

# Defect Review in the Photonics Revolution

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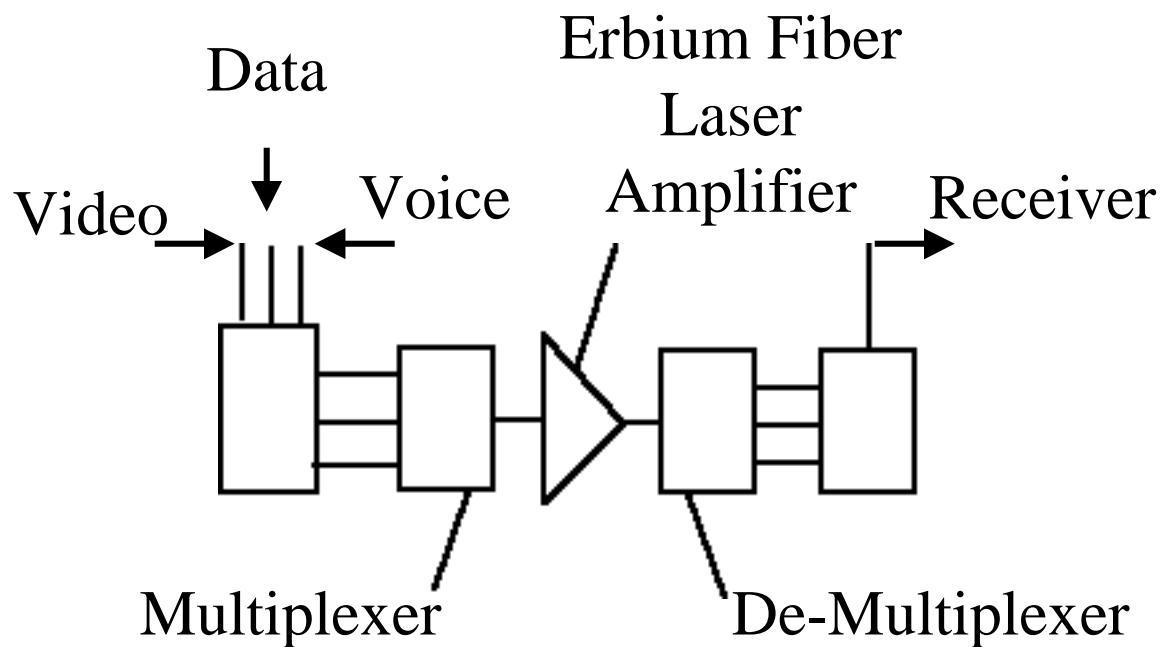
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# Components of The DWDM Revolution



# A New Direction for WDM Test & Measurement

- The Need - Decreasing Size and Increasing Integration
- The Technology - Near-field Optics
- 3. The level of Optical Resolution - 0.05 microns
- 4. New Correlations -  
Light distribution

*with simultaneous nanometer information on*

Topography

Polarization

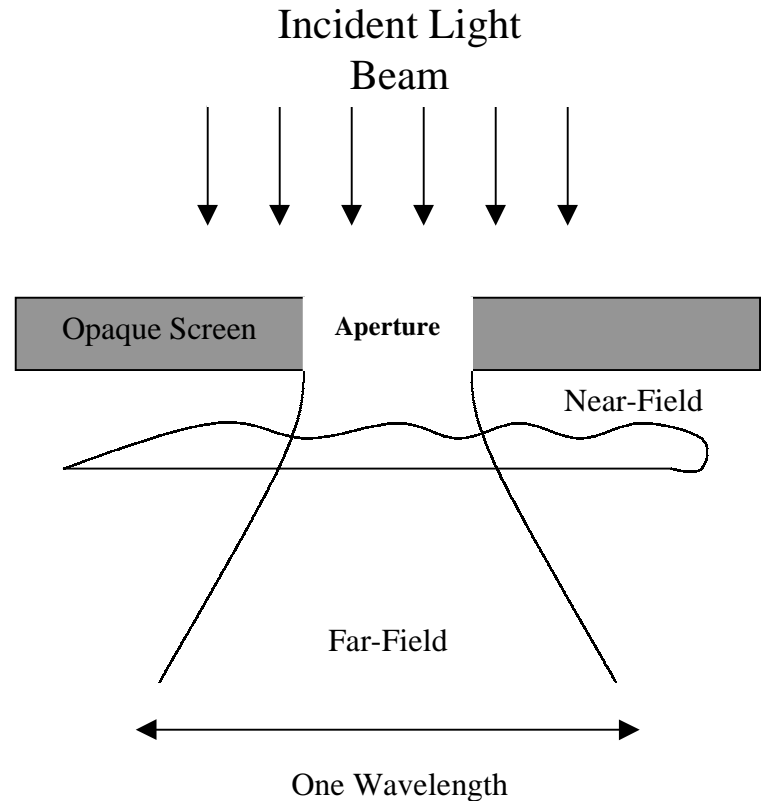
Electrical Characterization

Thermal Characterization

# What is Near-Field Optics?

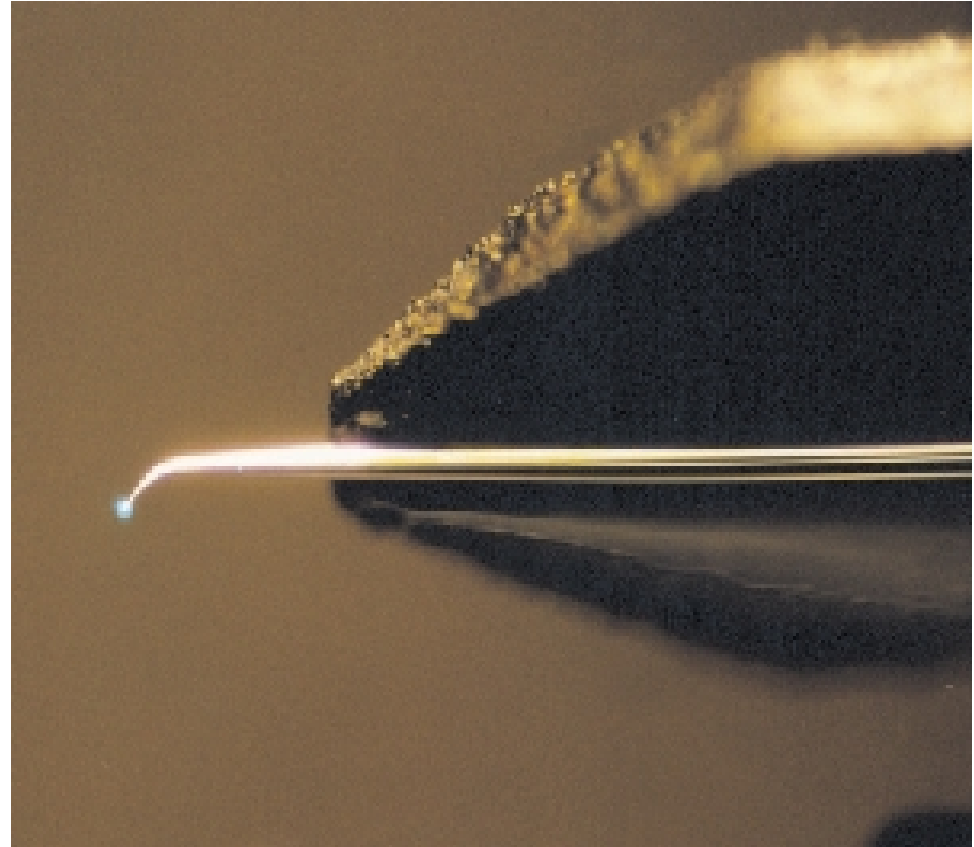
1. Collection or illumination of light through a sub-wavelength aperture

2. Scanning of sample or aperture relative to one another in the near-field

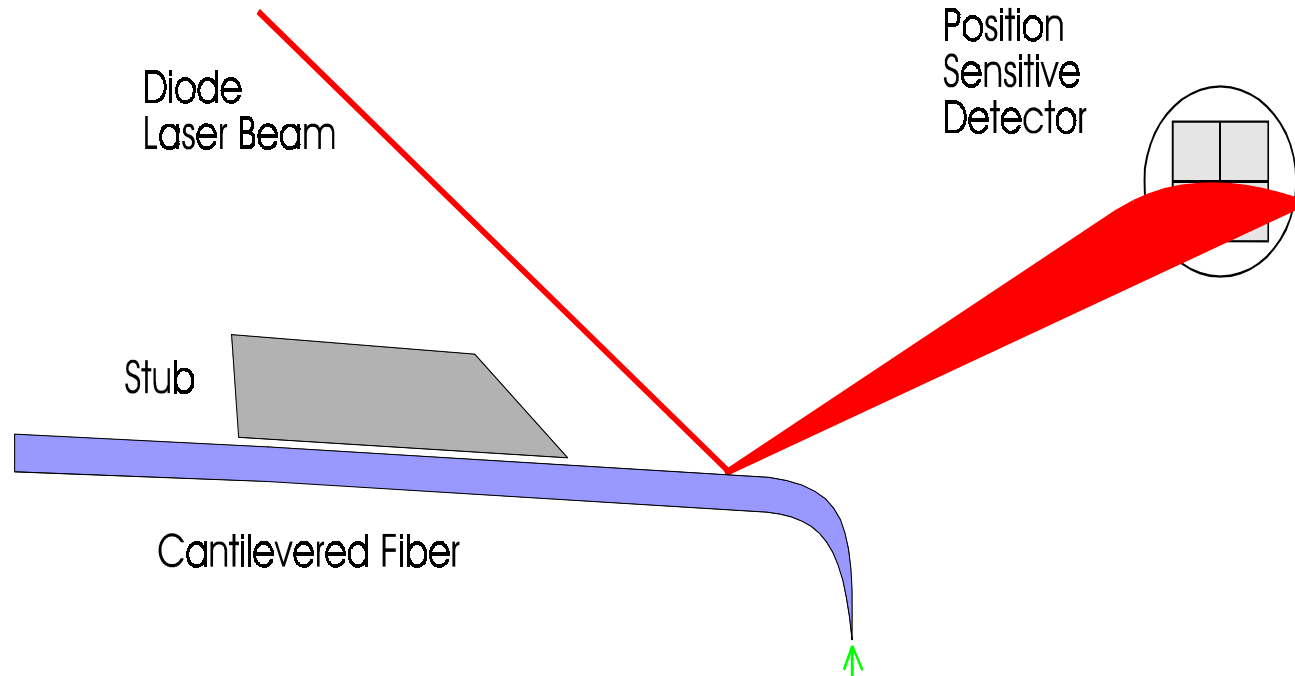


# Near-field Optical Element

1. Tapered cantilevered metal-coated optical fiber probe
2. Simultaneous optical and topographical imaging
3. Simultaneous electrical [resistance, capacitance etc.] imaging



# Deflection Force Sensing

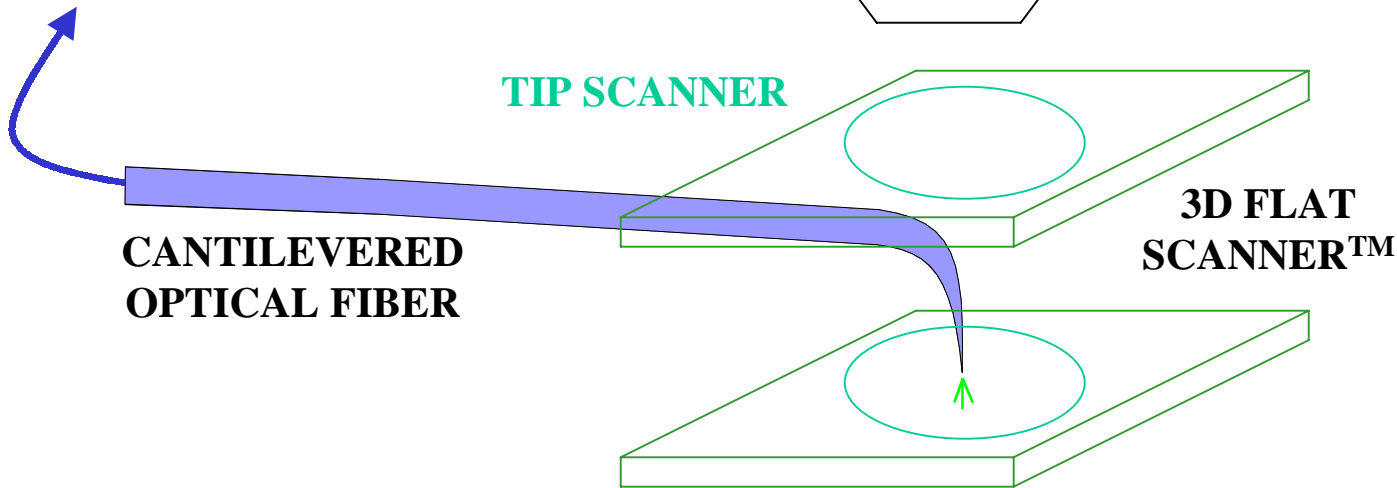


## The standard optical method

1. Cantilevered optical fibers are excellent atomic force sensors that can operate to detect surface topography either in contact or by being close but not in physical contact with the surface
2. Nanonics also provides non-optical means of deflection sensing

**Optical Spectrum Analysis**  
**Time Domain Measurements**  
**Electrical Measurements**  
**Polarization Analysis**  
**Thermal Measurements**

**CCD  
CAMERA**  
**LENS**



**TIP SCANNER**

**CANTILEVERED  
OPTICAL FIBER**

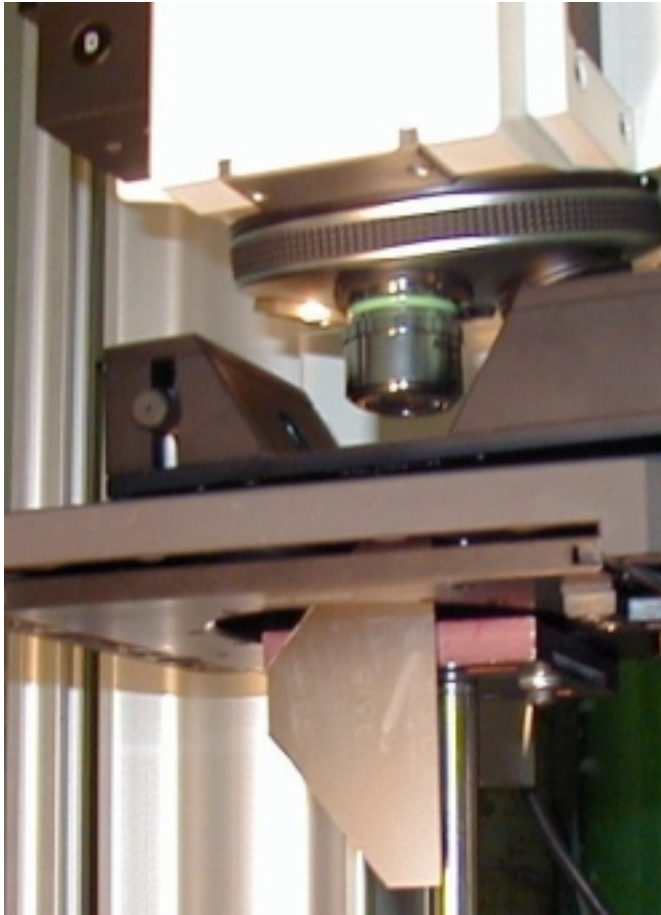
**3D FLAT  
SCANNER™**

**SAMPLE SCANNER**

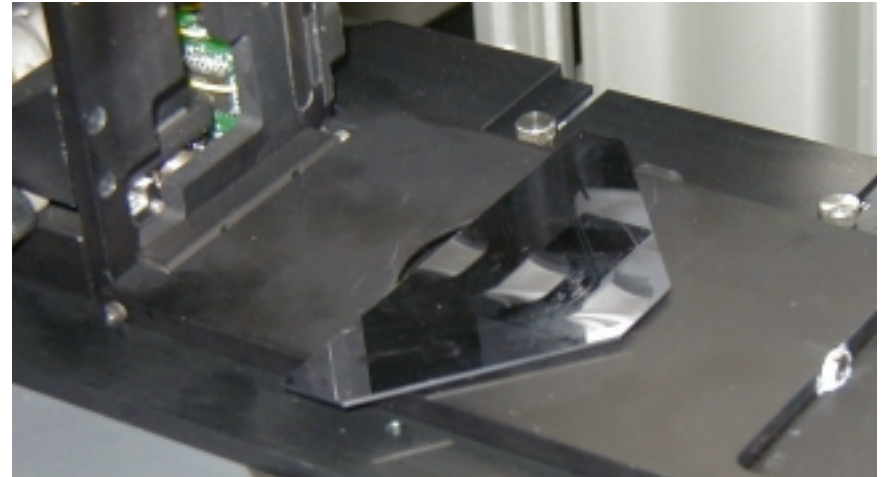
**LENS**  
**CCD  
CAMERA**

**Nanonics**  
**Near-field/Far-field**  
**Defect Review Station**

# System Flexibility



Placement of waveguide  
for high resolution  
injection of light at the  
edge of the guide



Placement of the waveguide  
for imaging evanescent  
fields



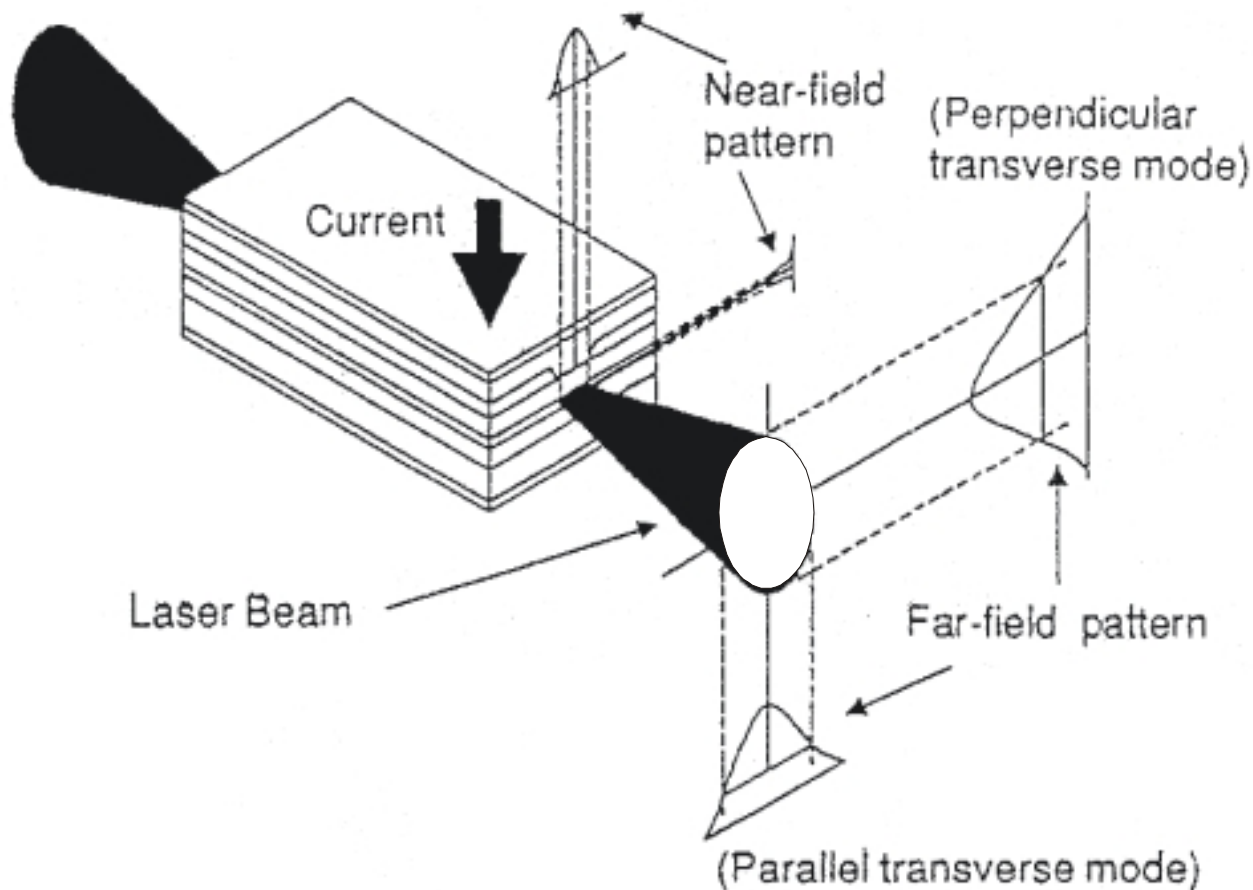


*Near-Field Optics (NSOM) Plays A Bridging Role Between Conventional Optical Microscopy And Atomic Force Microscopy*

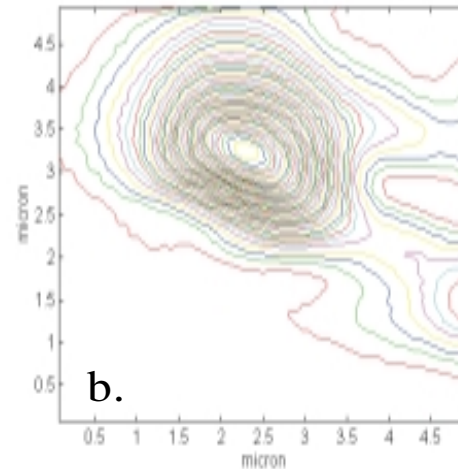
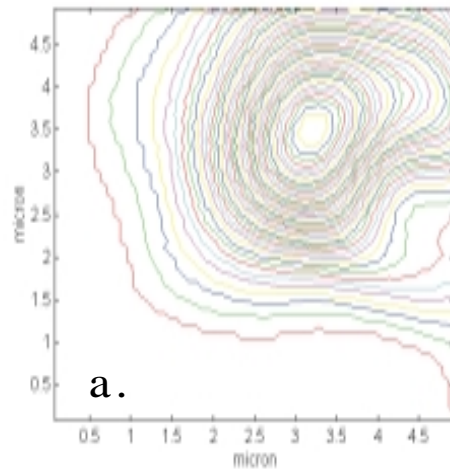
# Demonstrating the uses of near-field optics

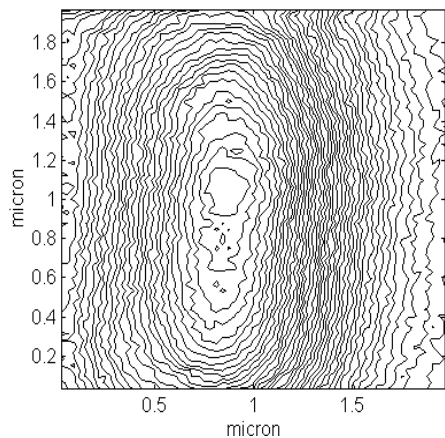
- Slab waveguide lasers
- V-Groove lasers
  - Correlating structure with light emission
  - Correlating mode structure with wavelength
  - Correlating mode structure with heat
- Optical waveguides
  - Optical fiber mode distribution with alterations in coupling
  - Polarization dependence of evanescent fields
  - Imaging the Tien effect
  - Imaging star couplers

# Light distribution analysis with 0.05 micron spatial resolution of slab waveguide lasers emitting at 1.5 microns

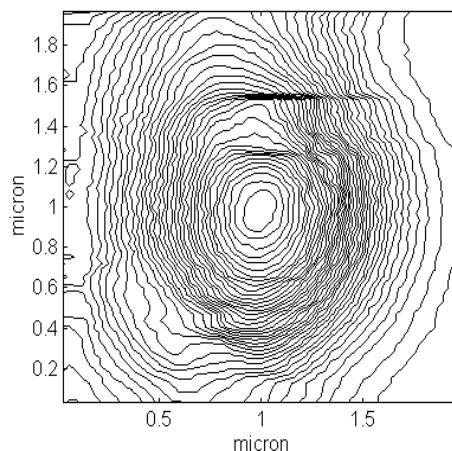


# A comparison of the (a) far-field and (b) near-field light distribution

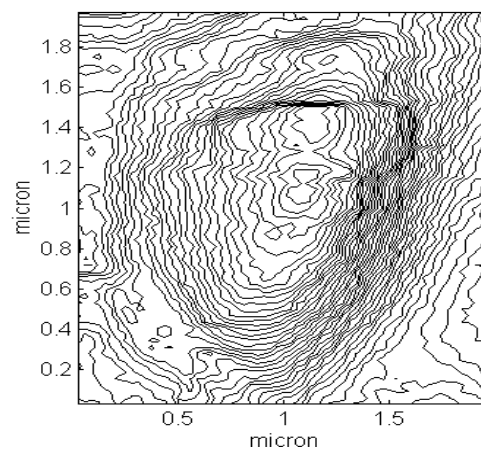




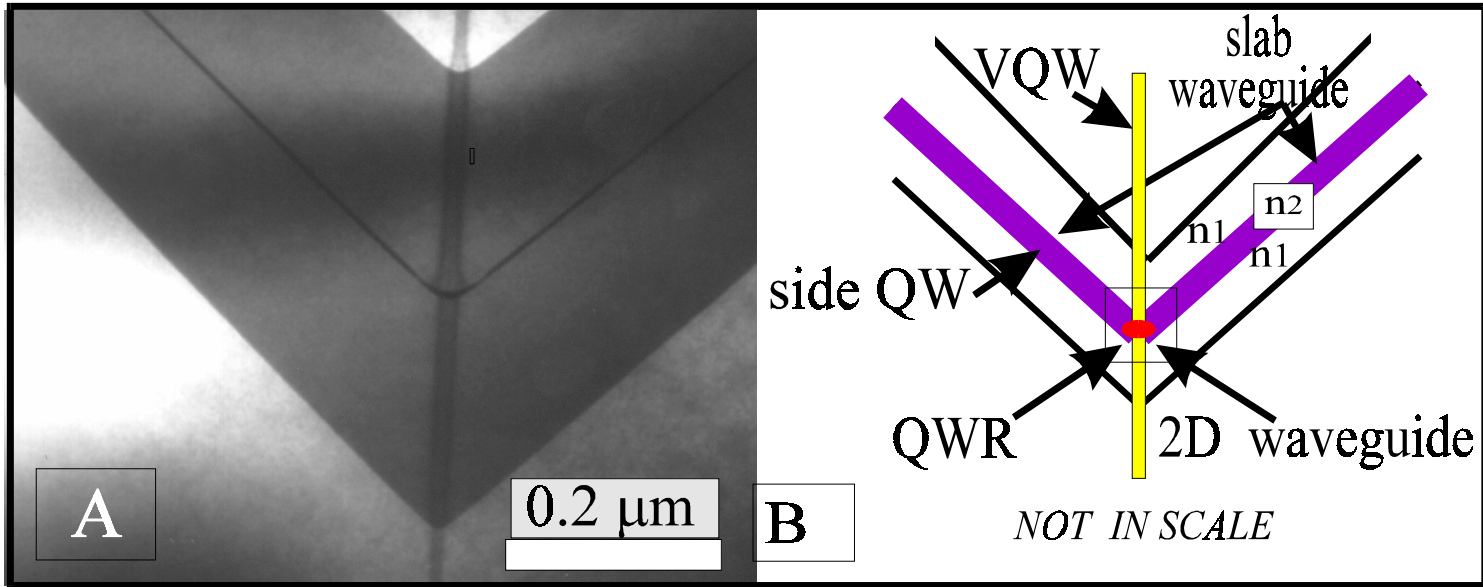
***NSOM Light  
Distribution  
From The Laser  
Cavity With An  
Injected Current  
That Is Below  
The Threshold  
For Lasing  
Action***



***NSOM Light  
Distribution  
From The Laser  
Cavity With An  
Injected Current  
That Is Above  
The Threshold  
For Lasing  
Action***

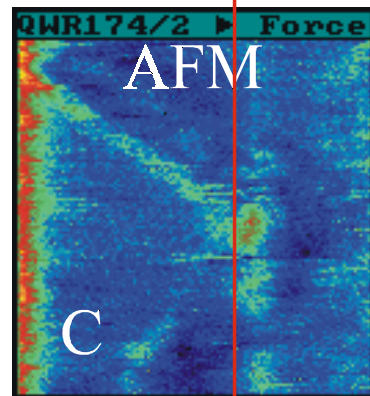
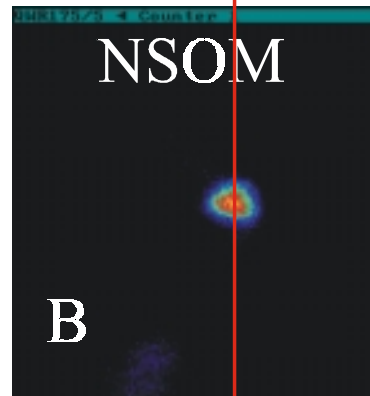
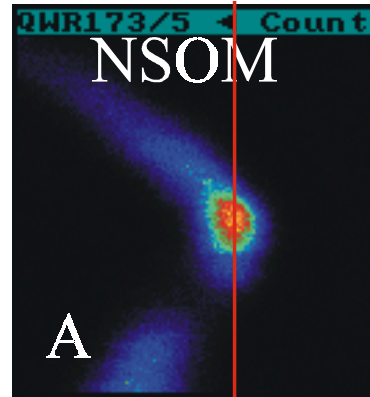


***Injected Charge  
Distribution  
Measured Using  
the Simultaneous  
Atomic Force  
Capabilities With  
an Injected  
Current Above  
the Threshold for  
Lasing Action***

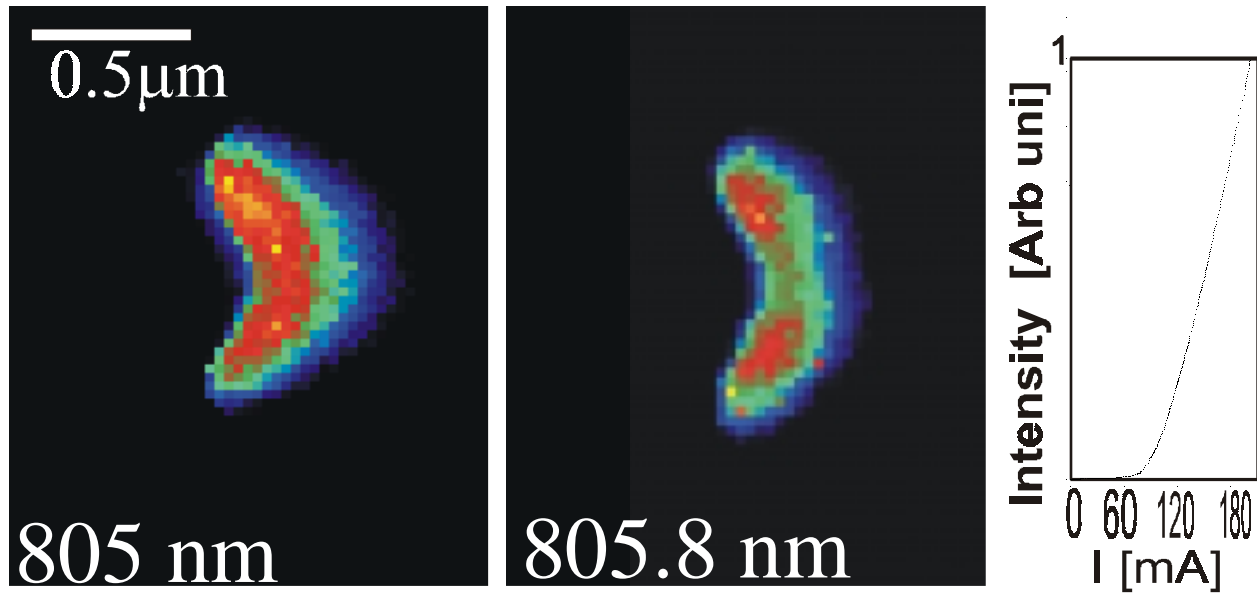


*An Electron  
Micrograph  
Of The V  
Groove Laser  
Structure*

*Diagrammatic  
Representation Of  
The Structure  
(B).*



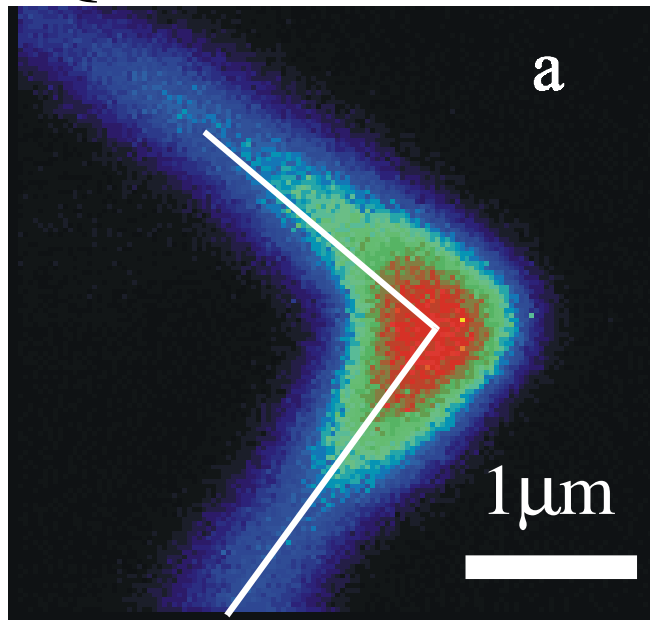
1. Correlation of the light distribution and geometric structure of the v groove laser
2. Notice the 150 nm offset



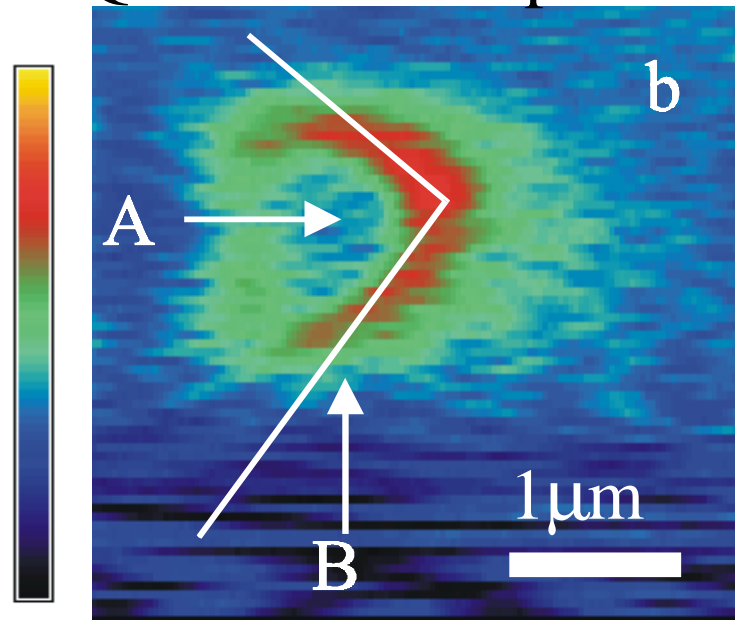
Correlation of mode structure with wavelength alteration



QWR293 -NSOM

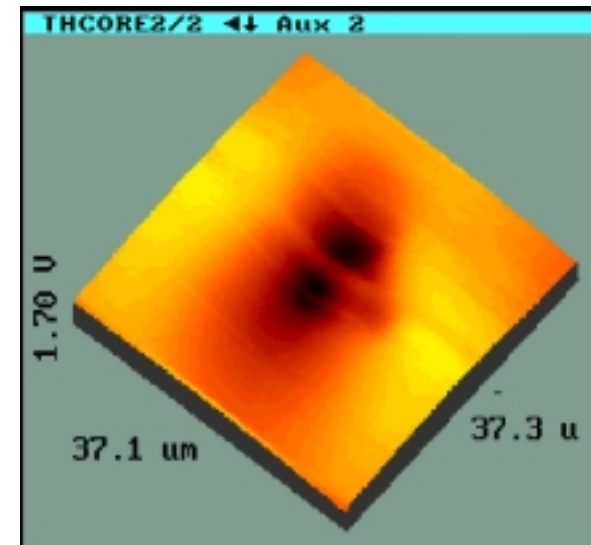
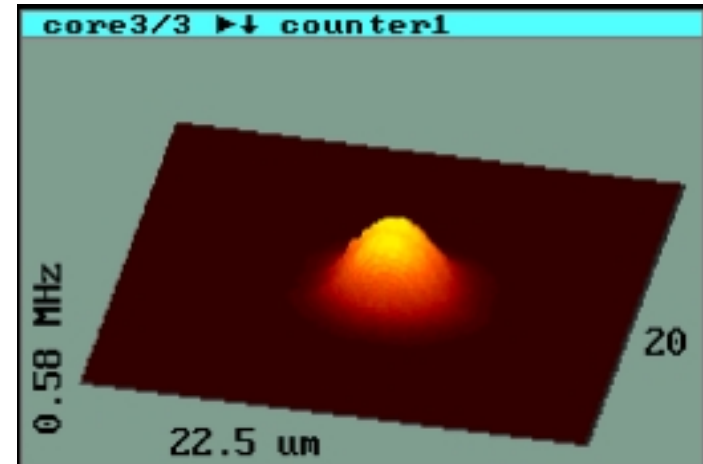
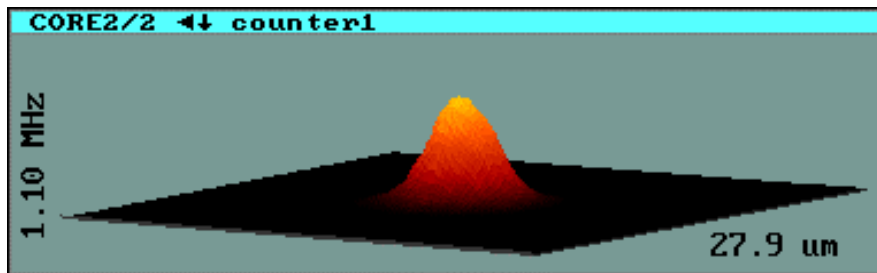
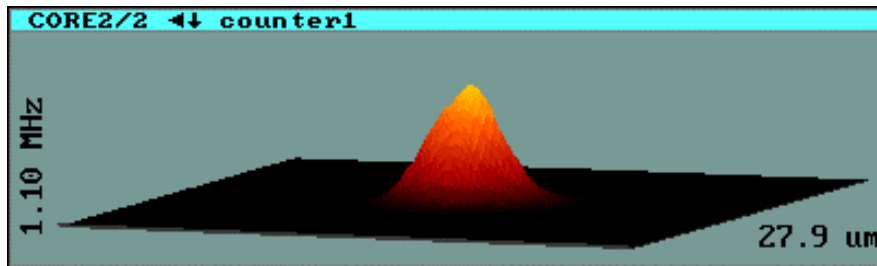
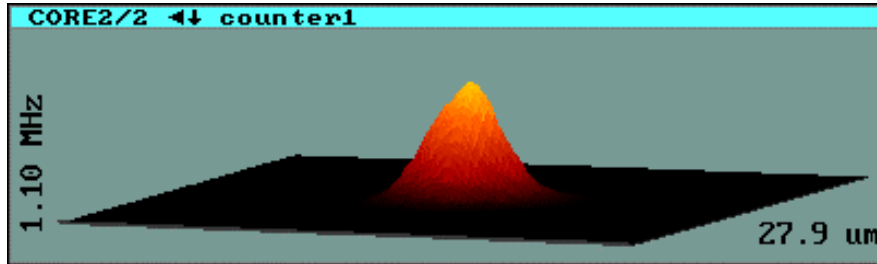


QWR294 -Temperature

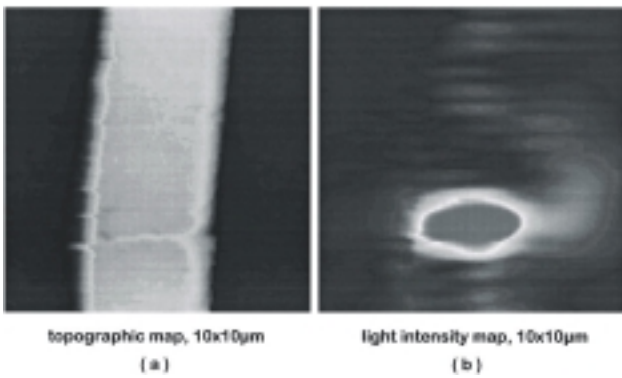


Correlation of light distribution with thermal characteristics

# Optical Fiber Output Analysis

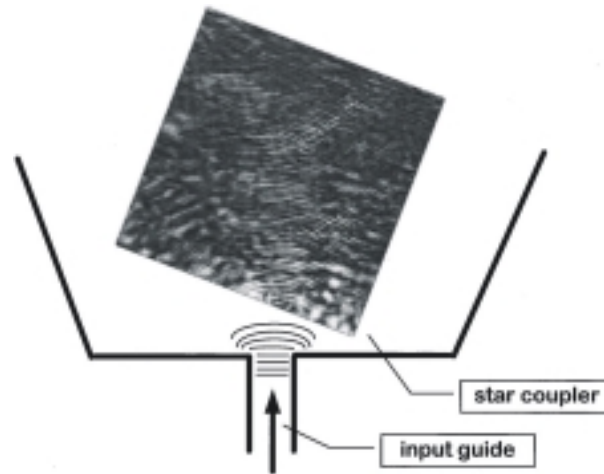
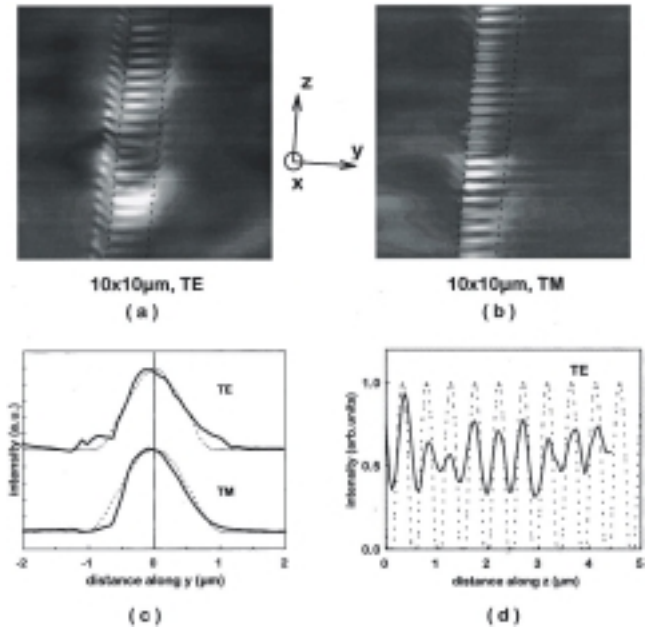


Correlation of light distribution with fiber coupling



10 nm deep topographic alteration correlated with light leakage from a waveguide that corresponds to an  $\sim 0.05$  dB guided power loss

*Images taken from Applied Physics Letters Vol. 73, 1035-1037 (1998)*



Near-field optical image of the star coupler section of a phasor device

Near-field optical images of the evanescent field for TE and TM polarization of a semiconductor waveguide

# Summary

## **Near-field Optics**

exceptional integrated information on today's components  
with a resolution and an information content critical  
for components in sight for tomorrow  
and  
being considered for tomorrow

[S. Shanhui, I. Appelbaum & J. D. Joannopoulos, "Near-field scanning optical microscopy as a simultaneous probe of fields and band structure of photonic crystals," Applied Physics Letters **75**, 3461 (1999)]

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