Rockwell Science Center (RSC) Technologies for WDM Components

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Introduction

- RSC has been a center of excellence for more than 20 years, performing R&D on components applicable to telecomm, e.g., sources, detectors, high speed microelectronics, and other components
- Technology transition to former Rockwell businesses (e.g., Conexant Systems, ROK/NTSD to Alcatel), and spin-offs (e.g., Vitesse)
- New RSC initiatives target R&D and business opportunities, including those related to WDM and telecomm, for military and commercial applications

WDM Offers Significant Benefits to the Military

Examples of Applications

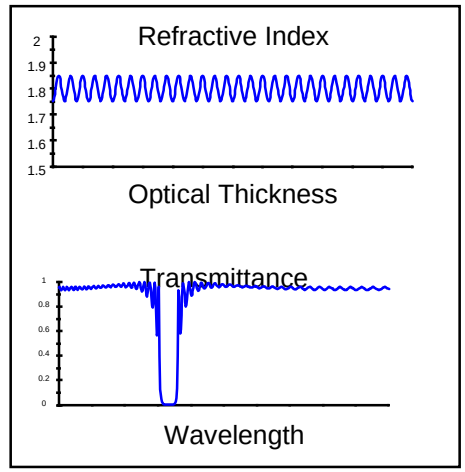
- Communication
  - Fiber Optic
  - Free Space Optical
  - Fiber & Free Space
  - Multi-Mode (RF & Optical)
- Replacing Wires on Military Platforms (Advantages: Weight, Size, Cost, Low/No EMI)
  - Sensors
  - Data
  - Control
- Others

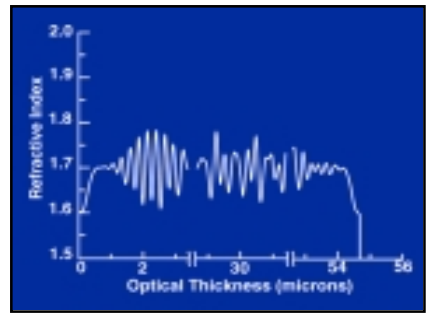
Technology Requirements

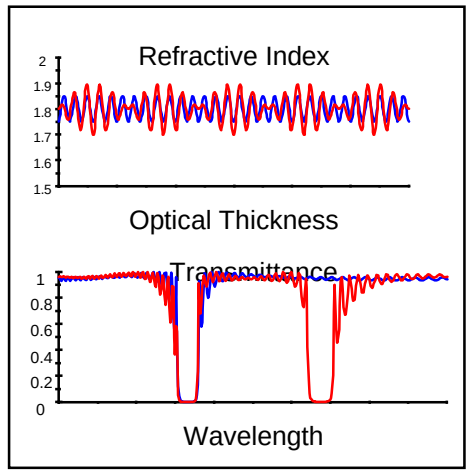
- DWDM
- Switching / Routing
- Infrastructure for Higher Speeds (e.g., 40 Gb/s)
- Fiber Dispersion Compensation
- Wide Band / Multi-Band WDM
- Beam Steering
- Eye Protection
- High Performance Vs Cost
- Robust & Affordable Components
- …….

“Rugate” Technology for Spectral Control

- **Rugate Technology**
  - Sinusoidal index profile(s)
  - Allows exquisite control of reflectivity and bandwidths for single or multi-line filters
  - Multi lines are integrated, not stacked
  - Graded index “Quintic” profile provides optimum index match to surrounding media
  - Apodization reduces sidebands near reflection peaks
  - Fabrication requires extreme control on index profile
  - Suitable for non-conventional WDM
- **An AFRL concept that has proven to be a powerful method for spectral control**
- **RSC is the technology leader in rugates and related developments**
- **Physics of rugates is related to (1-D) photonic bandgap materials**







Rugates + many other thin film & optical components are now RSC “products”

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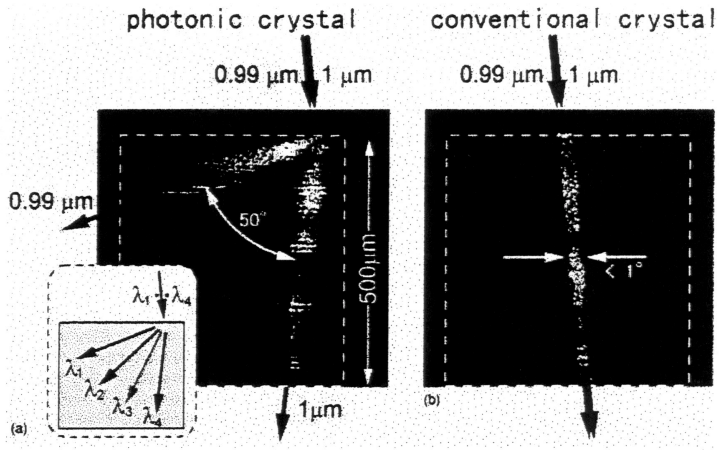
Photonic Crystals Offer New Capabilities for WDM

Photonic Crystal "Super-prisms"

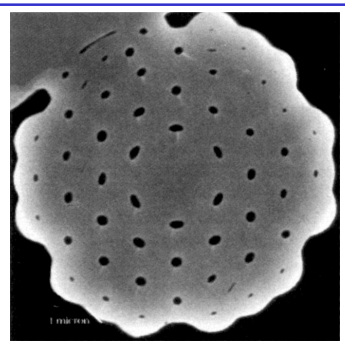
- Periodic structures with special properties
- Much larger (10-100X) dispersion than ordinary materials
- Super-refraction (~10X) allows construction of new optical devices
- Offer promise for new WDM & related applications



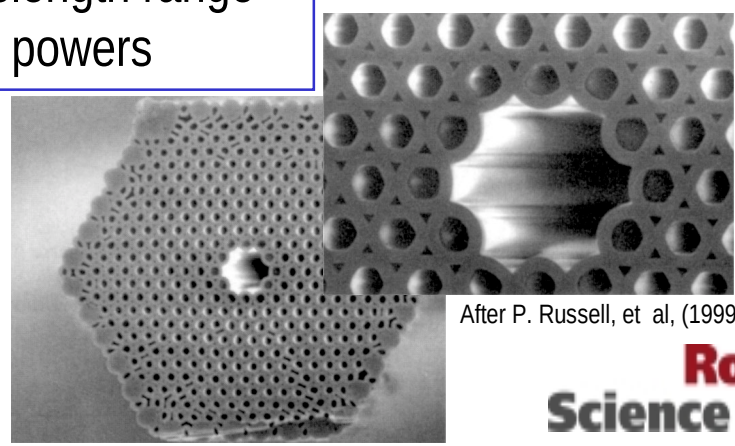
After H. Kosaka, et al, (1999) JP

Photonic Crystal Fibers

- Can confine light with or without photonic bandgap
- Single mode over much larger wavelength range
- Larger volume allows higher optical powers



After P.J. Bennett, et al (1999)



After P. Russell, et al, (1999)

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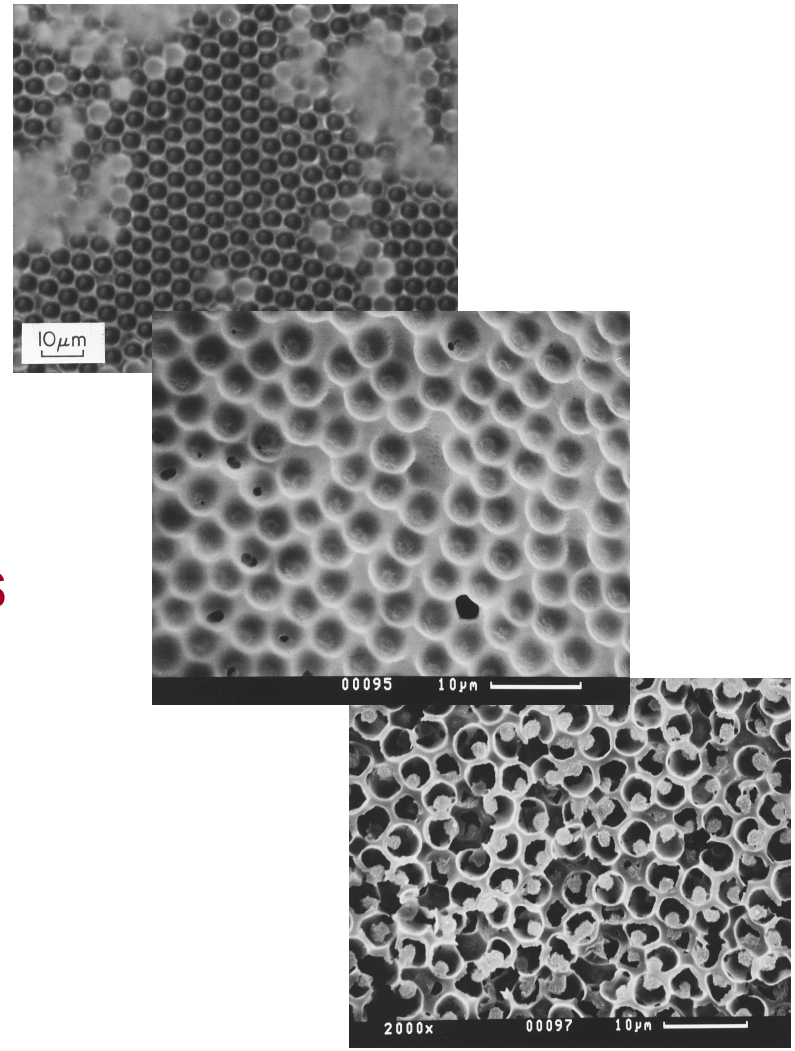
RSC Interests in Photonic Crystals

- Substantial history of RSC efforts in photonic bandgap materials and devices for microwave regime
- Recent focus on IR/Visible
- Collaborating with universities in structure design (UCLA, MIT)
- RSC material development approach is focused on self-organized materials
  - Dielectric
  - Metallized dielectrics
  - Tunable
- Applications (including WDM) drive RSC materials efforts



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WDM and optical Switching Technologies

Some RSC Contributions:

- OFCS 1986-1989
  - 16x16 Optical fiber crossconnect
- ONTC 1993-1995
  - All Optical WDM Network Consortium
  - Developed all optical switching and components for WDM
- NTONC 1996-Present
  - National Transparent Optical Network
  - Exploratory High bandwidth WDM network
- WEST 1995-1998
  - WDM network switching using electronics

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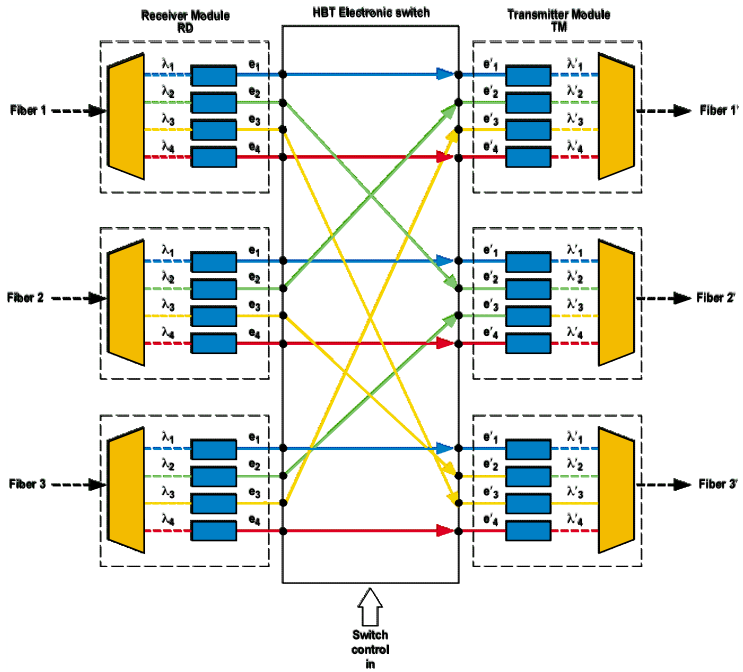
WEST Program (120 Gb/s Optical WDM Cross Connect Switch)

WDM with Electronic Switching Technology



Cross Connect Configuration
- 3x3 fiber switch
- 4 channels/fiber
- 10 Gb/s/channel

Electronic Switch Core
- OC192/OC48 compatible

Optical MUX/DEMUX
- ITU WDM channels

Key Technology
- Rockwell GaAs HBT
- Ortel DFB Laser/PIN

Advantages of an Electronic Core

- Data regeneration/retiming
- Wavelength translation
- Low crosstalk
- OC192/OC48 compatible
- Realizable with current state-of-the-art production technology
- Potential for additional processing of input signal (smart switch)

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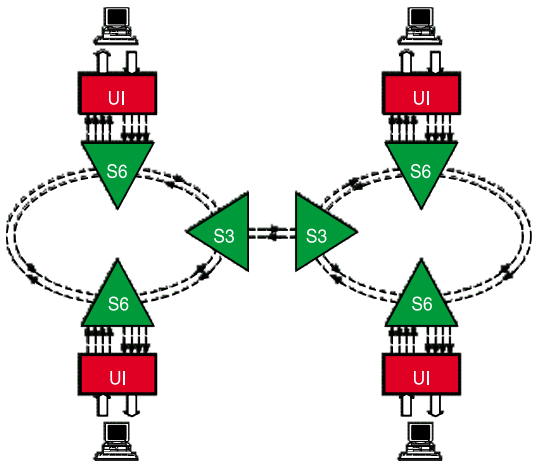
Advantages of WEST Switching Approach & Challenges for All-optical Approaches

Advantages:

- **Easier to monitor**
- **Inherent Fault Localization**
- **Fast Switching**
- **Quasi-Optical Layer Protection**
- **Enhanced Compatibility**



Applications:

- **WDM Network cross-connect**
  - •OC-48 or OC-192 systems
  - •Cross-connect switch
  - •Wavelength translation
- **Bi-directional SONET ring**
  - •Add/drop (S6)
  - •Ring interconnection (S3)
- **Distributed Computing**
  - •40 Gb/s/fiber
  - •40 Km distance
  - •Connect Caltech/JP
  - •Supercomputers

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Summary of WEST Accomplishments

- **3x3 WDM cross-connect system based on electronic switching**
- **ICs, optical devices, and modules for 4x10 Gb/s and 4x2.5 Gb/s lightwave transmission**
  - **ICs are currently in production**
- **120 Gb/s 12x12 cross-connect switch IC, packaging, and module**
  - **Switch ICs and design innovations are now embodied in Commercially available products**
- **WDM link models and simulation tools**
  - **Simulation software now a successful product**

Concluding Remarks

- **Multi-disciplinary RSC technologies for WDM components and applications:**
  - Optics, Photonics, Rugates, Cavity Filters, Micro-optics, Liquid Crystal Components & Devices, MOEMS
  - High Speed Microelectronics, Switch ICs, WDM Cross-connects, High speed Opto-electronics, MEMS
  - Key technology partnerships (e.g., Conexant, Boeing, Universities)
- **RSC activities range from basic R&D to (selected) low volume production ----** http://www.rsc.rockwell.com
  - Interested in WDM with both fiber optic and free space comm
  - Interested in a number of other dual use applications of WDM
  - RSC efforts emphasize state-of-the-art and new approaches (e.g., WEST, “super-prism” effects)
- **IR/visible Photonic Crystals offer important new capabilities for potential WDM and other applications**

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