Photonic Integration

Integrated photonics: the same benefits?
- Complexity
- Overall Performance
- Reliability
- Ergonomics
- Power consumption
- Ecological footprint
- Cost

Optical Waveguides
- Optical fiber
- Planar waveguide circuits
- Light is confined in A core with a high reflective index
- Surrounded by a cladding with low reflective index

Optical fiber vs. transistor
- Small vs. small
- Optical mode diameter ~ 8 um
- Fiber core diameter ~ 100 um

Photonics today
- Lighting
- Display
- Fibre communication
- Data storage
- Spectroscopy/Sensor analysis
- Structural monitoring

CMOS Scaling
- 50nm SRAM cell (2002)
- 10nm 32nm SRAM cell (2003)

Integration: Combining functions on a chip...
- Coupling
- Wavelength filtering
- Signal modulation
- Detection

...in a generic way: for many applications

Integrated electronics
- Scaling enables complexity
- Not necessarily better components
- Not necessarily replacing components
Ring resonator: Channel drop filter

Silicon wire waveguides
High contrast: Small core, tight bends
Low loss: ~ 1.5dB/cm
But sensitive to variations

Waveguide mode sizes depend on index contrast

Silicon wire:
Glass waveguide
index contrast: ~0.1%

index contrast: ~200%

Ring resonators
High-quality rings
Q = 30000 (TE polarization)
Q = 300000 (TM polarization)

Fabrication process (waveguides)

Higher contrast, smaller cores, tighter bends

Arrayed Waveguide Grating (AWG)

Optical ring resonator
Resonance condition

Why Silicon Photonics?
Good waveguide material
High material contrast: 3.45 to 1.45
Silicon waveguides and sharp bends
Transparent for telecom wavelengths

Processing technology
Supports integration of CMOS and Germanium processing for detectors
Integration with electronics

Photonic Large-scale Integration
Silicon-organic hybrid slot modulator

Fast and efficient modulation

All photonic functions are there...
— with a little help from III-V.

Application domains

40 years of optical communication

Optical Links: connecting boxes...

10Gbps Silicon E/O interposer: integration matters.

SOI microring sensor
MPW shuttle service

MPW service: technology
200mm pilot lines
- Continuous operation 24/7
- Dedicated support team and development team
- Manufacturing execution system
Well controlled environment:
- Gas contamination control
- Statistical process control (electronics)
- Procedures
High-end tools:
- Deep submicron technology (6,18,40nm)
- Wet cleaners (200mm)
- 138nm dry UV lithography

Fabless Silicon Photonics?
- fabs: Huge investment 24/7 operation
- Design houses: No money for technology based on standard fabs cannot start if there are no fabs

Absorption spectroscopy
- Absorption spectra: Fingerprinting

Biodiesel spectroscopy
- Spectra with biodiesel
- Spectra with pure diesel
- Spectra with pure biodiesel

Yes: Photonics can benefit from integration
- Complexity goes up
- Overall Performance goes up
- Reliability goes up
- Ergonomics goes up
- Ecological footprint goes down
- Cost goes down

...but who will make it?

ePIXfab
Services for R&D on silicon photonics
- Goals
  - enable cost-effective R&D with high-end technology
  - increase market take-up of silicon photonics
  - open up new research areas
- ePIXfab serves as a platform for the promotion and advancement of silicon photonics

Biodiesel spectroscopy

16.45-17.00  Coffee Break

17.00-17.30  «New approach for creation of nanocomposite with polymeric matrix»
Alexander Volynsky, RAS Corresponding member, Professor, Chemistry Faculty, M.V. Lomonosov Moscow State University (Russia).

17.30-18.00  «Macromolecular nanoscale objects and polymeric composites on their base»
Aziz Muzafarov, Professor, Head of Laboratory, Institute of Synthetic Polymer Materials RAS (Russia).

18.00-18.30  «Polymeric composites from micro to nano»
Vladimir Udin, Professor, Head Laboratory, Institute of Macromolecular Compounds RAS (Russia).

Hall J
10.00-18.00

«NANOELECTRONICS AND NANOPHOTONICS» SECTION

Session 2. «Optoelectronics and nanophotonics»

- Silicon Photonics
- Colloidal quantum dots and organic light-emitting devices
- Nanoreceiver network Yagi DND in the field of optics
- Spectroscopy of single molecules as a method for the nanodiagnosis of solid bodies.
- Methods to control the generation of electromagnetic radiation with the help of nanopatterned liquid crystals.

Moderator:
Sergey Bagaev, RAS member, Director, Institute of laser physics RAS (Russia).

10.00-10.30  «Silicon Photonics»
Wim Bogaerts, Professor, Interuniversity Microelectronics Center (IMEC) - Ghent University (Belgium).

10.30-11.00  «Organic emitted devices with colloidal quantum dots»
Aleksy Vitukhovskiy, Professor, Head of the Department of Luminescence, Lebedev Physical Institute RAS (Russia).

11.00-11.30  «Photonic structures as optical nanoantennas»
Sergey Tikhodeev, Professor, Pochio Institute of General Physics RAS (Russia).

11.45-12.00  Coffee Break

12.00-12.30  «New methods of highly efficient controlled generation of radiation by liquid crystal nanostructures in a wide spectral range including the THz one»
Sergey Trashkov, Professor, Senior Associate, Institute of Laser Physics RAS (Russia).

12.30-13.00  «Single-molecule spectromicroscopy: a tool for nanodiagnosis of solids»
Andrey Naumov, Deputy Director and Head of the Department of Molecular Spectroscopy, Institute of Spectroscopy RAS (Russia).

Session 3. «New devices and facilities in nanoelectronics and nanophotonics»

- Micro and nano-scale electromechanical devices from researchers at LETI, the major European micro and nanotechnology laboratory.
- Tunnel resonance heterojunction devices and ultrahigh-speed integrated circuits based on them, from designers at the P.N. Lebedev Physical Institute of the Russian Academy of Sciences.
- Ultraviolet lasers based on zinc oxide nanorods, from designers at the Institute for Design Problems in Microelectronics of the Russian Academy of Sciences.

Moderator:
Alexander Orlikovsky, Professor, RAS member; Director, Physics and Technologies Institute of the RAS (Russia).

15.00-15.30  «NEMS for sensing the world»
Jean-Philippe Poliatti, Professor, Microsystems Program Manager, CEA-LETI/ DIHS (France).

15.30-16.00  «Development of emerging nonvolatile memories and NVM technology transfer to production fabs»
Yakov Roinz, Professor, Director, Tower Jazz (Israel).

16.00-16.30  «Nanotransistors with ultrathin silicon and graphene channels»
Vladimir Vlaskov, Senior Associate, Physics and Technologies Institute RAS (Russia).

16.45-17.00  Coffee Break

17.00-17.30  «Tunnel resonance devices and super high-speed IS on their base»
Alexander Gorbatsevich, Professor, Main Researcher, Lebedev Physical Institute RAS (Russia).

17.30-18.00  «Heteroepitaxial structures CdHgTe on GaAs and Si substrate for IR and terahertz detectors»
Maxim Yakushev, Senior Associate, A.V. Zhukov Institute of Semiconductor Physics RAS (Russia).