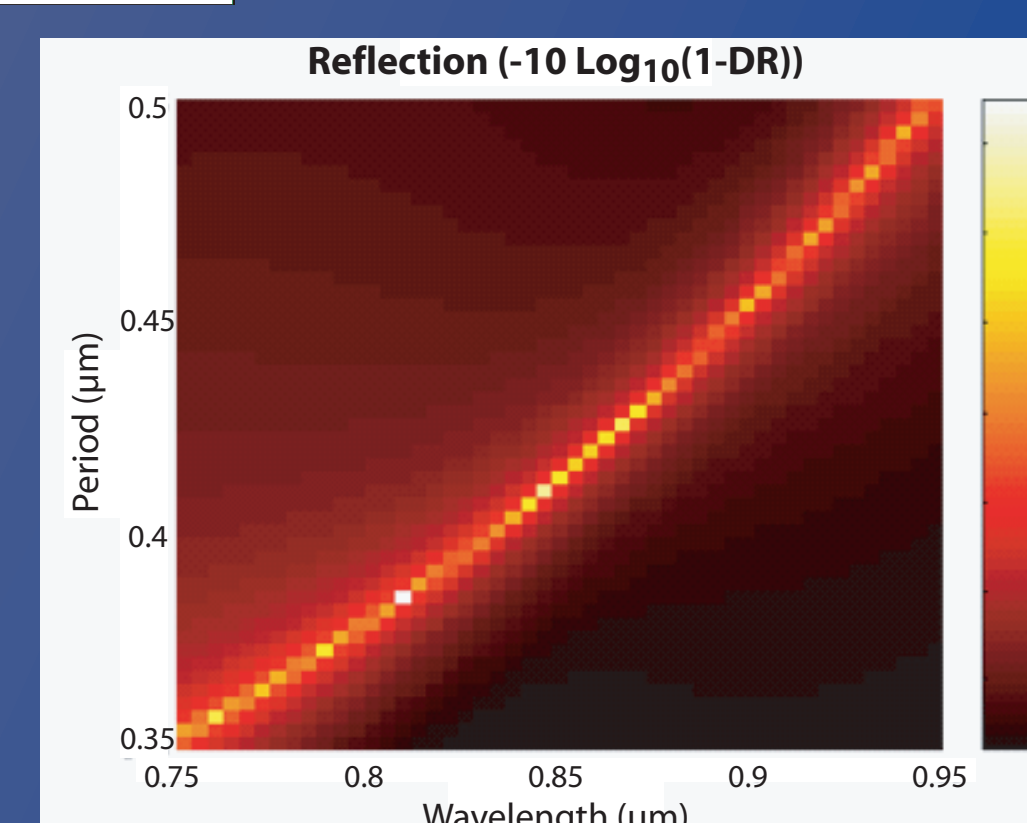


Layout of the resonant subwavelength grating in GaAs.



Fabricated SWGR membrane.

Ultra-high high reflectivity profile for the SWGR showing 200 nm adjustability.

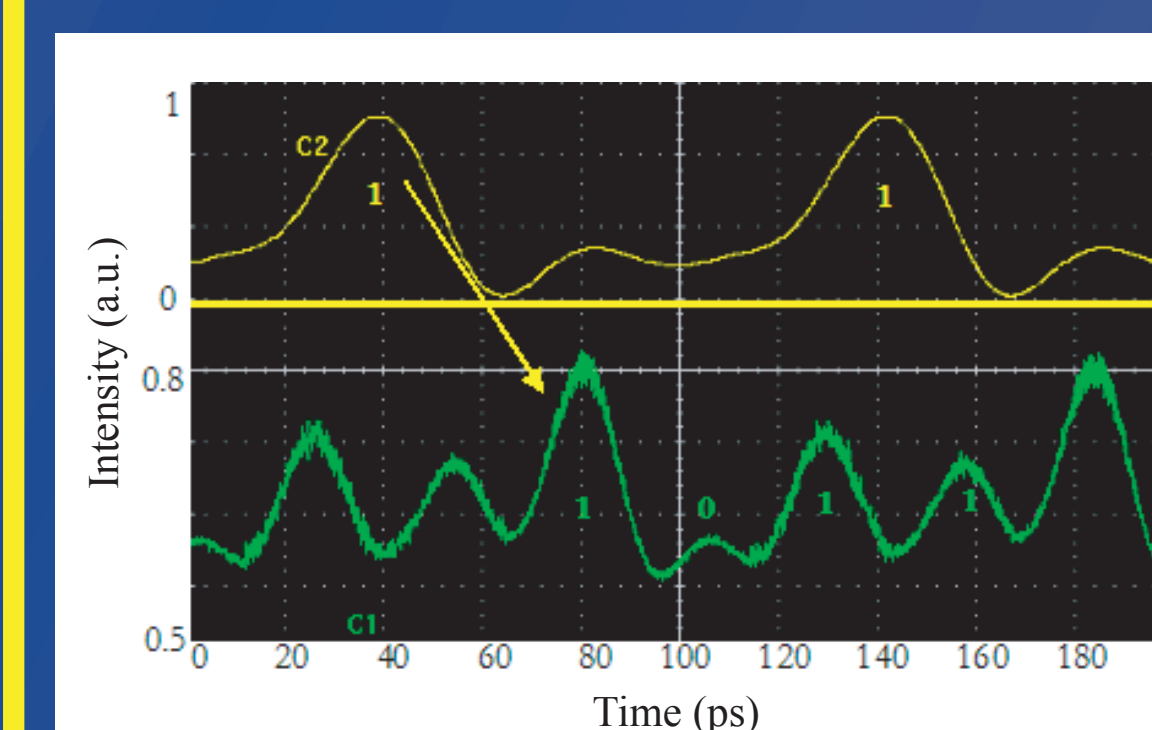


Ultrafast photonics and fiber optics

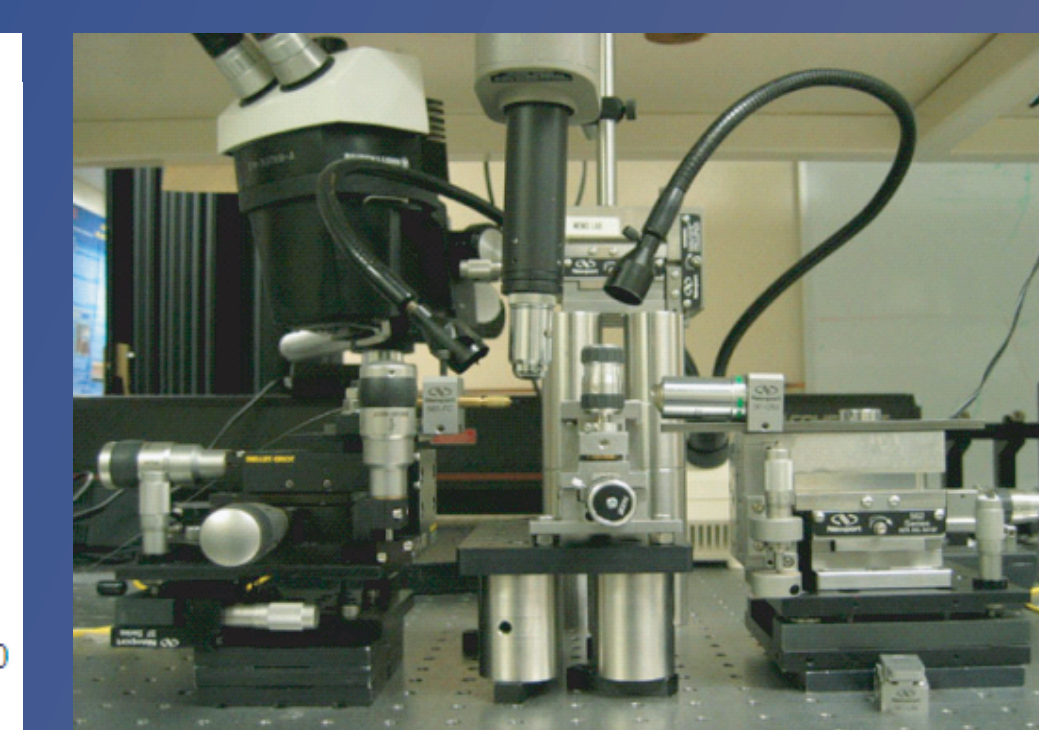
Ultrafast photonic signal processing

- Pulse repetition rate multiplication and arbitrary optical waveform generation using planar lightwave circuits.

Generation of 40 GHz binary code from a 10 GHz input



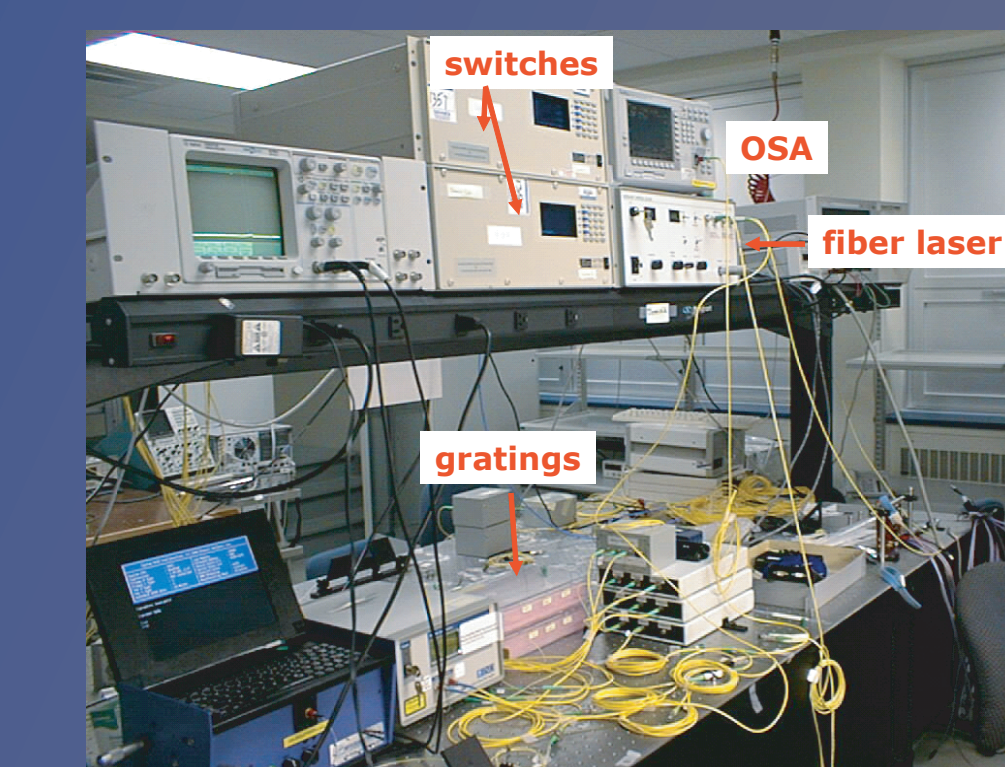
Measured generation of 40 GHz binary code from a 10 GHz input.



Waveguide coupling setup.

- Generation of ultrahigh repetition rate pulse trains.
Generation of 4×100 GHz pulse trains from a single 10 GHz input

Experimental setup for the generation of ultrahigh repetition rate pulse trains from a single 10 GHz input.



OCMA

- First demonstration of a two-dimensional wavelength-time system with full CDR.
- First demonstration of encoding and decoding two-dimensional wavelength-time bipolar codes.

Agile all-photonic networks

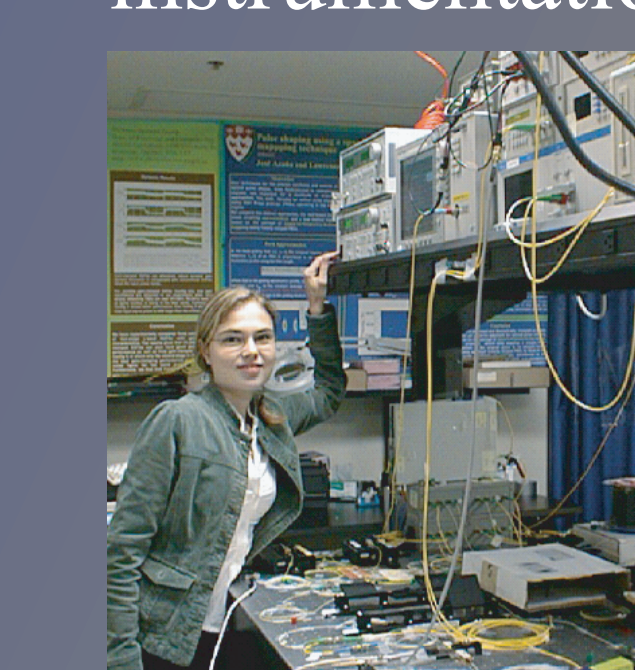
- Amplifiers dynamics in agile networks: discrete fiber Raman amplifiers and fiber optical parametric amplifiers.
- All-optical clock recovery.

Optical coherence tomography

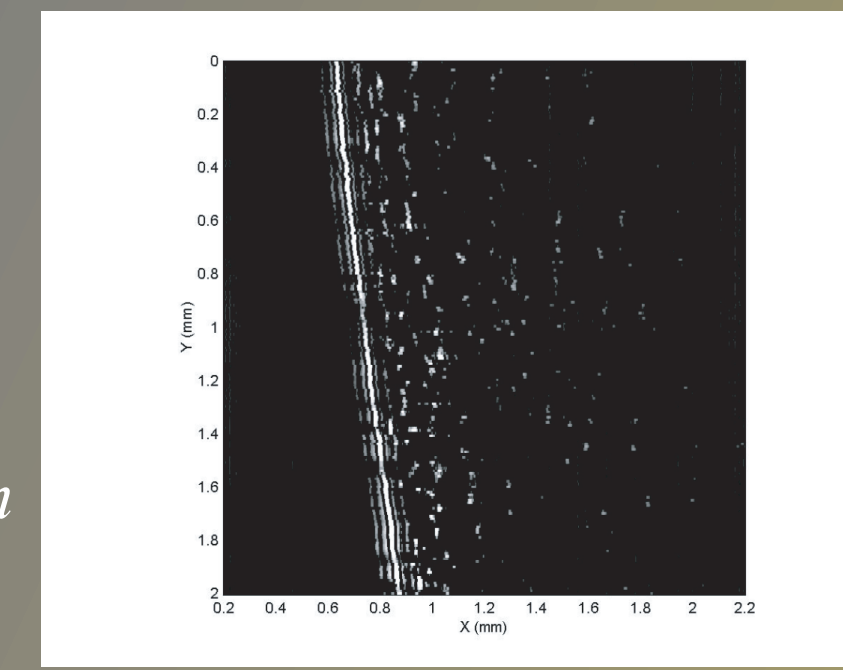
- Development of wideband sources for use in OCT.

Fiber lasers

- Development of multi-wavelength and tunable semiconductor fiber lasers (CW and mode-locked operation).
- Applications to microwave photonics and optical instrumentation.



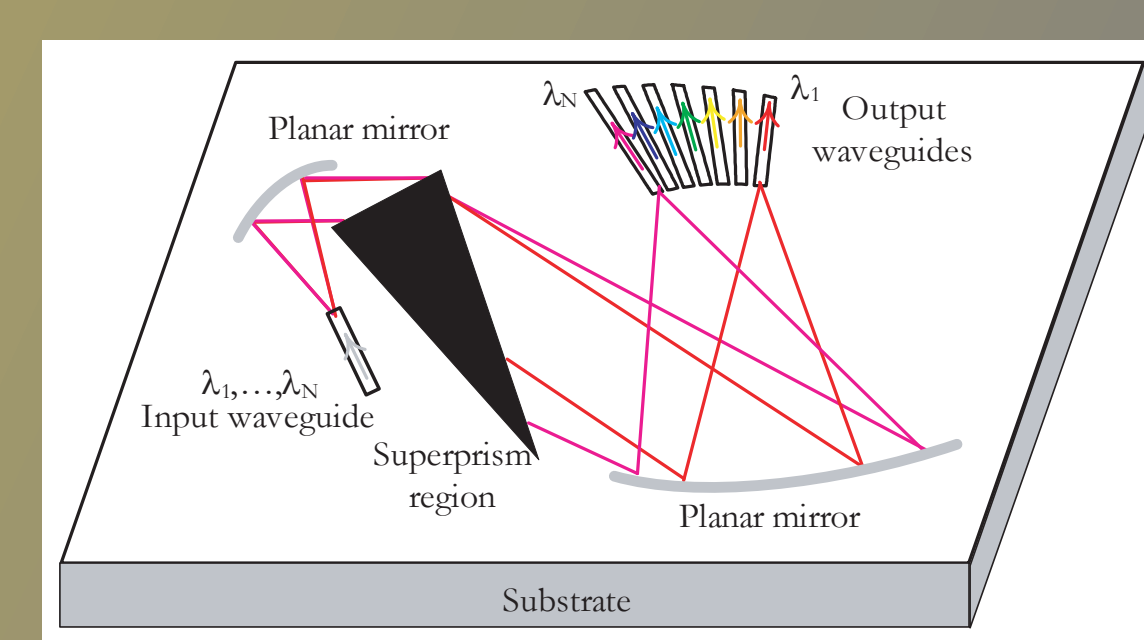
Tunable multi-wavelength source setup.
OCT image of onion skin using hybrid broadband source.



Photonic crystals and plasmonic devices

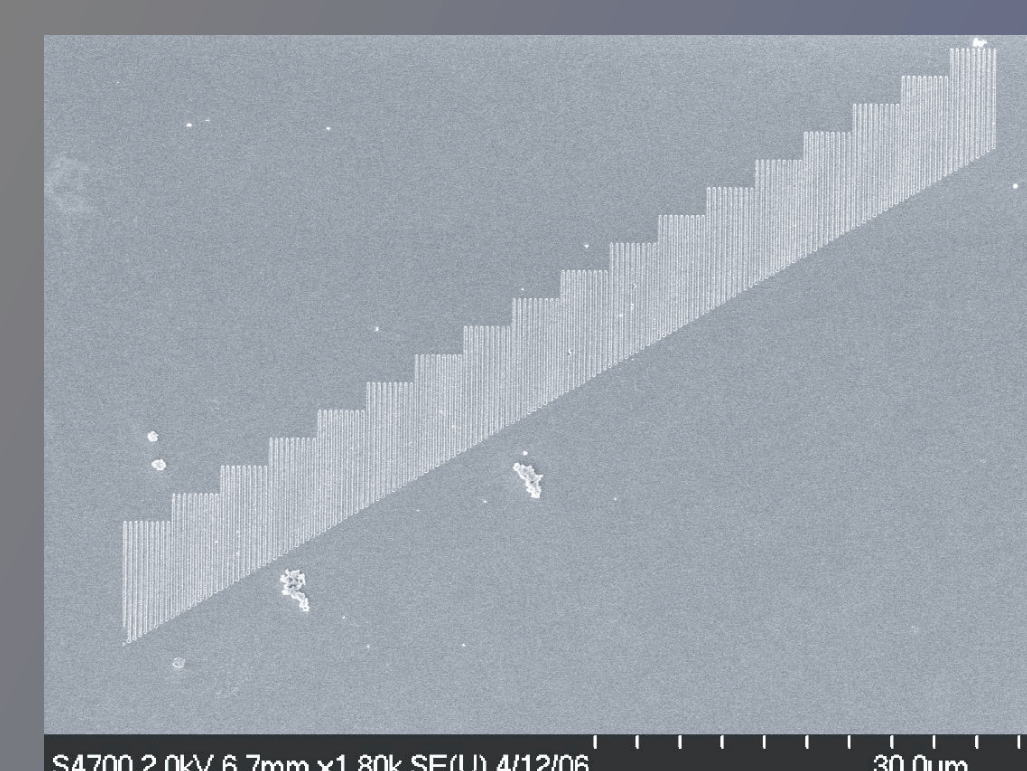
Planar waveguide devices

We are using simple yet versatile 1-D periodic structures in planar waveguides in order to increase optical circuits integration for telecommunication applications.

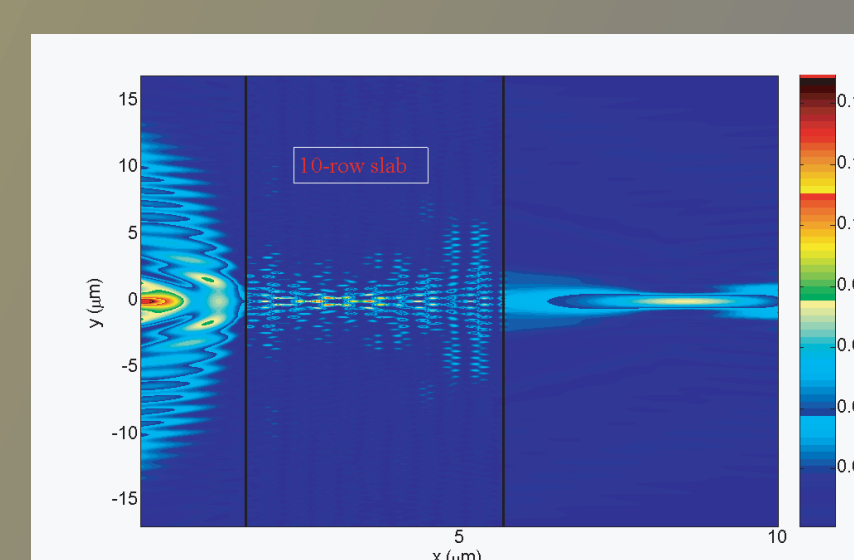


The k-vector superprism layout.

- Developed S and k photonic crystal (PC) superprisms.
- Device area less than $\frac{1}{4}$ of an AWG.



SEM of a shallow-etched grating.

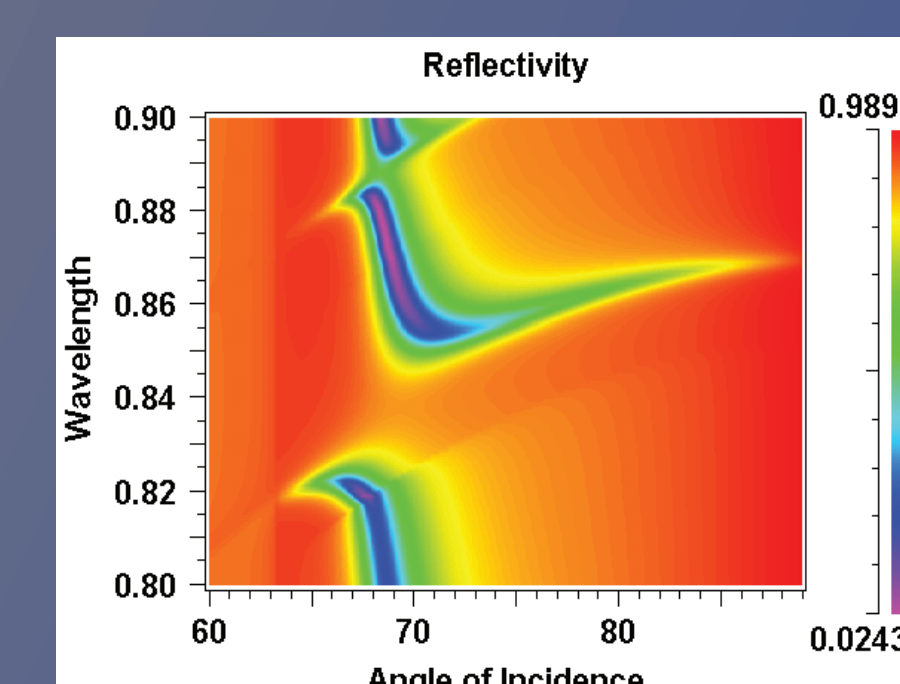


Point source amplitude distribution from a PC lens.

- Working on imaging with the negative index phenomenon in PC.
- Using deep-etched structures to design large electro-optic switch fabric.

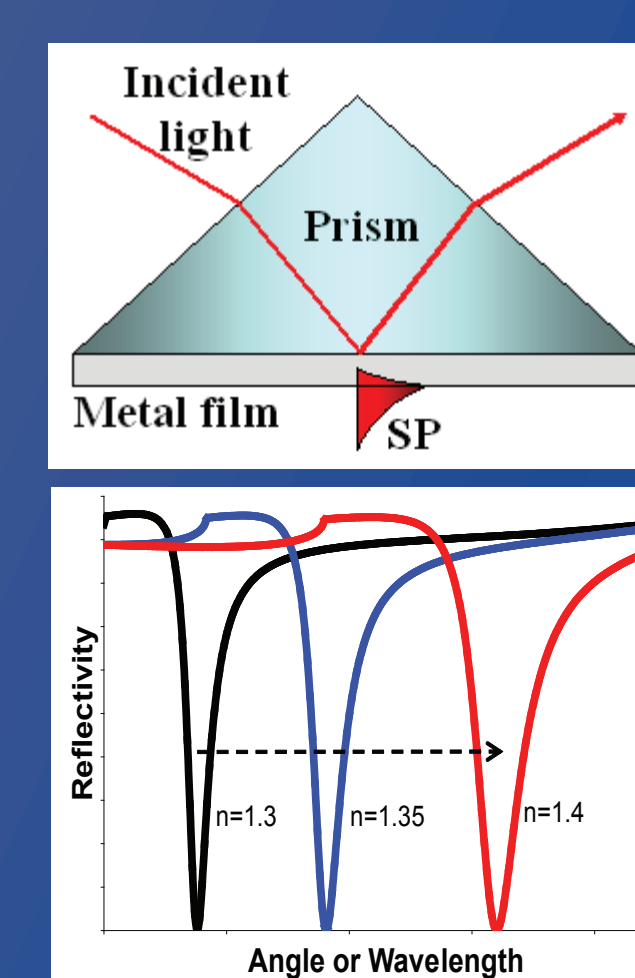
Surface plasmon resonance sensors

Surface plasmon resonance (SPR) sensing utilises the propagation of an evanescent EM wave on a metal-dielectric interface to detect the immobilisation of ligands in a label free way.



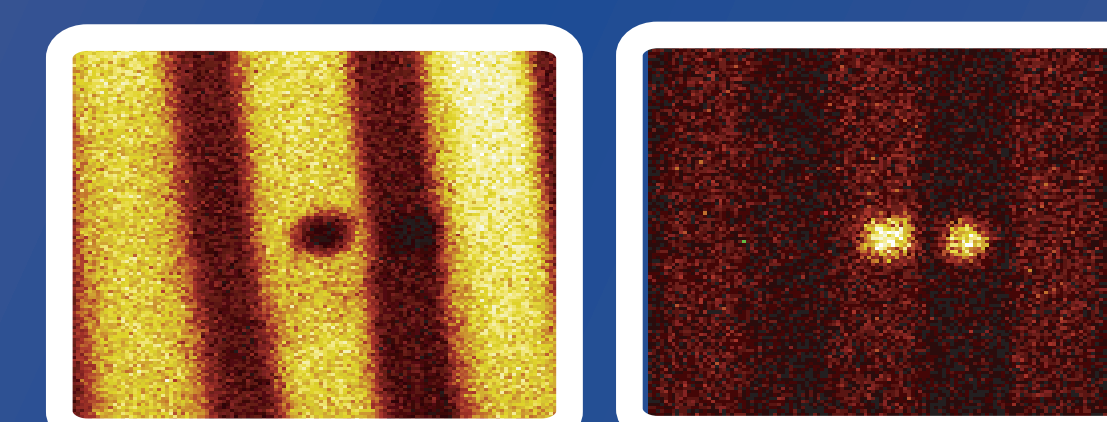
SP Bandgap.

- Tailoring of a biointerface for the immobilisation of ligand-specific probes can provide added sensitivity.
- Our bio-interface design incorporates nanogratings and guided molecular self-assembly.

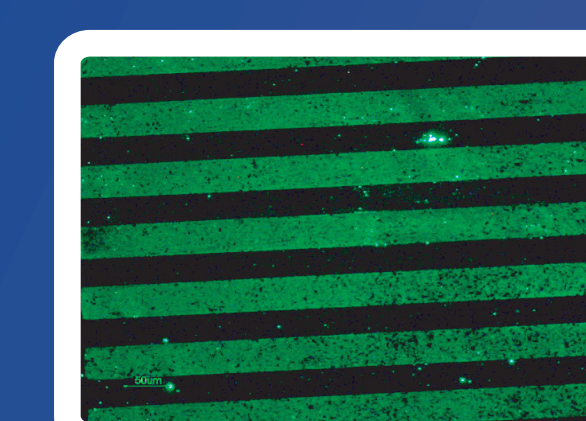


SPR Configuration.

- SPR bandgaps are created with the appropriate use of gratings to enhance sensitivity.



TOF-SIMS show NHS activation (left) and SAM formation (right).



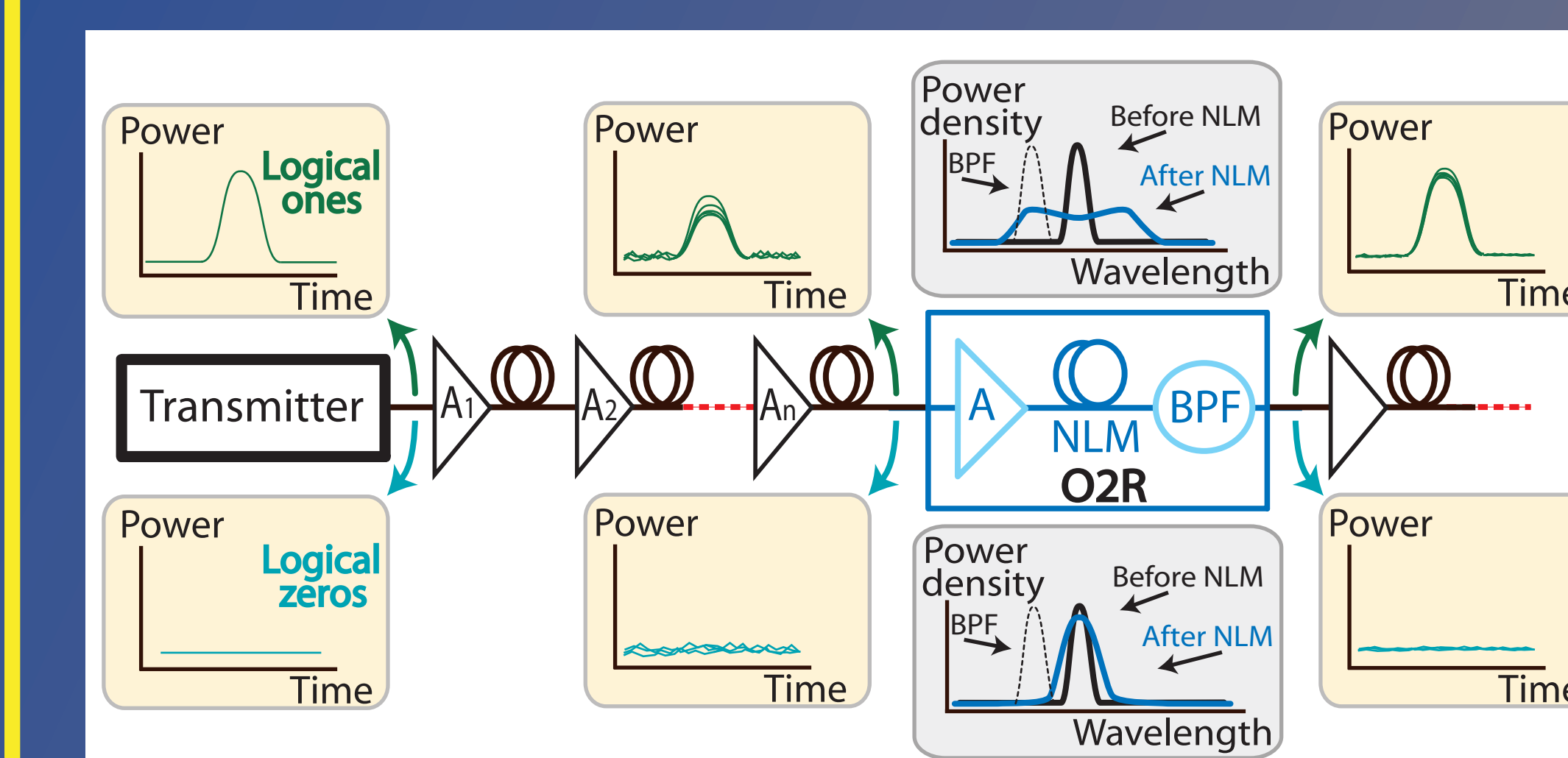
Selective immobilisation of IgG-FITC on binary grating.

All-optical processing using nonlinear effects

Optical regeneration using self-phase modulation

2R: re-amplifying + re-shaping
3R: re-amplifying + re-shaping + re-timing

First regenerator configuration that improves BER.



Schematic of a communication system with optical regenerators.
R: Regenerator, A: Amplifier.

Optical performance monitoring

Enables optical performance measurements of high data rate signals without using wideband electronics.

We have demonstrated:

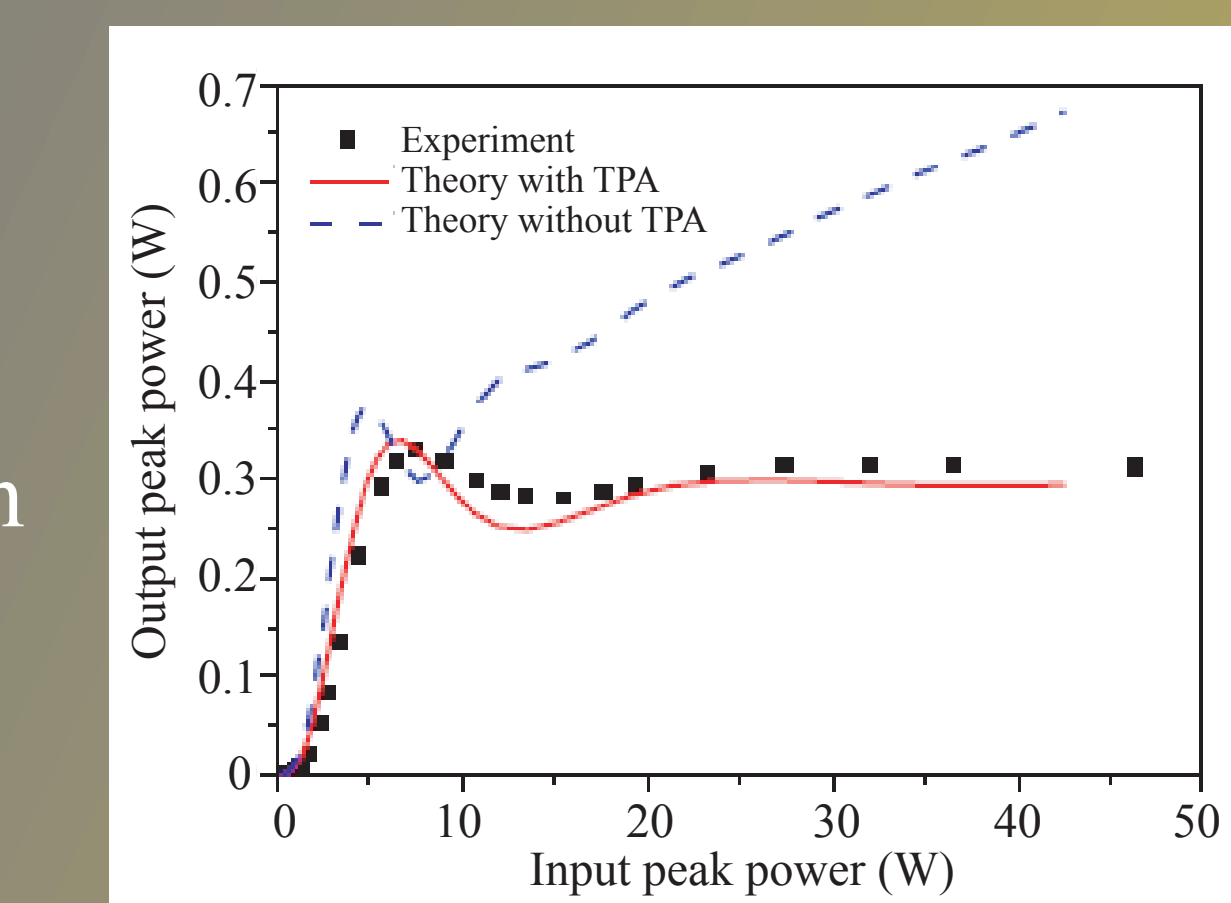
- OSNR measurement using an all-optical nonlinear loop mirror;
- OSNR measurement using four-wave mixing;
- PMD measurement using four-wave mixing.

Compact implementation of optical regenerator

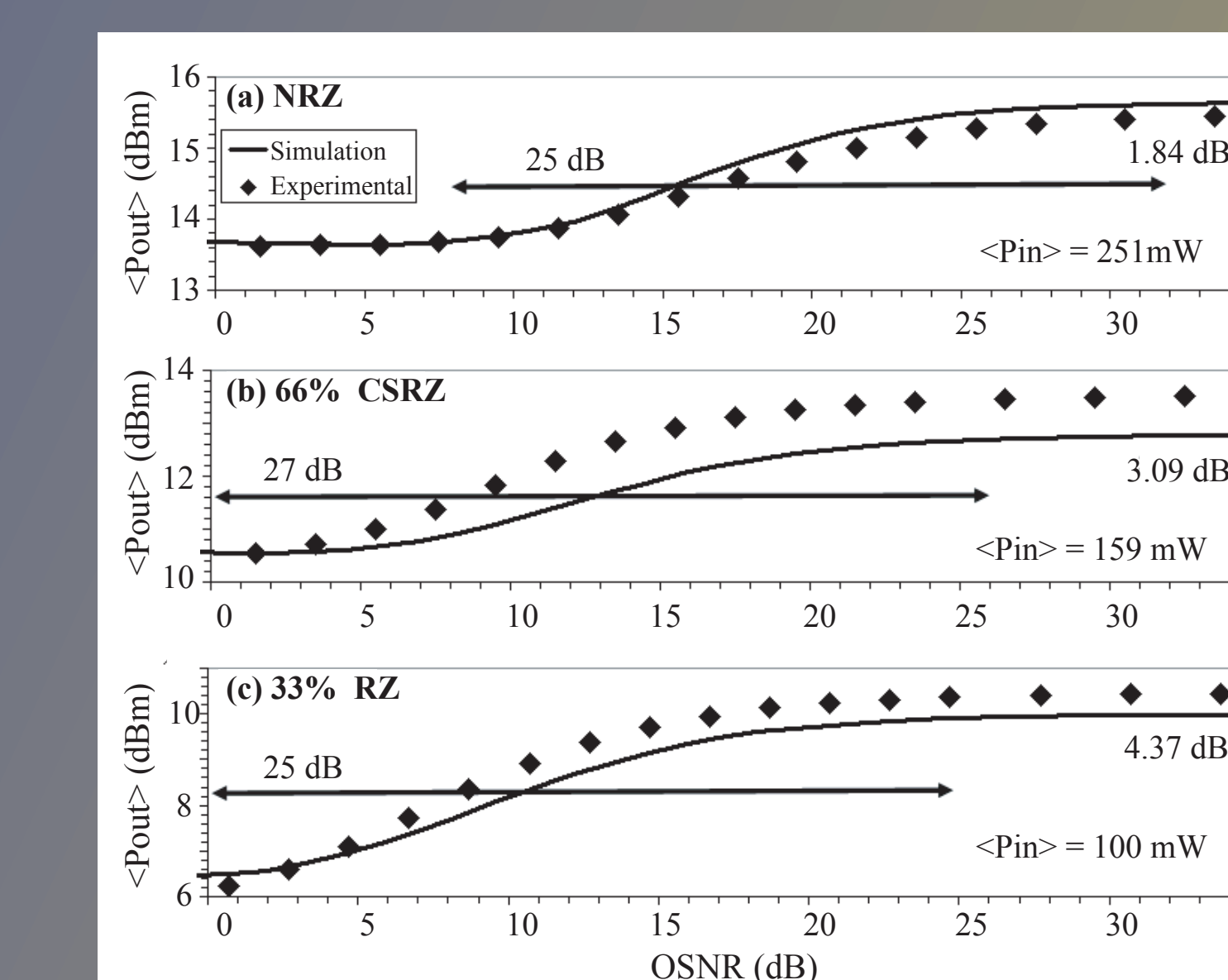
Highly nonlinear medium in As_2Se_3 fiber or waveguide.

Led to:

- Near step-like power transfer function with no pulse distortion;
- Excellent agreement between theory and experiment;
- Advantageous two photon absorption attenuation coefficient.



Power transfer function. Experiment compared to theory, with and without two photon absorption.



In-band OSNR monitoring results using 40 Gbps signal for (a) NRZ, (b) CSRZ and (c) RZ.
<Pin>, <Pout>: average input and output power.



Nonlinear optical signal processing setup.