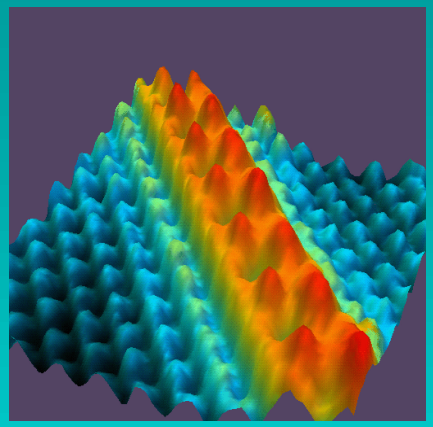


Meso/Micro/Nano Scale Technologies at NIST

John Evans, Chief, ISD, MEL

October 1999

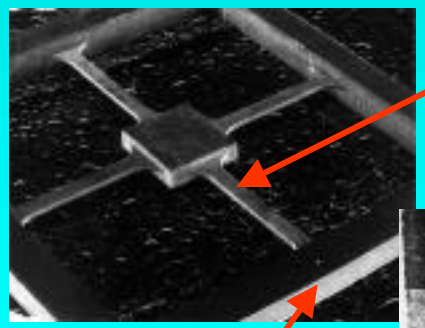
Examples of Industrial and NIST work at Meso-scale

Stents laser micromachined by Potomac Photonics

Hutchinson Technology Inc. suspensions for disk drives

NIST micromechanically machined STM components

NIST fabricated prototype force transducer for calibrating suspensions



Web dimensions 400 µm by 92 µm

Frame: 10 mm square

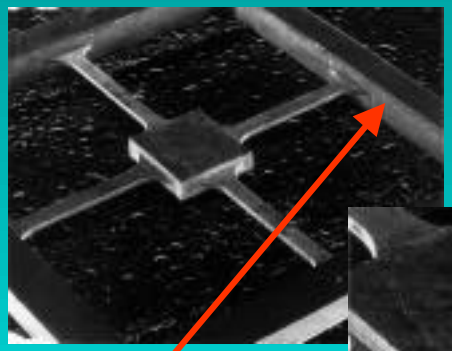
Needs

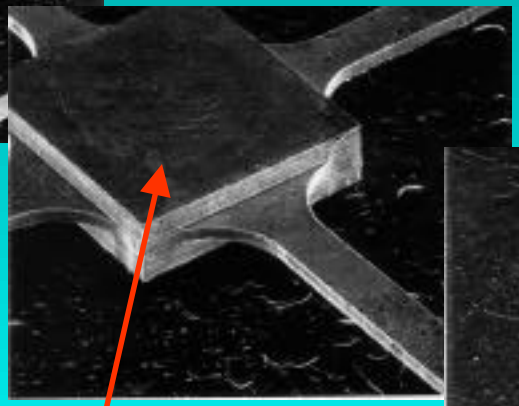
- Long term: basic science for nanotechnology and nanomaterials, measurements, standards, enabling technology.
- Short term: critical needs at mesoscale and microscale in metrology, in assembly and packaging, in process science and particularly materials testing and materials data.

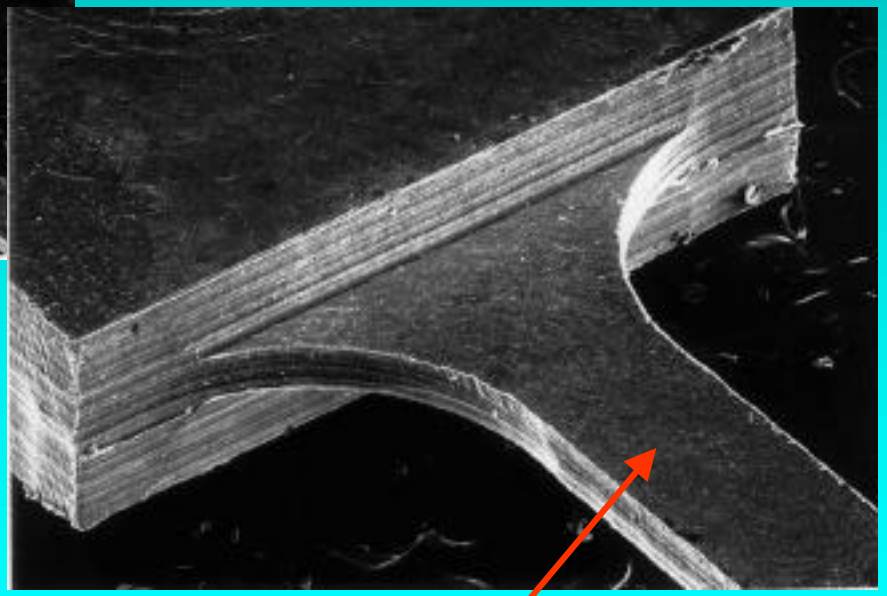
Meso/Micro/Nano Manufacturing at NIST

- New Strategic Program in the Manufacturing Engineering Laboratory (MEL) starting this month
- $2.5 M Reprogrammed Funding for FY2000
- Focus within MEL will be in:
  - Base technology in each Division
  - Creating a Microshops capability to focus efforts in all Divisions on working systems
  - In each scale domain, working on one NIST part and one DARPA part
  - Coordinating efforts across NIST

Micro-mechanical machining of Force Transducer







Design goals:
Maximum Load : ~40 mN
Maximum Torque: 1.5 mN-m
Resolution: ~10 mN/15 nN-m

Frame:
10 mm square

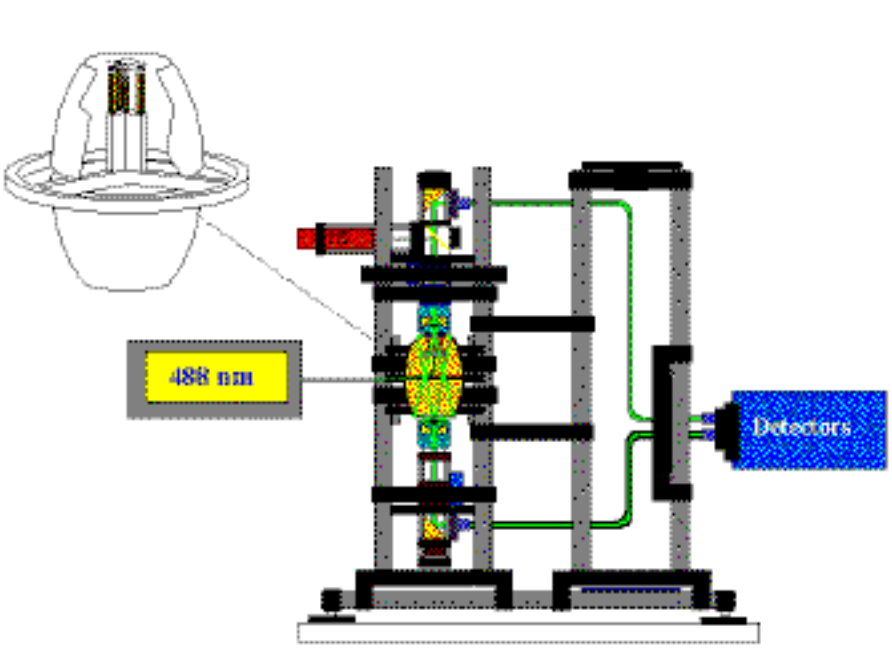
Pad size:
2mm square

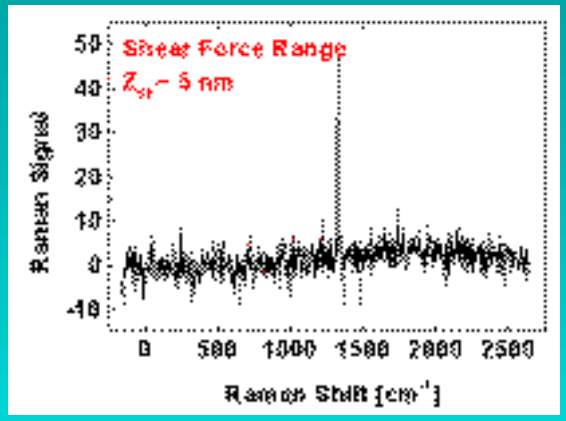
Web dimensions
400 mm by 92 mm

Measurement Needs:

Molecular Spectroscopy & Imaging

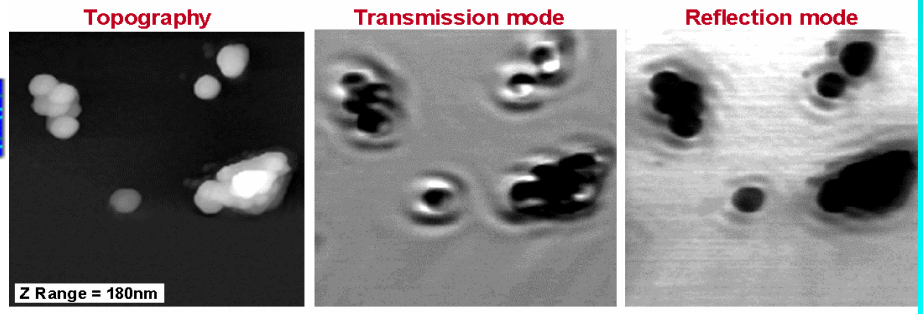
- Scanning Probe Microscopies
  - Nearfield Scanning Optical Microscopy
    - Raman, IR, visible spectroscopy at nanoscale resolution





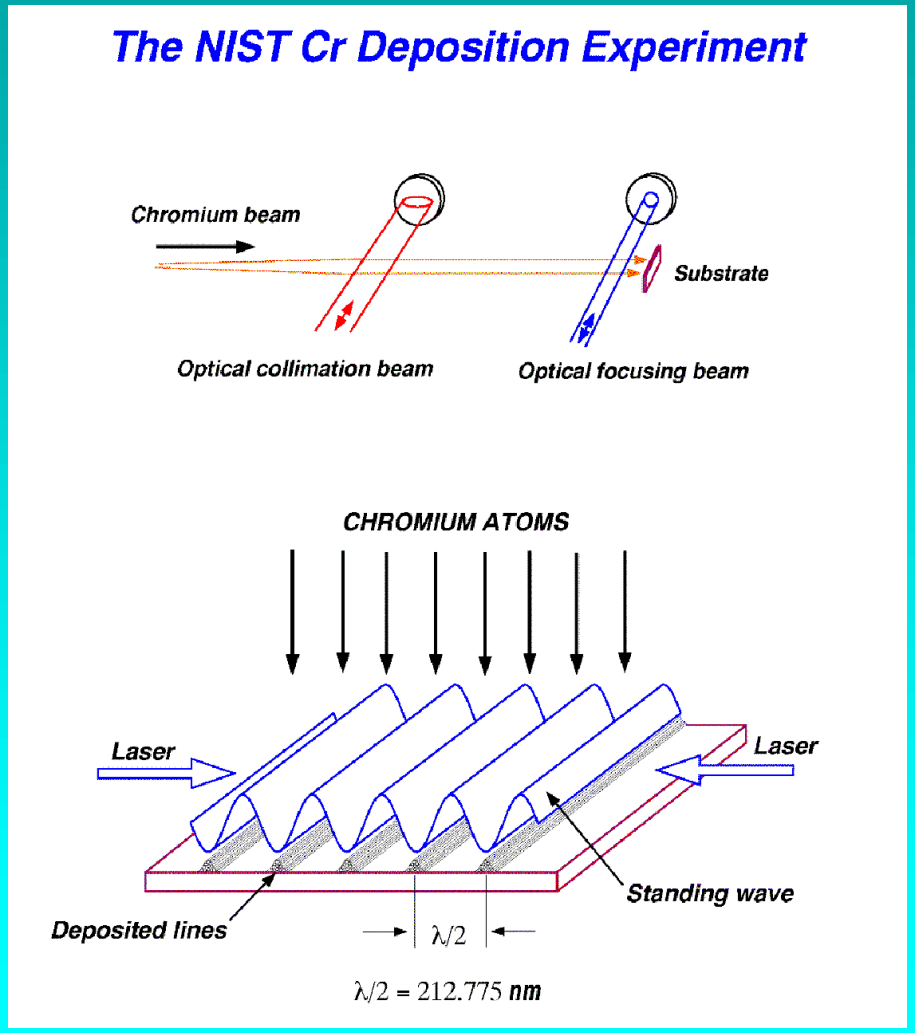
- 100 nm Colloidal Au Particle Scattering of 488 nm Light.

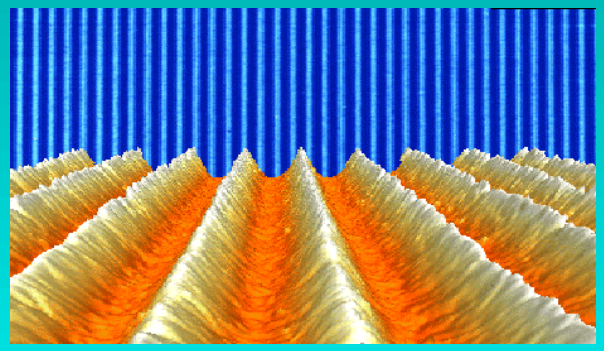
- *Simultaneously Recorded Images (3500 nm x 3500 nm) of 100 nm Colloidal Au Particles on a Silanized Glass Substrate.*



- Standing Waves have a period of $\lambda/2$ and extend beyond topography.
- Light scattered from the spheres modulates the total field emanating from the tip.

Measurement Needs: Dimensional Metrology

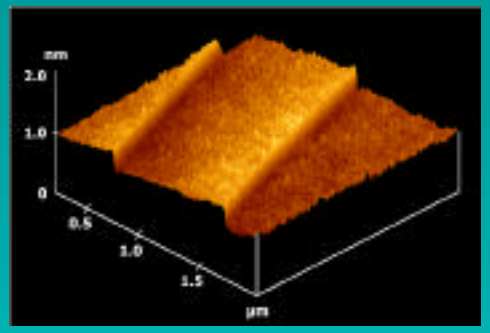


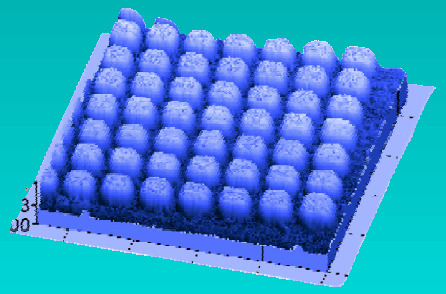


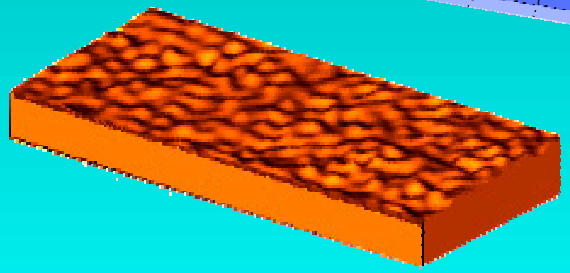
- Create a "nanoruler" directly traceable to the wavelength of light.
- Nanoscale accuracy and precision over millimeter distances.

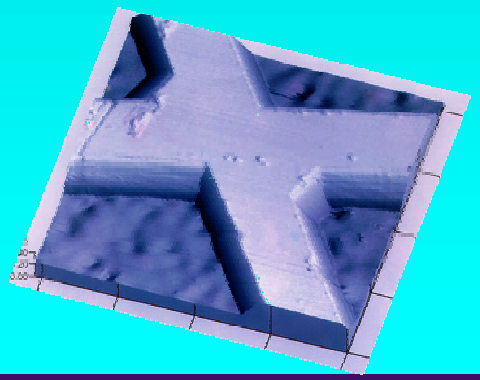
Measurement Needs: Dimensional Metrology

- Step Height
- Pitch
- Roughness
- Linewidth









Priority Needs for NIST

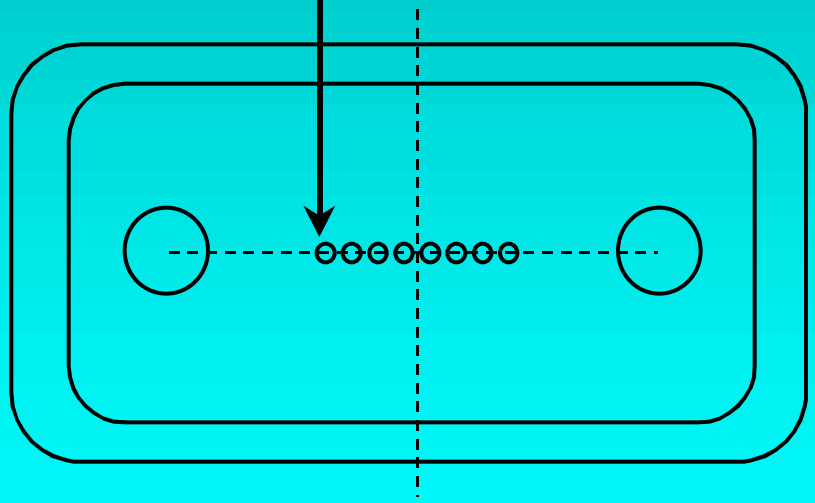
- Short Term:
  - Meso/micro metrology
  - Assembly and packaging
  - Science base for products and processes, particularly materials testing and materials data

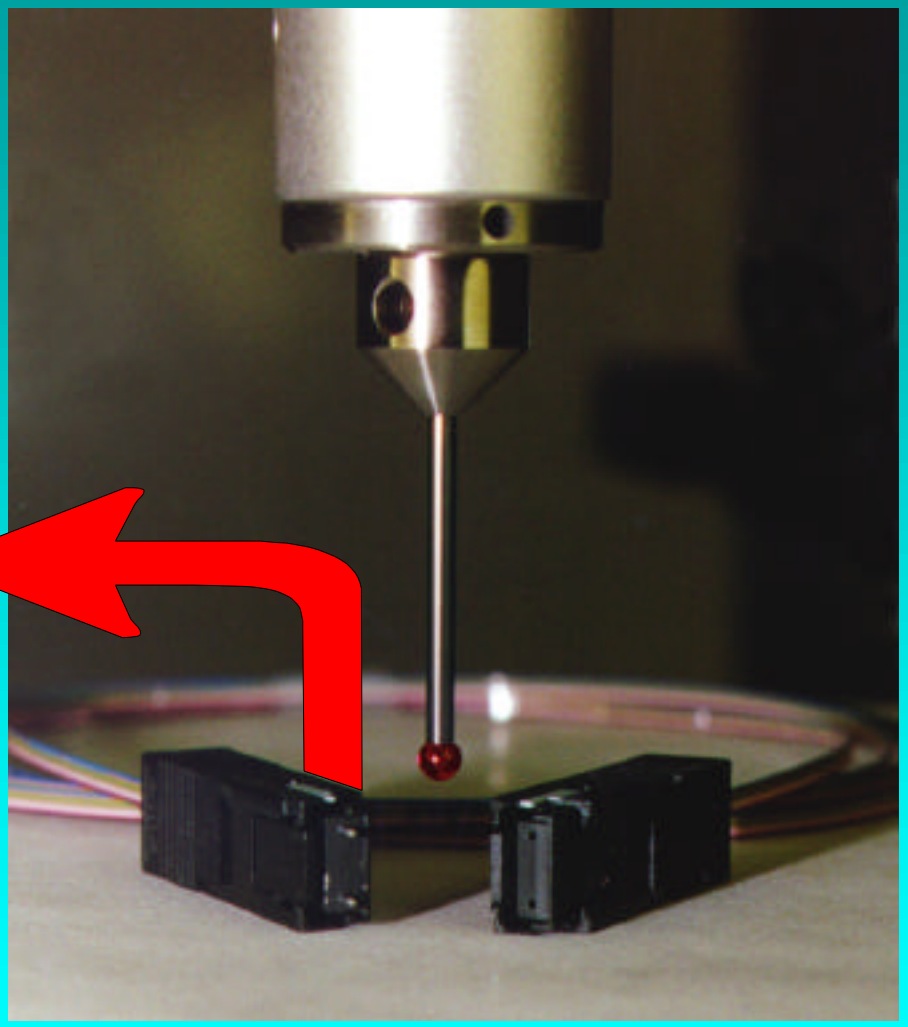
Meso/Micro Metrology

Fine CMM Probe

Diameter: $\left(125^{+1.5}_{-1.0}\right)\mu m$

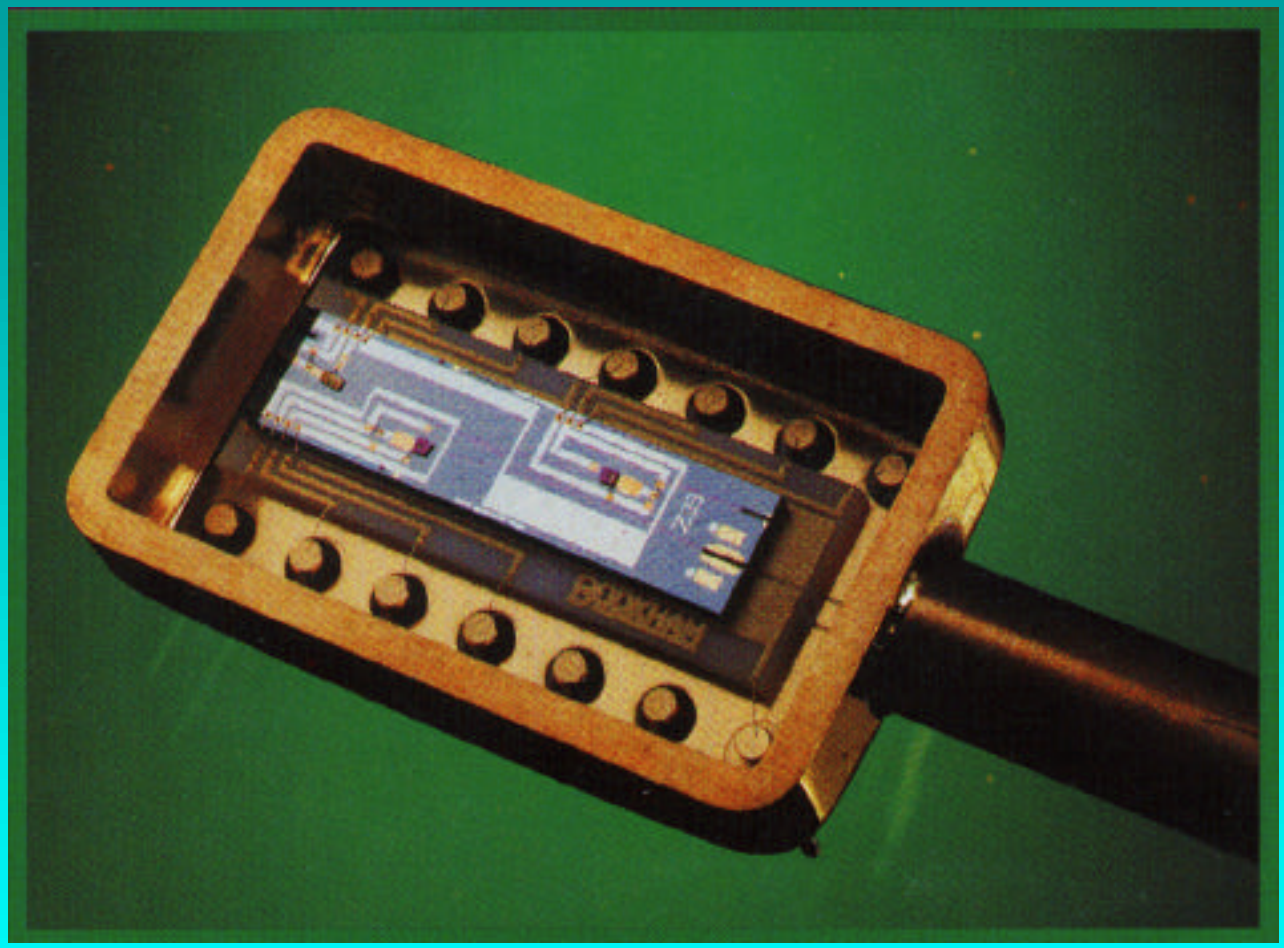
Position Tol: ± 1.5 µm





Meso/Micro Metrology

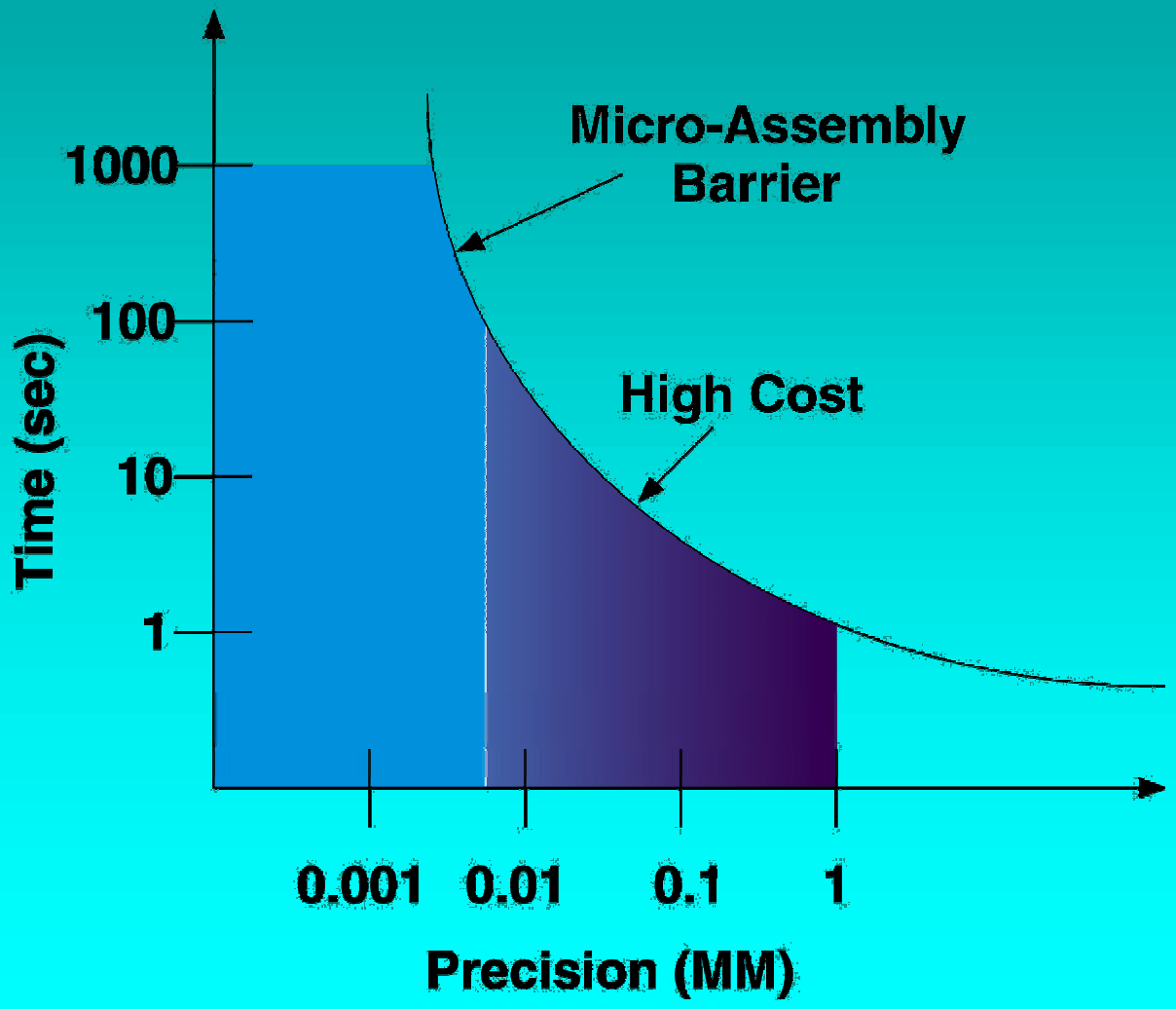
- NIST can provide:
  - Suite of optical, mechanical, electrical, and magnetic measurement techniques for dimension, materials properties, and mechanical properties
  - Calibration services for force to micro and nanoNewton levels and torque to pico N-m
- This is a “hole” in our support for industry that is critical in the near term.



Bookham Technology Transceiver, example of integrated optics.
Photonics Spectra Feb. 1997

Photonics Industry Problem

Cost of Assembly



MesoMicro Assembly and Packaging

- NIST needs to provide
  - Information exchange
  - Sensors (measurement technology) for microrobotics and microstages
  - Chemical and materials data
  - Performance measures and testing methods
  - Proactive role in creating interim de facto standards to help US industry and eventually supporting normative standards process

Data Implications of Meso-Machines

- Tolerance Challenges
  - Need support for linkage between product function and tolerance specifications
  - Need comprehensive tolerance definitions supporting improved tolerance analysis
- Tightly coupled product/process/material definitions
  - Need Need for high fidelity process characterization models
  - Incorporate materials and process model predictions earlier in design cycle

NIST Contributions

- We will be working on 3-5 year and longer problems
- Looking for problems/needs and for partnerships
- Consulting
- CRADAs and direct support