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Training Programs Answering the Technician Gap in Optics and Photonics Industry

Center for Applied Competitive Technologies

Irvine Valley College, Irvine, CA

Director, Larry DeShazer, PhD

Asst. Director, Donn Silberman

CACT Instructor, Gene Dempsey

Industry Advisor, Arnie Bazensky (Schott)

NSF OP-TEC Director, Dan Hull

CACT Located at Advanced Technology & Education Park (ATEP)

- Tustin Marine Corps Air Station Decommissioned July 1999
- ATEP Site Conveyed April 2004 to South Orange County CC District
- CACT at ATEP in September 2007
  In Building D with 3,024 sq. ft.

❖ ***Key Requirement - Dedicated Lab Space Needed***

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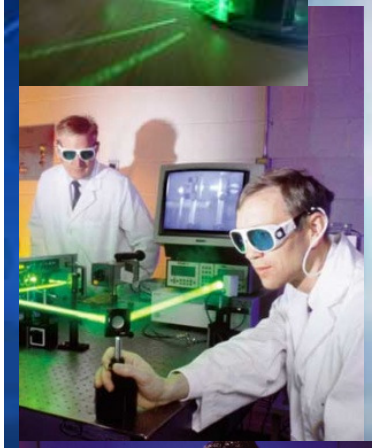
Optics Technician Training at Irvine CACT since 2001



- Concentrated on local industry needs
- Orange County has 23 companies associated with optics
- Equipment donations valued at $3.9 M
- Largest US commercial laser company is 6 blocks away: Newport Corporation
- Major support by Schott Glass, Zygo Corporation, and Northrop Grumman

❖ ***Key Requirement - Obtain Industry Support for Training***

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What is High Precision Optics?

It is not just eyeglasses!

Micreon 2006, ref: spectrum.ieee.org/jun06/3654

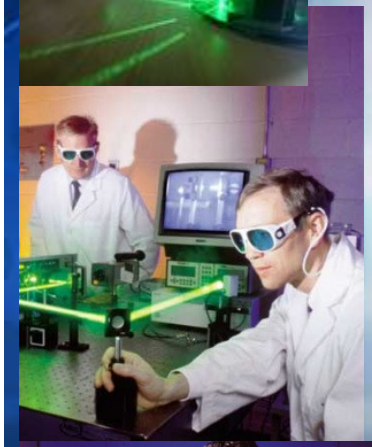
High Precision Optics

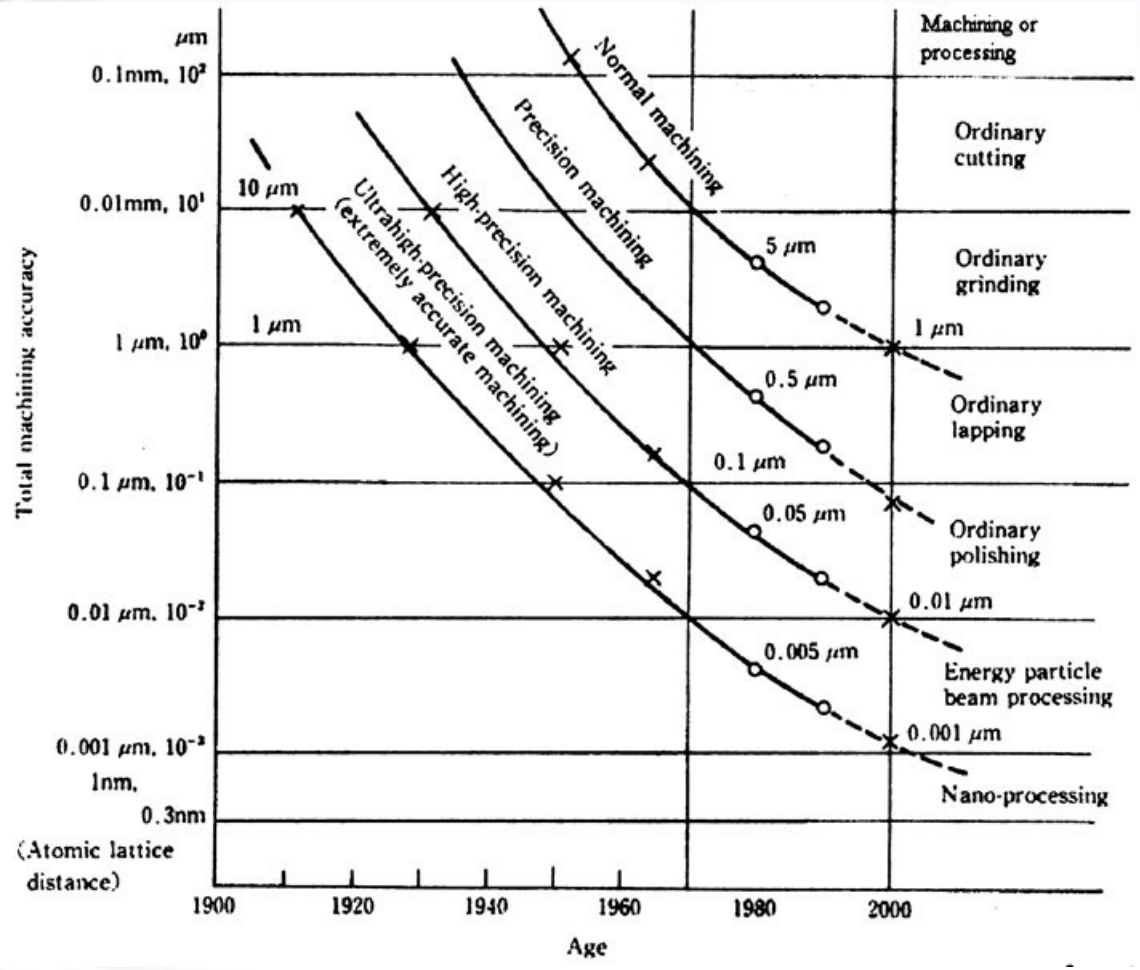
- **High-precision optics requires very accurate *form* and *position* for the functional elements of optical systems in order that the systems' performance requirements are met.**

- **High-precision optics are optical elements with**
  - **Surface accuracy of 38 nm (1.5 X 10^{-6} inch) or 1/16th wavelength**
  - **Positional accuracy of 6350 nm (2.5 X 10^{-4} inch) or 10 wavelengths**

  Measurement wavelength used is 632.8 nm of He-Ne laser

Tolerances in Optical Machining





Ref: Current Science 84, 1211 (2003)

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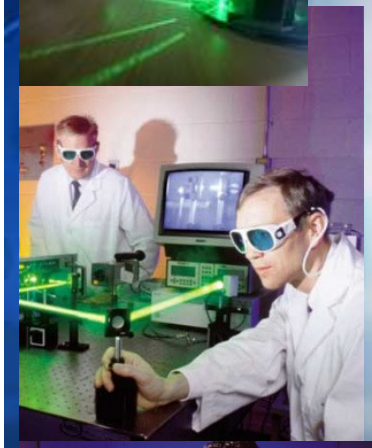
What is Photonics?



- The short definition is ‘electronics using light’
- Photonics is the new melding of disciplines replacing or augmenting electronics by using light to perform functions that once were the domain of electrons

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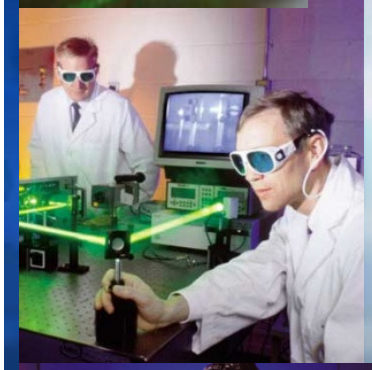
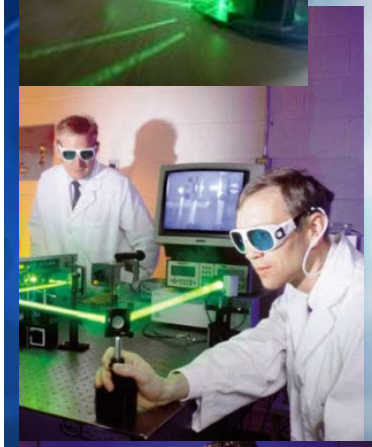
What is Photonics? cont.

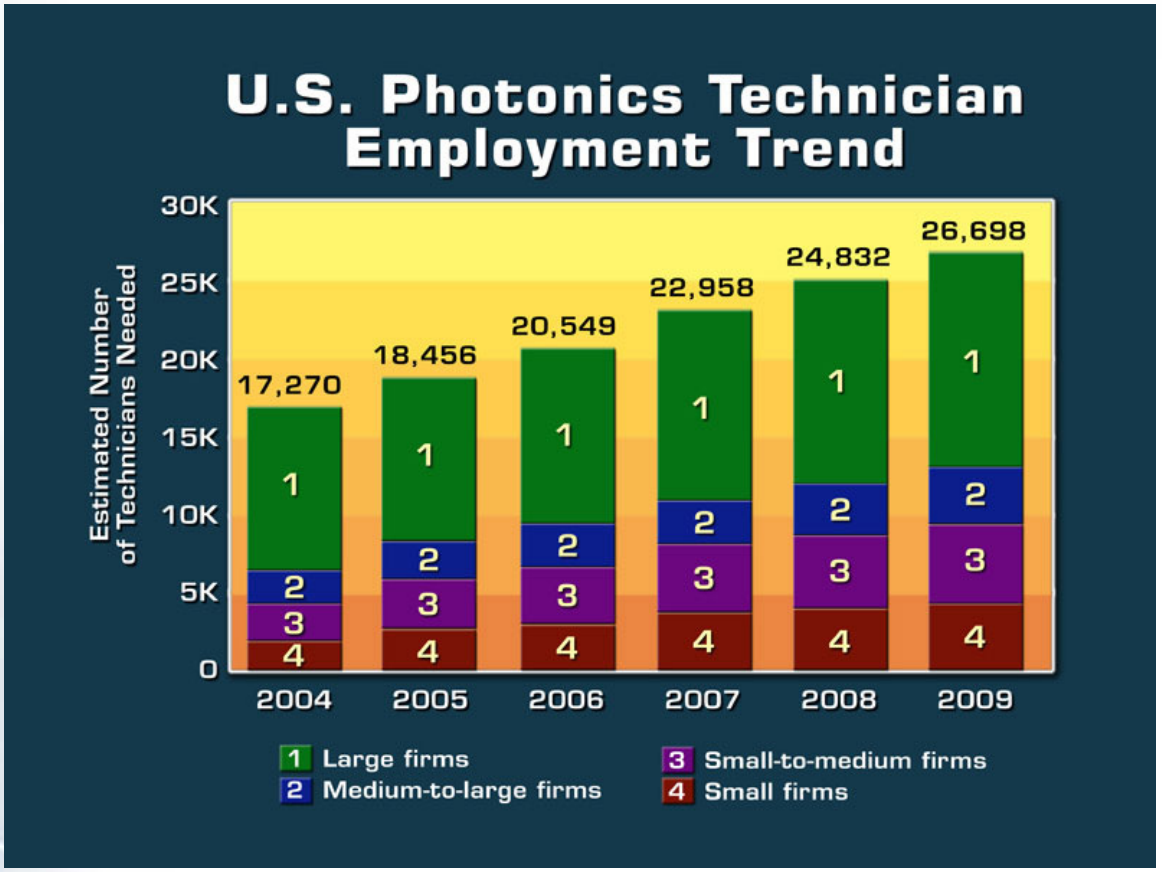


- Before 1980, photonics was spoken of in divided segments: lasers, fiber optics, astronomy, surveillance, communication, sensors, information storage/computers
- Photonics offers faster (psec), smaller (nm), cheaper technologies

❖ ***Key Point - Photonics Used In (almost) All Products***

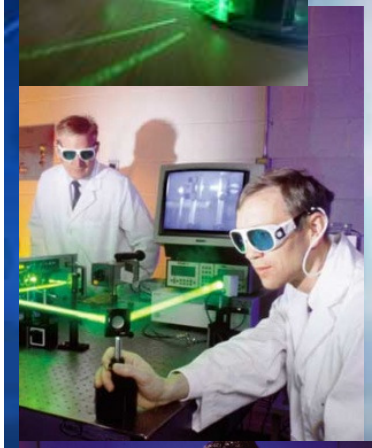
Need for Photonics Technicians in US





Ref:http://www.op-tec.org/step2.htm

What is Technician Gap in Photonics?



- **Skilled workforce retiring**

"*As Cold War workers begin to retire, the nation's aerospace and defense sector braces for a big brain drain,*" **LA Times, Mar. 20, 2008**

- **Boeing: 15% workforce are eligible to retire**
- **Northrop Grumman: 122,000 eligible to retire in 5-10 years**
- **Lockheed Martin: 70,000 to retire in next decade.**
- ***Key Point – Who will replace these skilled workers in the next 20 years?***

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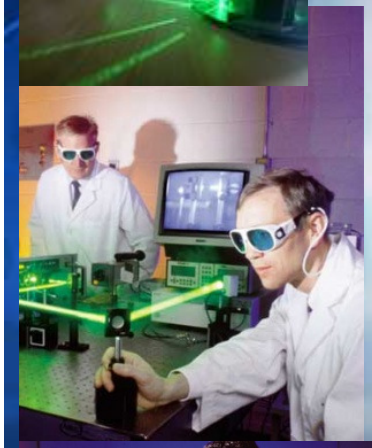
What is Technician Gap in Photonics? cont.



- **Replacement workers not adequate**
  - **In numbers**: OP-TEC has goal to prepare 1800 photonics technicians each year
  - **In skills**: Few college technician training programs in photonics (only two in CA); On-job training is common at this time

- **Key Question: Can skilled replacements be found in time?**

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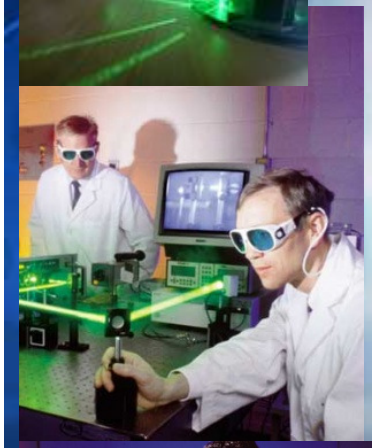
New Skills for Optics+Photonics



- Computer Controlled Optical Systems
  - Opto-mechanical design
- Robotic Assembly
- Computer Numerical Controlled Optical Machining and Polishing
  - Diamond Turning (SPDT)
  - Magneto-Rheological Finishing (MRF)
- New Material Handling
  - Crystals
  - Glass Ceramics
  - **Key Observation: Additional Technician Skills Needed**

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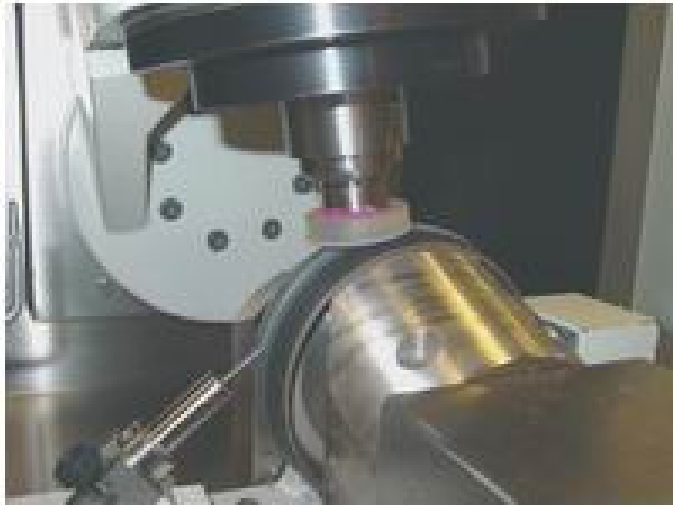
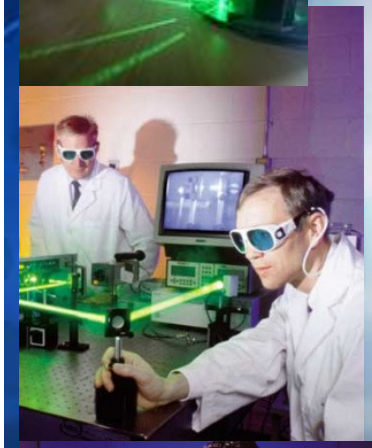
Magneto-Rheological Finishing (MRF)



Optics+Photonics is Expanding Field



- **New Spectral Regions**
  - **UV (application for lithography)**
  - **Terahertz Radiation (100 µm-1 mm wavelength, spectrum between IR and Microwaves)**
- **New Techniques**
  - **Aspheric Optics (components with non-spherical surfaces) common use is for laser diode collimation**
  - **Non-imaging Optics (solar energy, illumination) NIO Lab, Merced Energy Institute Research at UC Merced**
  - **Hollow Glass Waveguide Fibers (power delivery, sensing from IR to THz)**

❖**Key Point - Optics+Photonics Is Not Static**

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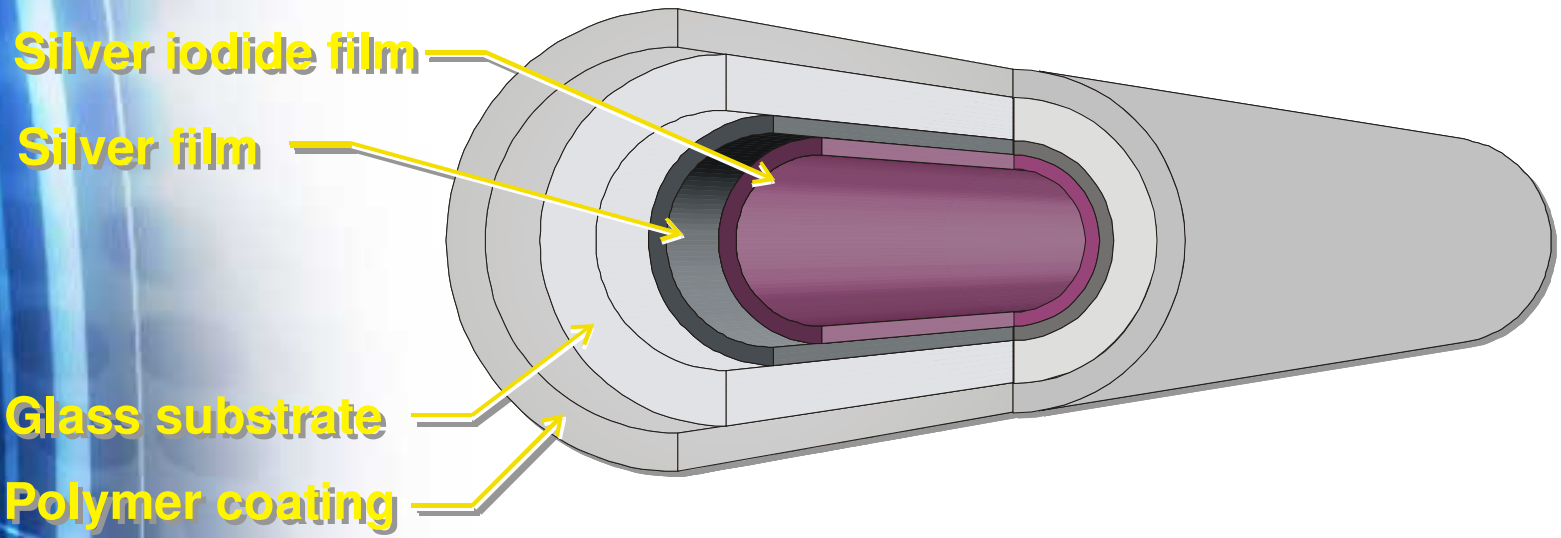
Non-imaging Optics for Solar Energy

Thermal solar power by heating fluid to create steam and power, NY Times March 6, 2008

Hollow Glass Waveguides

- Broadband transmission: 600 nm to >12 μm
- Losses as low as 0.02 dB/m @ 10.6 μm
- High laser power delivery: >1000 W



Ref: http://irfibers.rutgers.edu/hgw_index.html

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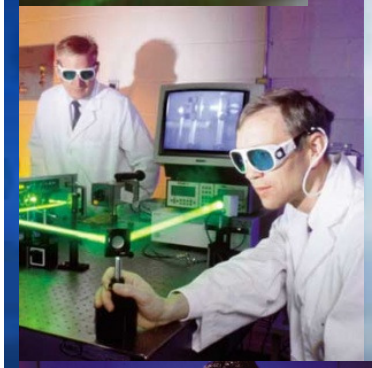
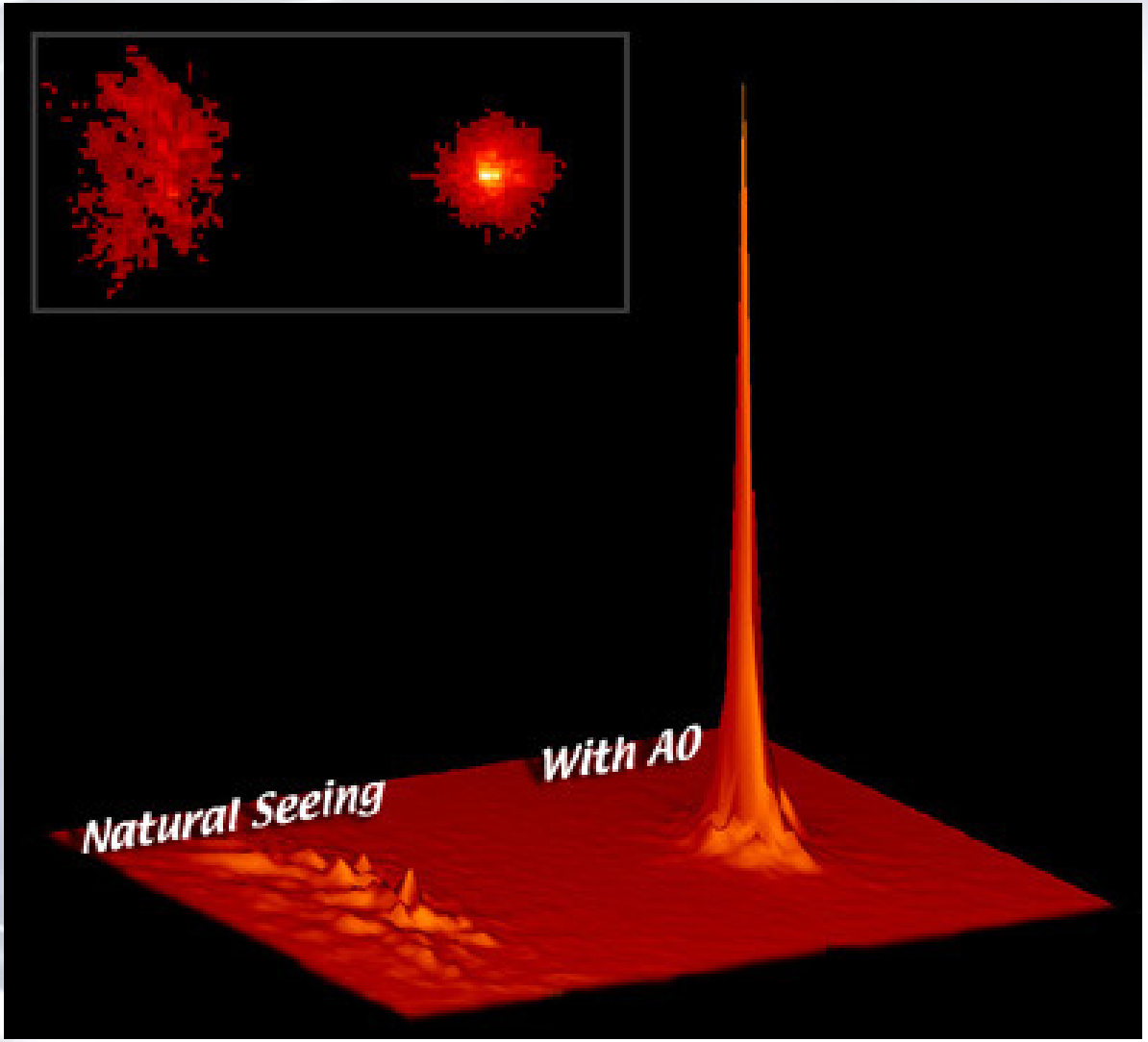
Optics+Photonics Expansion



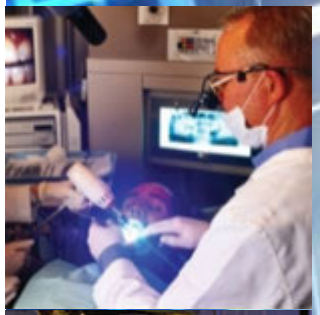
- **New Techniques – cont.**
  - **Adaptive Optics** (removing blurring of images caused by distortions – first applied in astronomy)
    Center for Adaptive Optics (CfAO), NSF Center at UC SCruz
    http://cfao.ucolick.org
  - **Metamaterials** (periodic optical structures having wavelength band gaps – negative refractive index)

❖**Industry Expansion Requires New Tools**

Adaptive Optics for Astronomy



Industries Involved



- Aerospace/military – missile guidance, autonomous technology (unmanned vehicle), airborne lasers
- Medical – surgery, imaging, sensing
- Information & Communication
- Astronomy – large telescopes, spacecraft optics
- Automotive – cutting, welding, assembly
- Identification & Surveillance
- Research – high-energy lasers (NIF Livermore)

❖ **Photonics is an Enabling Technology**

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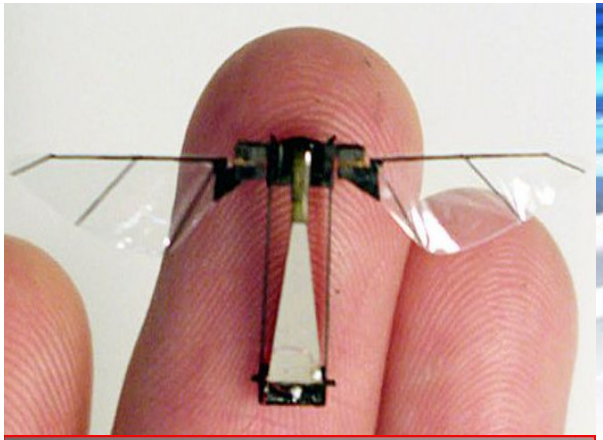
Optics for Homeland Security

- **Autonomous Technology**
  - Unmanned Vehicles (UAV, UUV, MAV)
- **Imaging and Identification**
  - Iris and Fingerprint Identification
  - Night Vision and High Altitude Imaging
- **Terahertz Technology**
  - Non-intrusive Inspection – penetrates fabrics & plastics
  - Safer than X-rays – no tissue damage since non-ionizing radiation

❖**No End in Sight for Optics**

(no pun intended)



X-45A UCAV under development at Boeing Phantom Works. Image source: Boeing

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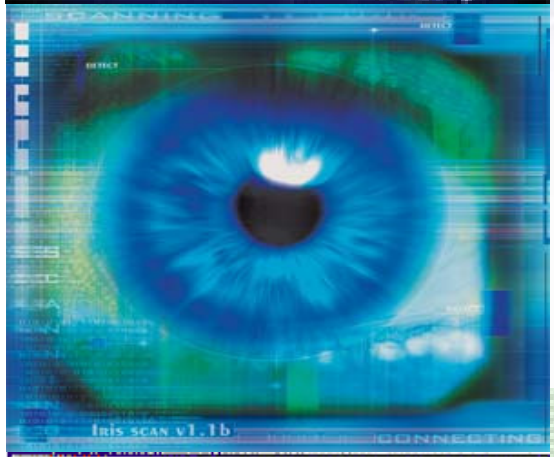
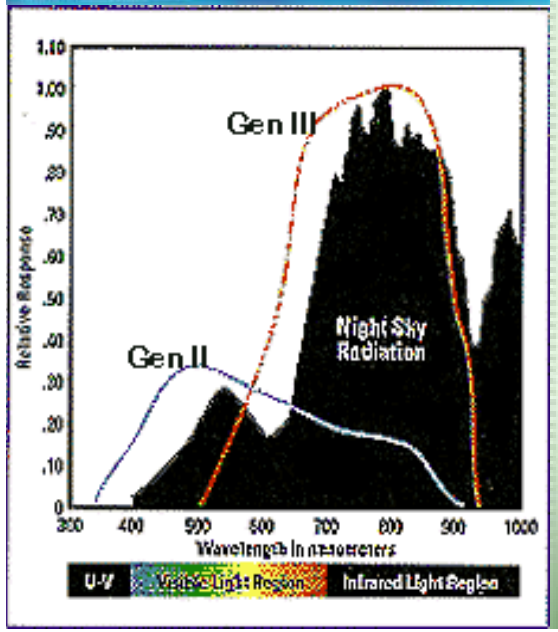
Optics for Unmanned Vehicles

- Unmanned Aerial Vehicles (UAV)
- Unmanned Underwater Vehicles (UUV)
- Micro Aerial Vehicles (MAV)





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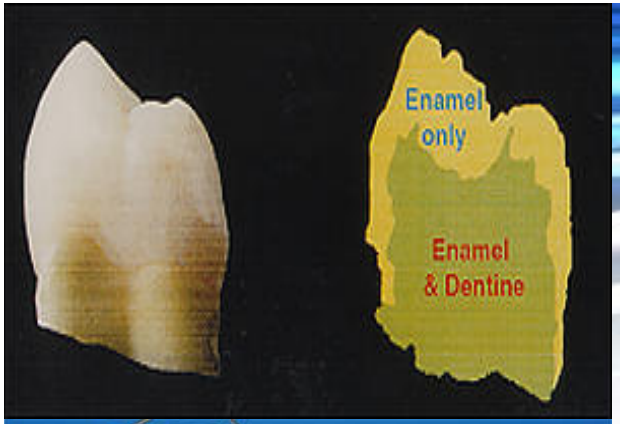
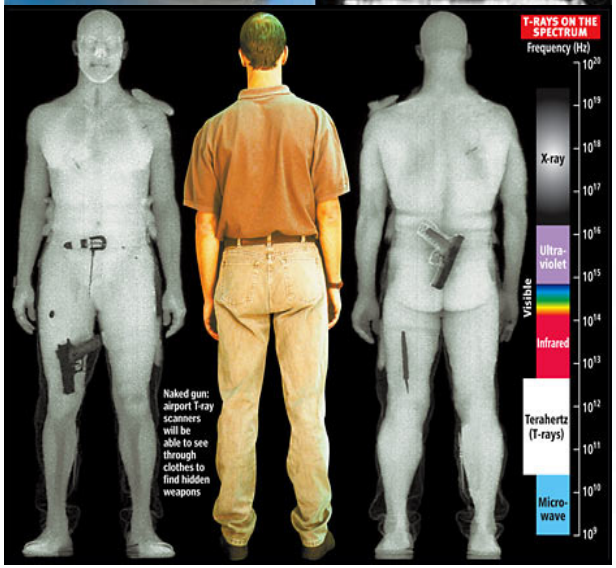
Optics for Imaging and Identification

- Iris and Fingerprint Identification
- Night Vision Imaging
- High Altitude Imaging





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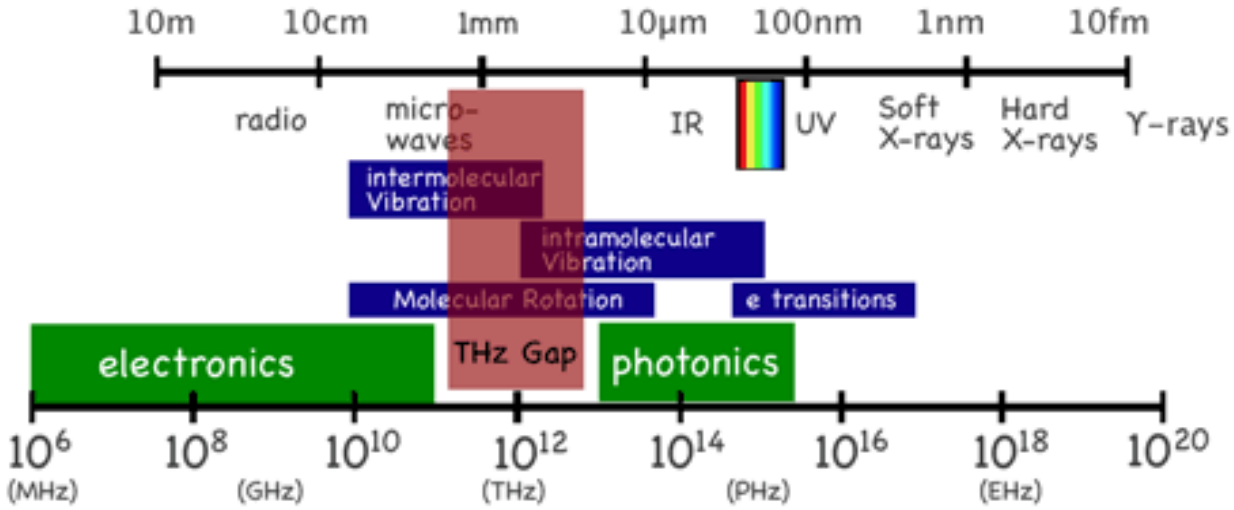
Terahertz Technology

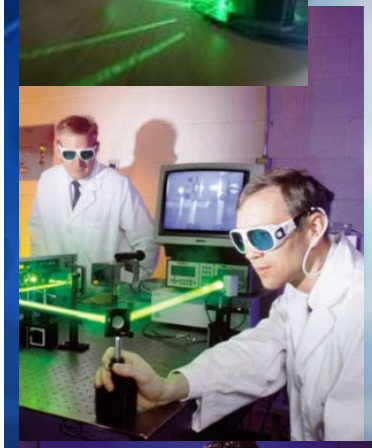
Non-intrusive Inspection – penetrates fabrics & plastics, security screening

Safer than X-rays – no tissue damage since THz is non-ionizing radiation

(*e.g.*, 3D imaging of teeth, BBC News 6/14/1999)



Manufacturing Outsourcing Issues



- China Optics Manufacturing
  - Cheap but of Variable Quality
    - "One third of optics received from China is *discarded* for being out of spec."
- Concern with transfer of high precision optical designs
  - Issue with Military and Homeland Security

- **Key Requirement: Need for Quality Assurance Technicians**

Skill Set for Optics Technician

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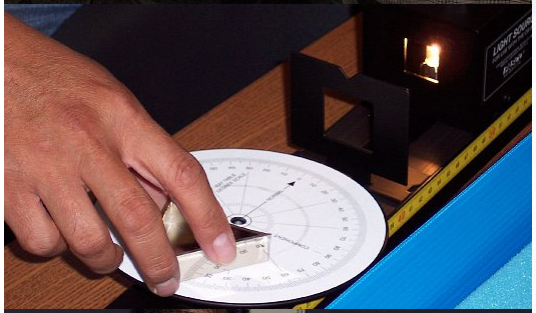
- Basic computational knowledge of
  - -- Geometric and physical optics
  - -- Geometry, algebra, and trig
  - -- Optical shop instruments
  - -- Measurement procedures and metric system
- Proficiency in using
  - -- Blueprints and tolerances for optics manufacturing
  - -- Computers
  - -- Common optical equipment and machinery
  - -- Computer Numerical Controlled (CNC) equipment
  - -- Optical interferometry
- Knowledge of
  - -- Cleaning and handling of optics
  - -- Clean room procedures and work area maintenance
  - -- Inspection procedures and quality control
- Ability to troubleshoot problems and maintain equipment for optimal use and productivity



Optics + Photonics Courses at Irvine CACT

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www.irvinecact.com

- ❑ 3 Curricula of 3 Courses Each
  - Core Photonics
  - Fabrication & Metrology
  - Optical Instrument Design
- ❑ Pilot Course: Holography -- Science & Art
- ❑ Math Pre-requisites
- ❑ Workshops
  - Laser Safety
  - Optics Cleaning, Handling and Inspection

❖ **Key Point - Qualified Instructors Essential**

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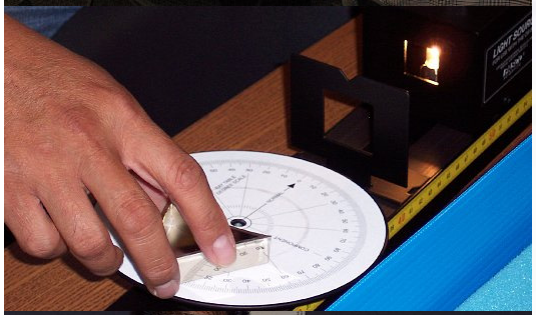
Hands-on Teaching Model

Fundamentals of Optics course taught using PASCO *Introductory Optics System* kit



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Core Photonics Curriculum

- Fundamentals of Optics
- Introduction to Lasers
- Introduction to Fiber Optics

Fundamentals of Optics (CACT 21)

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Textbook: Jenkins & White, Fundamentals of Optics, 4th ed. (McGraw-Hill, 2001)

- **Light Rays, Law of Reflection, Snell's Law, Index of Refraction, Scattering**
- **Paraxial Rays, Prisms, Dispersion**
- **Transmission and Reflection of Plane Surfaces (Fresnel Equations): Total Internal Reflection (Critical Angle), Brewster Angle**
- **Spherical Mirrors, Lenses: Lensmaker's Equation, real & virtual Images**
- **Aberrations (spherical, astigmatism, coma, field curvature, distortion, chromatic, polarization), Achromatic lenses**
- **Optics of Eye, Optical Instrument Speed, Microscopes**
- **Dioptric and Catoptric Telescopes, Adaptive Optics**
- **Light Waves: phase and group velocity, Michelson Speed of Light Interference: double slit, Michelson Interferometer, fringe visibility**
- **Diffraction: single slit, straight edge, Circular aperture, near & far fields**
- **Optical Gratings and Resonators, Thin Film Optics**
- **Polarization, Interference of polarized light, polarizers**
- **Crystal Optics: double refraction, uniaxial and biaxial crystals**
- **Optical Rotatory Power, Faraday Effect**

Introduction to Lasers (CACT 20)

Textbook: Jeff Hecht, Understanding Lasers: An Entry Level Guide (Wiley, Third Edition, 2008) in IEEE Press Series Understanding Science & Technology

- Spontaneous and induced atomic transitions, absorption and amplification, atomic pumping
- Optical resonators, modes, and Gaussian beams
- Mode-locked and Q-switched lasers,
- Review of specific lasers: Nd:YAG and other solid-state lasers; He-Ne, argon-ion, carbon dioxide lasers; semiconductor diode lasers
- Laser applications.

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Light Amplification by Stimulated Emission Radiation

Ted Maiman, 1960

First laser operated on May 16, 1960
at Hughes Research Lab, Malibu, California

Introduction to Fiber Optics (CACT 22)

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Textbook: *Understanding* Fiber *Optics*, 4th edition, Jeff Hecht (Prentice Hall, 2002)

- **Fundamentals of Fiber-Optic Components: power, power meters**
- **Types and Properties of Optical Fibers**
- **Fiber Materials & Manufacture**
- **Light Sources: lasers and light emitting diodes (LED), characteristics of laser pulses**
- **Optical Transmitters: introduction to modulators**
- **Optical Receivers, Repeaters, Amplifiers: digital-signal link**
- **Connectors, splices and other passive components**
- **Analog-signal Fiber Optic Link: FO link measurements**
- **O/E Switches, Modulators and WDM devices**
- **Wavelength-Division Multiplexing Optics**
- **Fiber Optic Measurements & Trouble Shooting**
- **Fiber Optic System Networking: Standards and Systems**
- **Local, Regional & Global Networks**
- **Fiber Optic Sensors & Imaging-Illuminating**

Fabrication & Metrology Curriculum

- Optics Fabrication I
- Optics Fabrication II
- Optical Interferometry & Metrology
- Workshop on Optics Cleaning, Handling and Inspection

Optics Fabrication I and II (CACT 101 &102)

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Textbook: Fabrication Methods for Precision Optics, Hank H. Karow (Wiley, 1993)

Skills in fabrication techniques with hands-on emphasis on the practices used in producing precision optical components. Successfully fabricate an optical component from raw form to a finished state.

Learn basic optics terms, raw materials, tooling, blocking, generating, shaping, beveling, grinding, polishing, edging, centering and final inspection.

CACT 101: Entry-level course involves plano shaping, grinding and polishing, resulting in a hand-polished 3.8-cm glass cube.

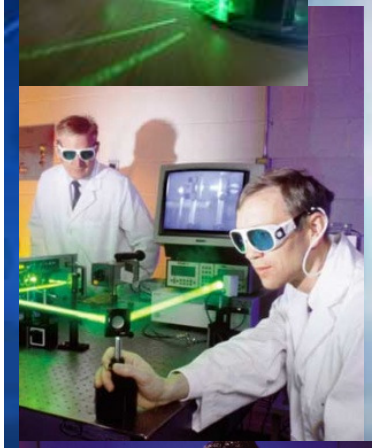
CACT 102: Second semester produces a matching set of master test plates to be standard for measuring optical wavefront radii.

Course is held in CACT optics fabrication workshop

Equipment donated by Newport Corp., Schott Glass, Zygo

Workshop on Optics Cleaning, Handling and Inspection

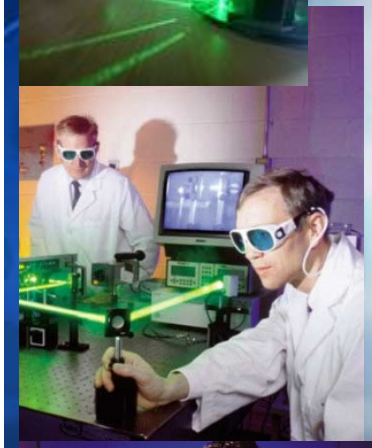
Workbook on Optics Cleaning, Handling and Inspection, Brian Seaman (Irvine CACT, 2004)



- Cleaning
  - Cleanroom work environment at laminar flow bench with no particles larger than 0.5 µm
  - Clean with solvent (acetone or IPA) with lens tissue swab
- Handling
  - Storage containers for transport
- Inspecting Optical Surface Quality
  - Inspection Box D-667-11 (Davidson Optronics)
  - Scratch & Dig Specification (Mil Spec)

Hands-on Exercises for Attendees

Military Specification
MIL-O-13830

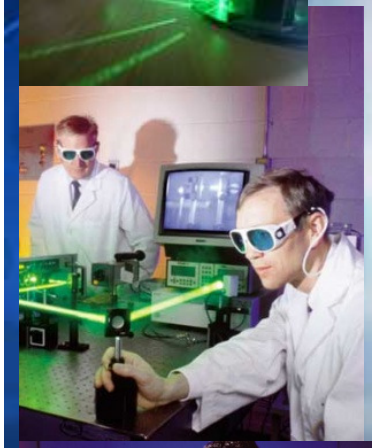


- 1954 -- MIL-O-13830 developed by U.S. Army to define method for specifying and inspecting optical surface quality.
- 1994—Department of Defense decided that it would no longer maintain standards for the military and will defer to voluntary national standards.
- 1996—Optics and Electro-Optics Standard Council (OEOSC) formed to provide mechanism for development of voluntary optical standards.
- 2000—American National Standards Institute (ANSI) accredited OEOSC to act as the national optical standards committee to develop a replacement standard for MIL-O-13830.

Inspection Box

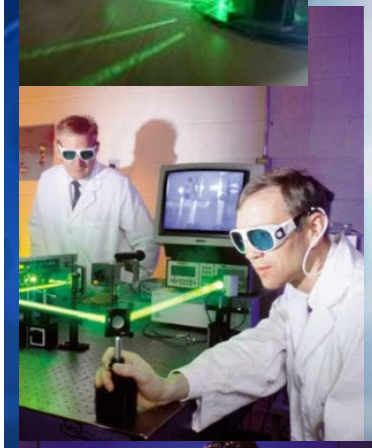
D- 667-11

Scratch & Dig Guide to Surface Quality



- Optical surface quality is specified by two numbers (*e*.g., 60-20). The first number is the maximum "scratch number" and the second number is the maximum "dig number."
- A scratch is a surface defect (tear) having length well in excess of width.
- A dig is a surface defect (pit or hole) having length approximately equal to width or being roughly circular in appearance.

Optical Interferometry & Metrology (CACT 105)



Textbook: Field Guide to Interferometric Optical Testing,
Eric P. Goodwin and James C. Wyant (SPIE Press, 2006)

Interferometry Fundamentals: coherence, fringe visibility, beamsplitters

Interferometers: Fizeau, Twyman-Green, Mach-Zehnder, lateral shear

Interferograms: aberration content, Zernike polynomials, moiré

Phase Shifting Interferometry: methods for phase shifting

Surface Microstructure

Flat Surface Testing: mirrors, windows, prisms, corner cubes

Curved Surface Testing: test plate, cat's eye position, lens testing, laser-based Fizeau

Absolute Measurements: flats, spheres

Aspheric Surface Testing: conics

Other Optical Testing: Foucault Knife-Edge, Shack-Hartmann test

Support by Zygo Corp. for Zygo GPI XP/D Interferometer at CACT

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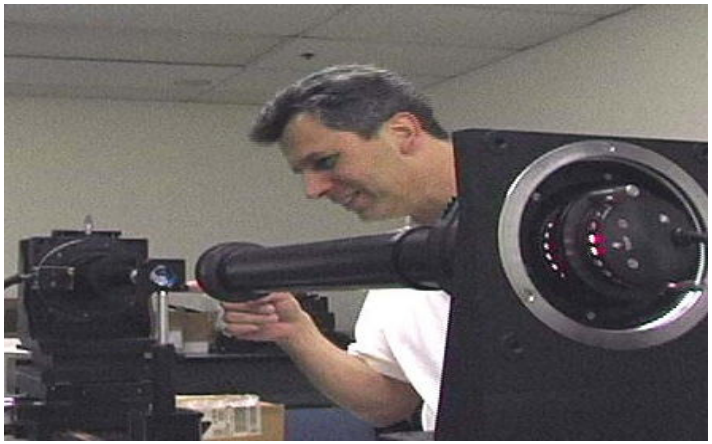
Optical Instrument Design Curriculum

- ❑ **Lens Design** (using Zemax®)
- ❑ **Optical System Design** (using Zemax®)
- ❑ **Opto-mechanical Design** (using SolidWorks®)



Lens Design
(CACT 120)

Textbook: Introduction to Lens Design: With Practical *Zemax* Examples, Joseph Geary (Willmann-Bell, 2002) www.willbell.com

Reference: Imaging System Performance for Homeland Security Applications, (CORD Optics and Photonics Series, 2007) – MTF measurement

First order optics: stops, pupils, marginal and chief rays

Aberration theory: description, identification and balancing

Lens design with *Zemax*® (How optical design programs model lenses)

Modulation transfer function (MTF): diffraction effects and measurement

Singlet lens design: merit function construction, optimization

Achromat lens design: correcting chromatic aberrations

Multi-element lenses: Cooke triplet, zoom lens, scanning systems

Optical System Design
(CACT 121)

Using Zemax® optical system design and SolidWorks® 3D CAD software

- **Modeling with coordinate break: prisms, beamsplitters, fold mirrors, off-axis design, tilting and de-centering, multiple apertures**
- **Modeling with multi-configurations: interferometers, multi-channel systems, zoom lens, scanning systems**
- **Optimization of multi-configured systems: merit function design, optimization with MTF & RMS, boundary constraints**
- **Systems analysis: spot size, optical path difference (OPD) diagrams, thermal analysis and system athermalization, wavefront analysis**
- **System tolerancing: error budget, construction and assembly errors, alignment design and analysis**
- **Gaussian beam propagation**

Opto-Mechanical Design
(CACT 122)

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Textbook: Opto-Mechanical Systems Design, 2nd edition,
Paul R. Yoder Jr. (Dekker, 1993)

Design Process: specifications, constraints, error budget and tolerances, modeling and design reviews

Environment: temperature, thermal expansion, vibration, shock

Materials for Mechanical Components

Mounting Optics: individual and multiple lenses, small mirrors, prisms, windows and filters

Mounting Mirrors: lightweight nonmetallic mirrors, large mirrors for horizontal, vertical and variable axis orientation

Metallic Mirrors: precision diamond turning, plating

Housing Configuration

Instrument Structural Design

Holography – Science & Art
(CACT 130)

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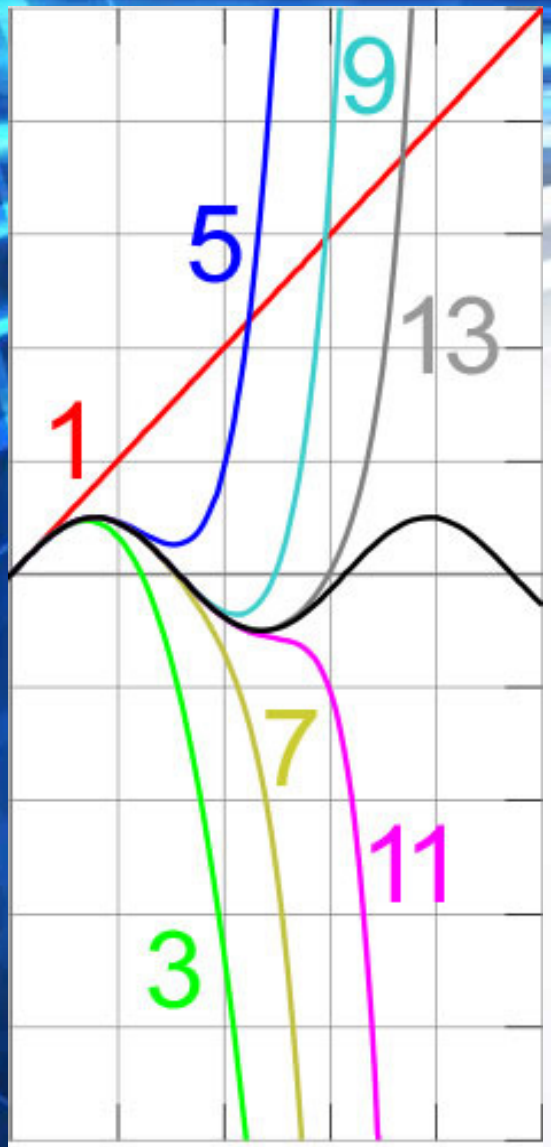
Textbook: Practical Holography, 3rd edition, Graham Saxby

(Institute of Physics, Taylor & Francis, Inc., 2003)

Form of photography that allows a 3D image to be viewed

- **Basic optics setup: producing gratings and moiré patterns**
- **Interferometry and diffraction topics**
- **Holography lab setup**
- **What are holograms and types of holograms**
- **Making and viewing holograms**
- **Critiquing holograms and holographic art**
- **Holographic optical elements (HOE)**
- **Holographic interferometry**
- **Applications of holography: advertising, security**

--Class taught without need for a math background--



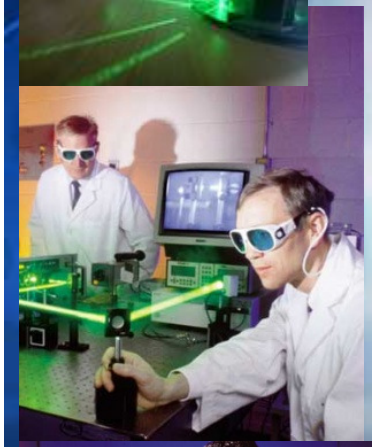
Basic Math is a Stumbling Block for Most

- ❑ Geometry
  - ❑ Conic Sections
- ❑ Algebra Fundamentals
  - ❑ Quadratic Equation
  - ❑ Taylor Series
- ❑ Elementary Trig
  - ❑ Sine Curve

-- shown on left is Taylor Series expansion of sine curve --

Can't Teach Geometrical Optics without Geometry

Partnerships



- **Commercial Companies**
  - Newport Corporation
  - Schott Glass
  - Zygo Corporation
  - Davidson Optronics
  - OptoSigma
  - Mark Optics
- **Aerospace Companies**
  - Northrop Grumman
  - Raytheon

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Newport Corporation

1791 Deere Ave., Irvine, CA 92606

www.newport.com

Newport Puts Light to Work

Newport's Capabilities Cover a Full Spectrum of Customer Needs for Photonic Applications

Make

- Lasers
- Diode Lasers
- Light Engines

Manage

- Optics
- Optical Positioning
- Motion Control
- Vibration

Measure

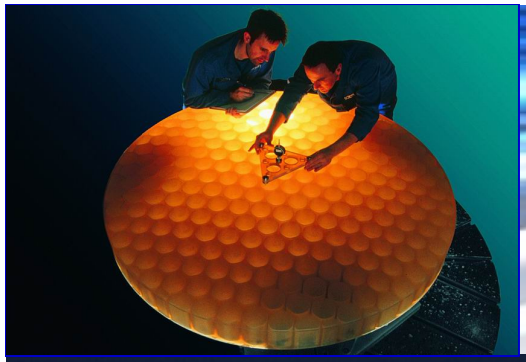
- Detection
- Feedback/Control

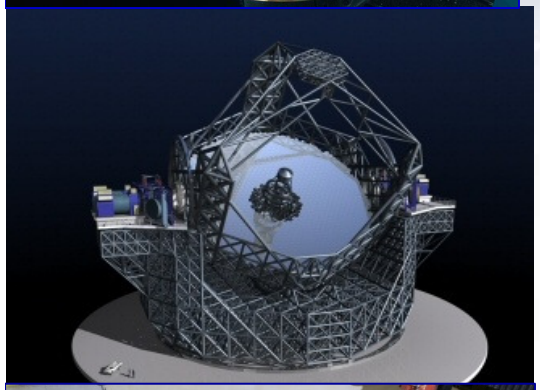
Putting Light to Work

Product Category Leaders

Lasers.....Spectra-Physics
Optical / Motion / VC.....Newport
Instrumentation.....Oriel
Automated Systems.....MRSI

Integrated Solutions for High Precision Photonic Applications





Schott Glass

Otto Schott is founder of modern glass technology

Company founded 1884 in Jena, Germany

Advanced materials

- **--Invented ZERODUR® glass ceramic having near-zero thermal expansion for telescope mirror substrates**

Advanced optics

Solar energy

Fiber optics

Lithography

Home technology

- **--Invented CERAN® glass ceramic cooktop resisting thermal shock up to 700C**

Schott Glass

26-ft. **ZERODUR®** mirror blank for European Space Observatory in Chile.

Zygo Corporation

Headquarters in Middlefield, CT
Local Location: Zygo Optical Systems, Costa Mesa, CA

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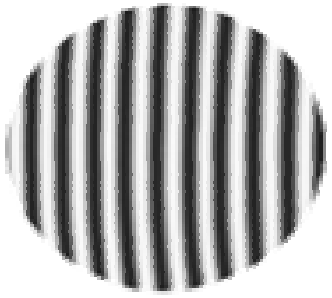
GPI family™ of interferometers is the industry standard for noncontact measurement of flat or spherical surfaces, and transmitted wavefront measurement of optical components and assemblies. When combined with Zygo's MetroPro™ software, the GPI systems give a wide range of operational features and data analysis tools.

GPI XP/D uses the precision of *phase modulation* to show fine measurement detail on optical parts with excellent accuracy and repeatability.

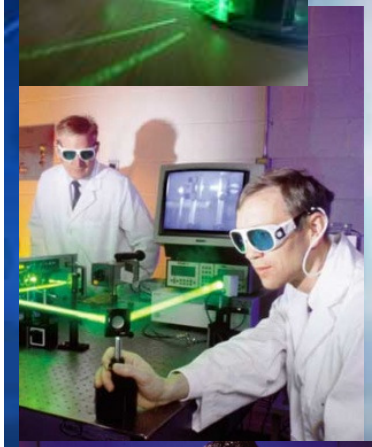
www.zygo.com



Partnerships

- **Professional Societies**
  - Optical Society of Southern California, OSSC
  - Optical Society of America, OSA
  - SPIE
- **Universities & Colleges**
  - UC Irvine
  - UC Davis
- **Non-profit Organizations**
  - Optics Institute of Southern California, OISC
  - Achievement Institute for Scientific Studies, AISS

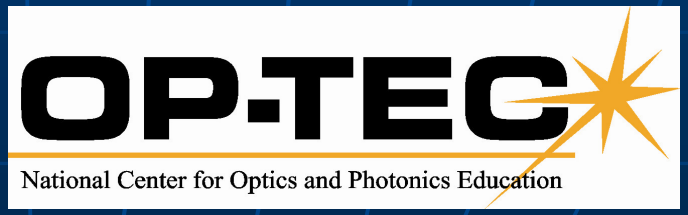
Partnerships



- **Industry Advisory Committee**
- **Company Tours & Invited Speakers**
- **Donations**
  - **IBM San Jose**
  - **Newport Corporation**
  - **Schott Glass**
  - **Northrop Grumman**
  - **OptoSigma**
  - **CVI Melles Griot**

OP-TEC
The National Center for Optics and Photonics Education

Daniel M. Hull,
Director OP-TEC
hull@cord.org



OP-TEC

The National Center for Optics and Photonics Education

- NSF/ATE National Center of Excellence
- $5 Million Initial Grant
- 4 Years Minimum
- Began September 1, 2006
- Headquarters in Waco TX

OP-TEC PARTNERS

- 8 Community/Technical Colleges
- Over 40 National/International Employers of Photonics Technicians
- 4 Universities
- 7 Professional Societies
- CORD
- State/Regional Photonics Clusters

College Partners

- Camden County College—Telecommunications
- Central Carolina CC—Photonics Specialists
- Indian Hills CC--Manufacturing
- Indian River CC—Biomedical/Homeland Security
- Indiana Univ. of Pennsylvania—Remote Sensing
- Irvine Valley College/CACT—Retrain Employed Techs
- Texas State Technical College System—Semiconductor Manufacturing and Nanotechnology
- TriCounty Technical College—Electronics

1800 New Photonics Technicians are Needed Each Year

- At current capacity, twelve U.S. Colleges produce less than 200 Techs/year
- OP-TEC's goal is to recruit and assist enough colleges to teach photonics so that our capacity will meet the need

Plan for Producing 1,800 Photonics Technicians Each Year

- 1/3 of the techs will work in R&D, for OEM's & in field service--They will require an AAS in photonics
- 2/3 will work in other fields where photonics is an *Enabling Technology* – Infuse 2 photonics in existing programs
- Retrain current employees – 300-500/year
- Target: Reach Capacity by 2013

OP-TEC Services

- Provide Info about Photonics & Careers
- Skill Standards
- Assist in Program Feasibility/Planning
- Assist in Curriculum Design/Development
- Design Labs & Specify Equipment
- Train Faculty
- Build High School Pipelines

OP-TEC Materials

- Skill Standards
- Program Planning Guides
- Modular Teaching Materials for full AAS Programs
- Modular Teaching Materials for infusing Photonics into 8 Related Fields
- Math Supplements
- Career Pathway Strategies for HS's

Colleges Can Provide Photonics Education/Training in Four Ways

- A Full, Two-Year AAS Degree in Photonics
- Infusion of Photonics into existing Programs Where Photonics is an Enabling Technology
- Infuse Photonics into Electronics Core
- Retrain Existing Workers

Two Year AAS Programs in Photonics Technology

- Complete curriculum materials are in use and are being updated in 2007-08
- Current programs experience 2-5 job offers for each graduate
- Starting salaries in the $40K's & $50K's
- Required labs & equipment are very expensive
- Most colleges take several years to develop these programs & Labs

Photonics Infusion is a More Realistic Way for a College to Begin

- Enhance/Update Existing Programs
- Utilize Photonics as an Enabling Technology
- Start with two courses
- Use the High Tech aspect of Photonics to attract students & build enrollment
- Grow your photonics capability over several years

Four Infusion Models

- Replace two courses with photonics courses in existing curriculum
- Infuse Photonics modules into existing courses
- Create a “Photonics Option” from a technical core curriculum
- Create an “Advanced Certificate” in Photonics Applications

PROGRAM PLANNING GUIDES

- Photonics in an Enabled Technology
- Applicable Skill Standards
- Curriculum, Courses, Materials
- Labs and Equipment
- Faculty Requirements & Training
- Building the High School Pipeline

Photonics Skill Standard

- Specifies the knowledge and skill requirements for a variety of technicians in the Photonics industry
- Identifies six specialty areas for Photonics Technicians
- Provides the foundation for AAS curriculum and materials development in Photonics Technology
- Can be adapted by local employers for curriculum design at a particular college
- Suggests how Optics and Photonics can be infused into a technology that is “photonics enhanced”
- Provides model (4+2) curriculum framework

Infusion Course #1
FUNDAMENTALS OF LIGHT & LASERS

- Nature and Properties of Light
- Optical Handling and Positioning
- Light Sources and Laser Safety
- Basic Geometrical Optics
- Basic Physical Optics
- Principles of Lasers

Infusion Course #2

ELEMENTS OF PHOTONICS

(Replace last 3 modules with different application)

- Operational Characteristics of Lasers
- Specific Laser Types
- Optical Detectors and Human Vision
- Principles of Fiber Optic Communication and Other Applications
- Photonic Devices for Imaging, Storage, and Display
- Basic Principles and Applications of Holography

PHOTONICS APPLICATIONS MODULES

- Laser Welding and Surface Treatment
- Laser Material Removal: Drilling, Cutting, and Marking
- Lasers in Testing and Measurement: Alignment, Profiling, and Position Sensing
- Lasers in Testing and Measurement: Interferometric Methods and Nondestructive Testing
- Lasers in Medicine and Surgery
- Lasers in Forensic Science and Homeland Security

ADDITIONAL MODULES IN PHOTONICS APPLICATIONS

- Laser Spectroscopy for Environmental Monitoring
- Laser Medical Equipment for Diagnostics and Therapeutic Applications
- Laser Tracking and Ranging Systems
- Electro-Optical Systems for Defense and Homeland Security
- Laser Construction Systems
- Photonics for Semiconductor Manufacturing & Nanotechnology

SUPPLEMENTAL MATH UNITS

- Scientific notation
- Unit conversion
- Introductory algebra
- Powers and roots
- Ratio and proportion
- Exponents and logarithms
- Graphing
- Geometry
- Angle measures
- Trigonometry

Challenge for Secondary-Post Secondary Partnerships

- **Colleges Introducing one or two courses in Optics/Photonics Technology**
  - Faculty require orientation to the technology
  - Laboratory Equipment ($$)
  - Local Industry or Knowledgeable Scientist (where?)
  - Curriculum? (STEP II has a solution)
- **Secondary-Postsecondary Partnerships**
  - Creating the pipeline
  - Establishing a 4+2 Career Pathway
  - Engaging students early
  - Ensuring solid foundation in math/science

Colleges Alone Cannot Satisfy the Demand Without Partnerships with High Schools

- Secondary school "pipelines" are needed that provide focused, well-prepared students
- Two-year colleges that are capable of serving industry are essential
- The ideal model works in partnerships among 2-year colleges, secondary schools, 4-year colleges and universities, business, industry, and government

The High School Role

- Provide context for academic achievement
- Provide motivation (and desire) to remain in school
- Provide a "level playing field" for students with diversified learning styles
- Provide guidance for career selection and a foundation for career pursuit
- Use career preparation to provide interdisciplinary problem-solving and critical thinking
- Provide a basis for lifelong learning…and lifelong earning

Planning of NSF Initiative for Precision Optical Technicians

- Response to loss of experienced opticians in US
- Only a few colleges created programs in optical fabrication
- Need to form additional technical programs for precision optical fabrication
- Far from a craft worker apprenticeship
- US military, defense and homeland security rely on a domestic source of precision optics

www.op-tec.org

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Career Pathways Educational Outreach

- **Memberships**
  - Optics Institute of Southern California
  - Optical Society of Southern California
  - Achievement Institute for Scientific Studies
- **Educational Grants from SPIE**
- ***Optricks Days* at Discovery Science Center in Santa Ana** (5^{th} Annual in March 2008)
- **Industry and University Tours**
- **CACT at ATEP Open House**

Non-profit organizations

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Optics Institute of Southern California
Focus on Science Education Outreach

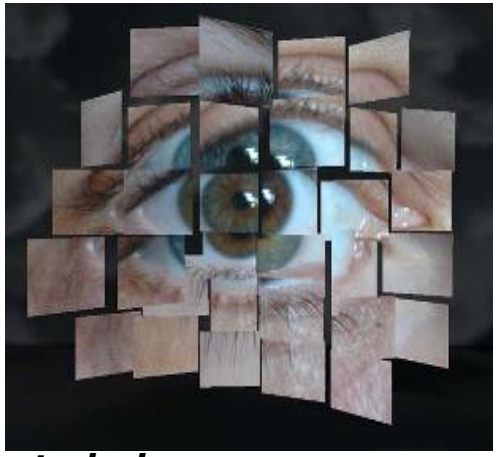
- K-12 After-School & Summer Programs
  - Think Together, UC Irvine Gifted Student Academy
- Science Center Special Event Days
  - Discovery Science Center – Optricks Days
- Family Day Events
  - UC Irvine Beall Center for Art + Technology

The Optics Institute of Southern California

Non-profit organizations

University of California, Irvine
Beall Center for Art + Technology

The OISC has been providing *Optricks* at the Beall Center's Family Day events since2007



in a thousand drops…refracted glances
Computational Poetics
Family Day February 2nd 11:00 a.m. – 3:00 p.m.

OPTRICKS Suitcase

An Educational Outreach Presentation Guide

With Inspiration By:

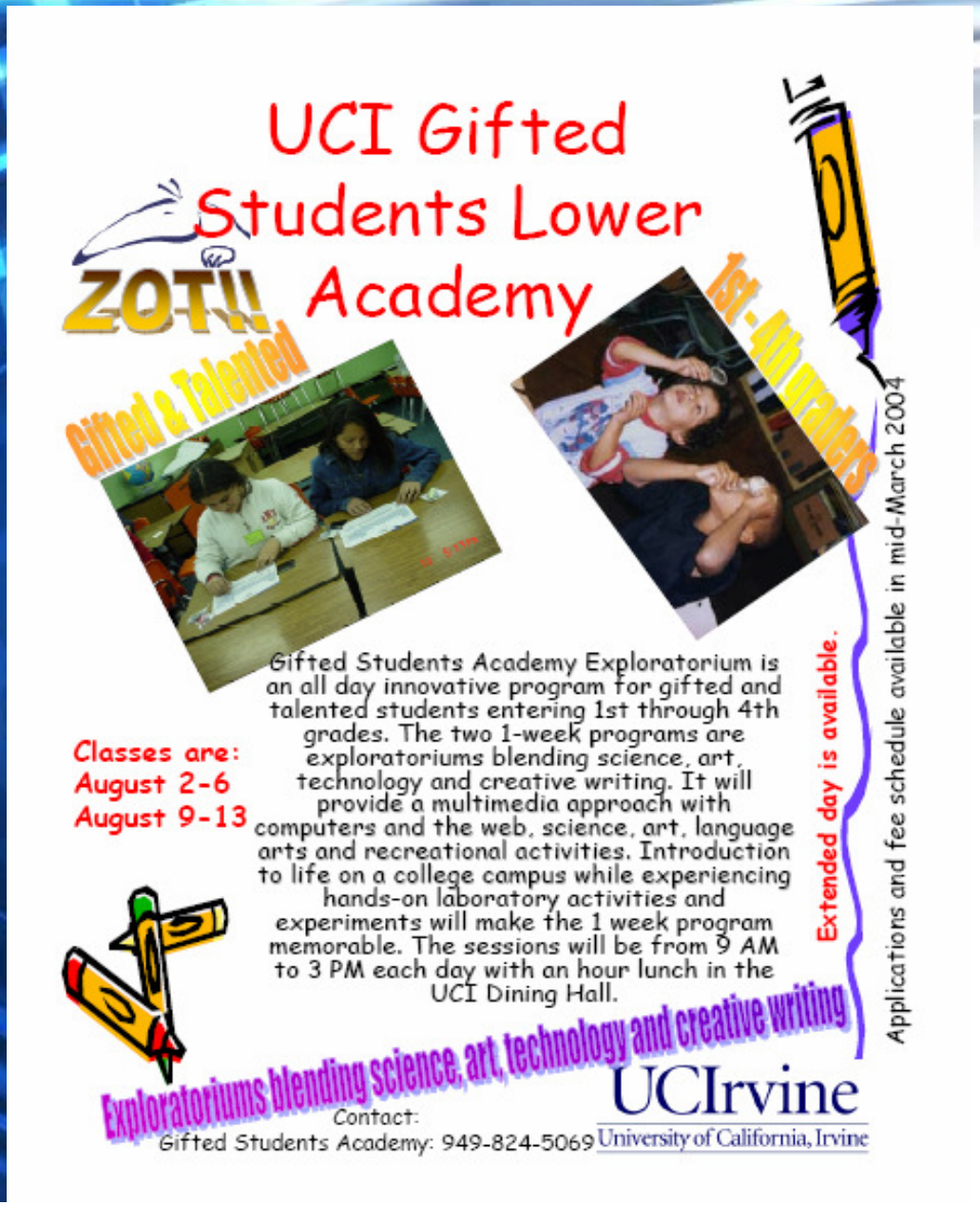
Dr. Murty

The Wizard of Light

OPTICAL SOCIETY OF SOUTHERN CALIFORNIA

The Optics Institute Of Southern California

2003 SPIE Grant to IVC



OISC received $5000 SPIE grant through Irvine Valley College to work with UC Irvine's *Gifted Students Academy* to develop and implement a HANDS-ON OPTICS program for gifted students in Grades 1-4.

This complemented the very successful Middle School program and is still going strong today.

OISC has since received other SPIE grants for additional optics programs.

Optical Society of Southern California

Local Chapter of OSA Professional Society

Monthly Meetings & Newsletter

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PTICAL SOCIETY OF SOUTHERN CALIFORNIA

IMAGES

Newsletter volume 14, number 7 | WWW.OSSC.ORG | March 2008

From the President
Donn Silberman

The OSSC's March meeting at the UC Irvine Alumni House was another nice change of both venue and presentation topic from some of our more traditional affairs. The Alumni House provided a cozy atmosphere (and the food was good – in my opinion) and the presentation had a very nice mix of graphics, theory and mathematics. If you were unable to attend, we hope to have the slides on the OSSC website soon.

Regarding our Annual Opticks Days Event at the Discovery Science Center March 1 & 2, I can't say enough to thank all the volunteers that continue to help make this event so special. We already had some photos in the Feb. newsletter, so if you would like to see more they are on-line at both the http://www.OSSC.org and the http://oisc.net websites.

On another topic, our local chapter has been awarded two grants from OSA, one for $1000 to help move and test an old 40" diameter telescope mirror from a storage locker to our CACT @ ATEP facility where we can evaluate its condition and plan to fund, design and build a telescope for the public's use. This project will be collaboration between the LAAS, OSSC, OISC and OC Astronomers (and others as they join in to help and have fun.) The second grant for $575 is to help the OSSC sponsor students to our meetings and national OSA meetings. The OSSC has been sponsoring students for at least a few years and OSA recognizes rewards and now helps in these efforts. If you would like to help out on either of these projects, please contact an OSSC officer.

Speaking of helping students, this month's meeting at UCLA is in part to see if we can help get an OSA Student Chapter established at UCLA. So please download the meeting announcement and spread the word to students and faculty you know at UCLA.

Do you have any optics friends in N. Cal?

A very good thing is happening in Northern California. John Gunel, the new Schott Glass Sales Engineer working in the Bay Area with Arnie has volunteered to help get the Optical Society of Northern California revitalized. I have put him in touch with the student OSA Chapters at Stanford and Berkeley and one of the OSNC active members as a starting point; but I think the more help he gets the better.

I believe there is a lot we here in the OSSC can do to help, even by helping to advertise and promote their first meeting (TBD) through this newsletter and the OSA mailing list. But once we have a date set for their first 'kick-off' meeting, any help we can get from OSSC members to call and e-mail to our friends up north and encourage them to attend will be time well spent.

John can be contacted at:
Cell: (408) 420-3881
E-mail: john.gunel@us.schott.com

OSSC members enjoying the presentation at the UC Irvine Alumni House during our meeting.

In This Issue

PTICAL SOCIETY OF SOUTHERN CALIFORNIA

Aim and Purpose

It is the aim and purpose of this society to increase and disseminate the knowledge of Optics and closely allied sciences, to promote the mutual interests of investigators, teachers and students in these fields, and of designers, manufacturers and users of optical instruments and allied scientific apparatus as well as those who have optics as a hobby and to encourage cooperation and establish acquaintanceship among these persons.

ATEP ADVANCED TECHNOLOGY & EDUCATION PARK

CACT

www.ATEP.us/CACT
New Summer Intro to Lasers Course Mons & Weds
Meets 07-02-08 through 08-06-08

Around the OSSC

Last year, Don Wolpert, Susan Rico & friends at NGST helped donate a very nice Beckman Spectrophotometer to the OISC.
We hope to have our first Spectroscopy class this fall at CACT@ATEP. Our friend Wytze Van der Veer from UC Irvine Laser Spectroscopy lab will be the instructor.

Meetings of Related Societies

Orange County Astronomers – Monthly Meeting
April 16th. http://www.ocastronomers.org/

So Cal Science Café-
http://science.meetup.com/39/calendar/

Los Angeles Astronomical Society – General Meeting
April 14th, http://www.laas.org/Events.htm

UC Irvine OSA Student Chapter Meetings
Friday April 4th: Prof. Zhopping Chen
(UC Irvine Beckman Laser Institute) " High Speed and High Resolution 3D Endoscopic Fourier Domain OCT"

Friday May 9th: Prof. Eric Van Stryland
(College of Optics and Photonics-UCF)
"Nonlinear Optical Spectroscopy"

Educational Outreach
UC Irvine Beall Center for Art + Technology
Thurs. April 3rd - LIVE – Opening Reception
Sat. May 3rd – LIVE – Family Day Event with the OISC
http://www.beallcenter.uci.edu/

Up Coming Meetings

Date	Location	Speaker	Topic
14 May 2008*	TBD*	TBD*	TBD*
17 May 2008 9:00a.m. (First Tee)*	Whispering Lakes Golf Club*	Golf Chair: Fred Houston	OSSC Annual Golf Tournament
11 June 2008*	Cerritos*	Kalin Spariosu	Industrial Applications of Nanotechnology
9 July 2008*	TBD*	2008-9 Board Planning Meeting	2008-9 Potential Programs, etc.

Optical Society of Southern California

Convergence of Industry & Academia

- Lecture: Jet Propulsion Lab (April meeting on left)
- Corporate Member: Zygo Corporation (profile on right)

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PTICAL SOCIETY OF SOUTHERN CALIFORNIA

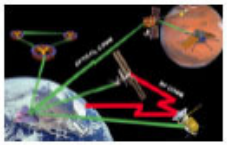
Meeting Announcement Wed. April 9, 2008

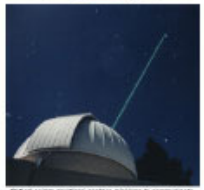
Deep-Space Optical Communications

Hamid Hemmati, Ph.D., JPL

Abstract:
Among the technologies for achieving higher data rates, free-space optical communication is a "promising yet challenging area of development". Furthermore, this technology has been identified as one that could potentially afford orders of magnitude increase in data rates. Recent analysis indicates that technology advances in the next decade should support as much as 30 dB higher data rates relative to the current state-of-the-art without heroic efforts. The obvious drivers for deep-space laser communication capabilities for future deep-space missions are: (i) the higher number of bits per unit mass per unit power, a benefit that increases with farther ranges; (ii) unregulated and "unlimited" bandwidth and (iii) enhanced bi-directional data transfer capacity that will be required for human missions and for high-resolution science.

Status of near-earth and planetary range laser-communications with spacecraft will be reviewed.





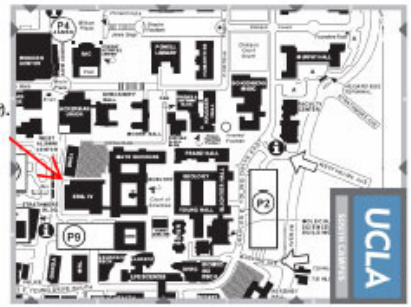
About the Speaker:
Hamid Hemmati received his M.S. in Physics from University of Southern California, and his Ph.D. in Physics from Colorado Univ. in 1981. Prior to joining the Jet Propulsion Laboratory (JPL) in 1986, he worked as a researcher at NASA's Goddard Space Flight Center and at the NIST (Boulder, CO). He is now the Supervisor of JPL's Optical Communications Group developing laser-communications technologies and systems for planetary and satellite communications. Dr. Hemmati holds seven patents, received 3 NASA Space Act Board Awards, and 34 NASA certificates of appreciation. He has taught optical communications courses at CSULA and the UCLA Extension. He is the editor and author of a book on Deep Space Optical Communications (Wiley, 2006) and Near-Earth Laser Communications (Tyler and Francis, 2008).

Dr. Hemmati's active area of research: Systems engineering for electro-optical systems, particularly for Optical Communications from Space; solid-state lasers, particularly pulsed fiber lasers and microchip lasers, flight qualification of optical and electro-optical systems and components; low-cost multi-meter diameter optical ground receiver telescope; active and adaptive optics; novel deformable mirrors; free-space laser communication systems for short range to planetary distances; coherent optical communications; and laser beam acquisition, tracking and pointing.

Meeting Details:

Date:	Wed. April 9, 2008
Times:	6:00 p.m. Social Hour 7:00 p.m. Dinner 8:00 p.m. Speaker Presentation
Location:	UCLA Engineering IV, 57-124 (5th floor). Park in adjacent lot P9 – $9 to park
Cost:	$15 for Dinner, $5 for Students
RSVP:	By Apr. 4, on the OSSC Website, or Call Scott Rowe at 949-735-9927

Please visit www.ossc.org for directions & updates.



Please post and encourage your colleagues to attend.

PTICAL SOCIETY OF SOUTHERN CALIFORNIA

OSSC Corporate Profile

Zygo Corporation: A Global Enterprise

Zygo Corporation's three founders set out to manufacture high-end optical components. To verify the quality of their own products they developed the industry's first easy-to-use commercial interferometer. Almost 40 years later, ZYGO continues to innovate optical systems and metrology solutions, and has extended their reach beyond optics into semiconductor, flat panel displays, life sciences and a broad range of global markets.

NewView™7300 3D Profiler

VeriFire™ Interferometer

The founders chose the word ZYGO, meaning a bridge or yoke, referring to the original investor group of the three founders, Wesleyan University in Middletown, Connecticut and Canon Incorporated in Tokyo, Japan. ZYGO is a bridge between academia and business; a bridge between the East and the West; a bridge between our customer's needs and innovative solutions.

Today, ZYGO is comprised of two divisions: The Optical Systems Division and Metrology Solutions Division. The Optical Systems Division, with operations in California, Arizona, and Connecticut globally recognized as a precision optics and complex electro-optical systems developer and contract manufacturer for high precision Life Sciences, Industrial, and Defense/Aerospace products. The Metrology Solutions Division, with operations in Florida, Taiwan, Oregon, and Connecticut, is a global leader in noncontact interferometric metrology process control and R&D tools for Semiconductor, Optics, Industrial and Research applications. With direct sales offices in Europe, USA, Asia and Japan, ZYGO is well placed to meet the growing needs of our customers worldwide.

Precision Optical Components

ZYGO Integrated System Design and Prototyping
www.zygo.com
1590 Corporate Drive
Costa Mesa, CA 92626
Phone: 714-918-7433 / Fax: 714-918-7436

Optical Society of Southern California

63 Corporate Members (CACT is member)

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PTICAL SOCIETY OF SOUTHERN CALIFORNIA

OSSC Corporate Members

These companies provide funding to the Optical Society of Southern California, enabling the OSSC to operate. We are grateful for their support.

A.W. I. Industries
Alson E. Hathaway, Inc.
Advanced Medical Optics
Britek Laser Optics
CACT @ ATEP
Cal Tech's Nanofabrication Lab
Cimarron Optical Consulting
City of El Segundo
Combination Technology
Curt Deckert Associates
CVI Optical Components
Cylinder Optics, Inc.
Davidson Optronics, Inc.
Daylight Solutions
Del Mar Photonics, Inc.
DMK Engineering, Inc.
DRS-Sensors & Targeting Syst.
Eidetic Optical Systems
Elcan Optical Technologies
Foil Flex Products
Griffith Observatory
Jet Propulsion Laboratory
Hardin Optical Company
Harold Johnson Optical Lab
Kaiser Electro-Optics, Inc.
LightWorks Optics, Inc.
Mark Optics, Inc.
Melles Griot, Inc.
Mendez R&D Associates
Mindrum Precision
Newport Corporation
Newport Industrial Glass, Inc.
Newport Thin Film Laboratory
Northrop Grumman Space Tech
Ohara Corporation
Optical Research Associates
Optics 1, Inc.
Optimum Optical Systems
Optiwave Systems
OptoSigma Corporation
Pacific Coast Optics
Panavision
Physical Optics Corporation
PI (Physik Instrumente) L.P.
Precision Applied Products
Precision Glass & Optics
Precision Optical
Raytheon Space & Airborne Systems
Reynard Corporation
Rolyn Optics Company
RSoft Design Group
Schott North America, - Optics for Devices
Southern California College of Optometry
Spectrum Scientific, Inc.
The City of El Segundo
Thirty Meter Telescope
Univ. of Cal., Irvine, Chemistry Dept.
& Laser Spectroscopy Facility
Beall Center for Art & Technology
Beckman Laser Institute
UCLA, Optoelectronics Circuits and
Systems Laboratory
Verizon
ZC&R, Inc.
Zygo Corp.

Achievement Institute for Scientific Studies (AISS)

Non-profit Organization for Orange County High Schools

- Academically gifted but economically under represented students (6 high schools involved)
- After-school programs for grades 10-12
- Extension of student's academic studies
- Company sponsored seminars and tours
- Docent training for Discovery Science Center
- Student stipends

CACT is Sponsor and on Board of Directors

Optricks Days
@ Discovery Science Center

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Fun learning about optics – play with the real thing!!

Students having fun with the Teen Optics Benches

Centers for Applied Competitive Technologies
Assisting California Manufacturers to Compete in a Global Economy
www.irvinecact.com www.atep.us

Center for Applied Competitive Technologies (CACT) in Irvine is one of twelve chosen for the National Center for Photonics Education, a National Science Foundation Center of Excellence

NSF

Providing courses in Optics, Lasers, Fiber optics & related technologies Irvine CACT is at your service.

The Optics Institute Of Southern California
http://oisc.net

Providing Optics, Laser Fiber Optics Education & Science Outreach

ATEP
ADVANCED TECHNOLOGY & EDUCATION PARK

Advanced Technology & Education Park (ATEP)
15445 Lansdowne Road, Tustin, CA 92782
The OISCis A Community Partners Project

Optricks Days
5th Annual
Sat. & Sun.
March 1st & 2nd, 2008

An Activities Guide

TACO BELL DISCOVERY SCIENCE CENTER

HOGWARTS
School of Optricks

With Inspiration By:

Dr. Murty
The Wizard of Light

OPTICAL SOCIETY OF SOUTHERN CALIFORNIA

The Optics Institute Of Southern California

Funded in part by SPIE & OSA grants

Optricks Days

one weekend every March, since 2004

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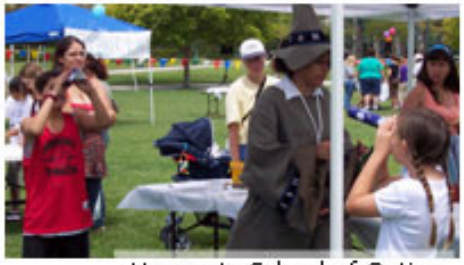
Optricks Days Activities

TIME	EVENT	LOCATION
10am – 4pm	Optricks Education Stations	1st Floor Exhibit Areas
11:00am	"The Optricks Suitcase" *Including Take Home Theme Packets* Exploring and applying color & optics all around us!	1st Floor – 4D Theater
12:30pm	*"Hogwarts School of Optics presents – Optics for a Greener World"*	1st Floor – 4D Theater
12:45pm To 3:00pm	*Hogwarts School of Optics Telescope Challenge and Spinning Your (color) Wheels* Teen Optics Bench Workshop *Exploring colored light & more*	2nd Floor Large Challenge Room
3pm (2:30 pm On Sun.)	"The Optricks Suitcase" *Including Take Home Theme Packets* Exploring and applying color & optics all around us!	1st Floor – 4D Theater

Fun with Fresnel Lenses & the Optricks Apprentice

Young Scouts at an Optricks Education Station



Hogwarts School of Optics Telescope Challenge

Students making "Spinning Your (color) Wheels"

Hogwarts School of Optics Headmaster & Apprentice With new optics students

Lenses handed out during the Optricks Suitcase presentations have been generously donated by:

OptoSigma® Your First Source for Precision Optics and Hardware

DISCOVERY SCIENCE CENTER

Discovery Science Center
Main Number: 714-542-CUBE (2823)
Address: 2500 North Main Street Santa Ana, CA 92705

Industry & University Tours

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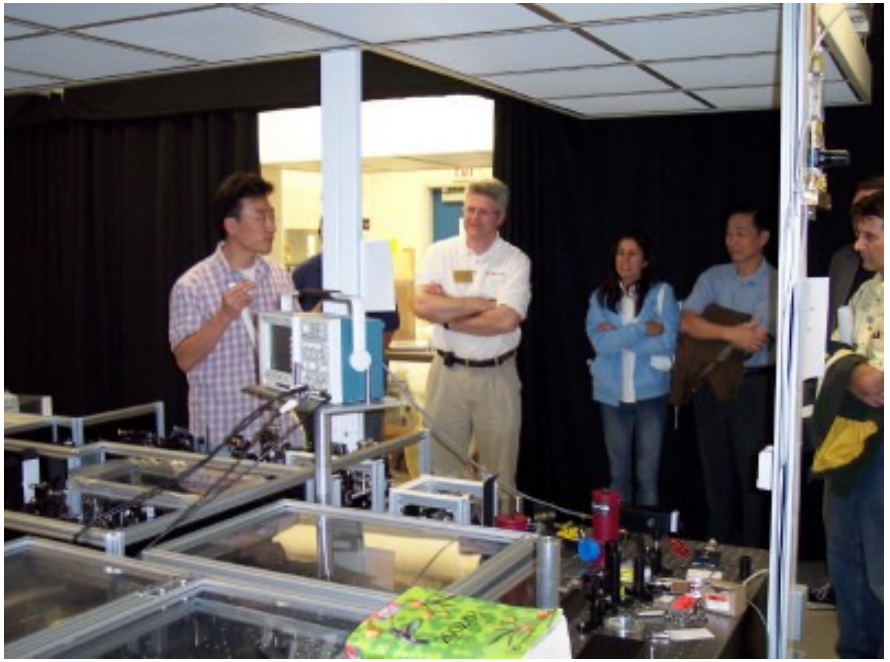
Examples Include:

- UC Irvine, Laser Spectroscopy Labs
- Cal Tech, NanoPhotonics Labs
- Newport Corp., Advanced Optics Fabrication
- Mark Optics, Precision Optics Fabrication
- Trimedyne, Medical Lasers



Student Tour of Industry
Trimedyne Medical Lasers, Inc.

Students cutting steak with holmium laser (2µm)

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CACT @ ATEP Open House

Community Recognition of Optics

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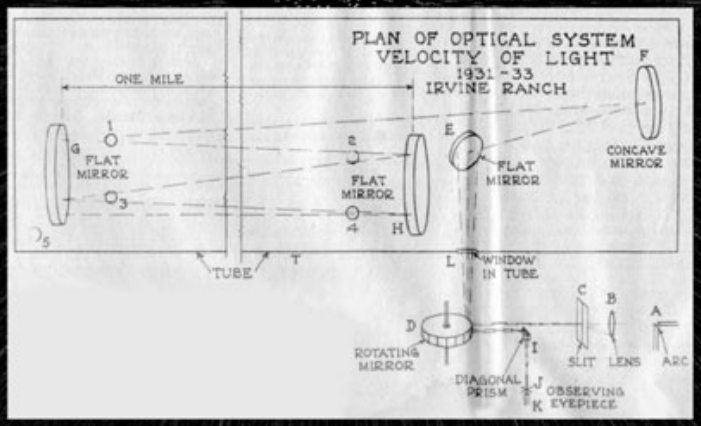
Michelson Speed-Of-Light Exhibit at Irvine City Hall

The Speed of Light

The speed of light was measured by Dr. Albert Michelson at the Irvine Ranch in the early 1930s.

Many modern physics students repeat the experiment in their college laboratory classes.

Light...What is it?
How do you measure it?



Come share a story and begin a journey that will last longer than a lifetime…it will go on for generations!

One of the important experiments in physics and optics was made at Irvine Ranch in 1931, just five blocks from CACT. It was the measurement by Albert Michelson of the speed of light in partial vacuum using an evacuated pipe, one-mile long and three-feet in diameter, in order to eliminate uncertainties in air refraction. Original experiment was parallel to Armstrong Avenue in Irvine.

The month-long exhibit at City Hall demonstrated a modern version of the experiment using a helium-neon laser with a rotating mirror similar to the one used by Michelson in the Irvine Ranch Experiment.

A Test:

Here's A "Light Quiz"

Which statement is true?

- Light is a
  - sound wave in vacuum
  - shear wave in ether
  - electromagnetic wave
  - neutrino wave
- Light travels faster in
  - vacuum
  - water
  - quartz crystal
  - diamond
- Snell's Law states
  - Anything that can go wrong, will go wrong
  - Reflection angle of light ray equals its angle of incidence
  - Data density of integrated circuits doubles every 18 months
  - How much light rays bend going from air into water
- Purple is a
  - shade of violet
  - pure spectral color
  - combination of blue and red light
  - color of alien people-eaters

- Color blindness is
  - vision loss caused by a bright light
  - eye defect preventing seeing certain colors
  - blocking of certain colors by red glass
  - inability to see infrared colors
- Antireflection is
  - lack of surface reflection at Brewster's Angle
  - reflection from backside of mirror
  - removing light reflection from an optical surface by a thin film coating
  - a Weight Friendly Rights Organization against light reflection
- 'Interference filter' is a
  - method of legally blocking an opponent in sports
  - device selecting a particular wavelength band for transmission
  - device to remove noise from optical signals
  - porous paper separating unwanted impurities from optical fluids
- *Laser* is an acronym for
  - *L*ight from *A*toms *S*tressed by *E*instein's *R*elativity
  - *L*ight *A*ttenuation *S*ources for *E*nergy *R*esearch
  - *L*ight *A*mplification by *S*timulated *E*mission *R*adiation
  - *L*ight *A*pplication for *S*mart *E*ngineering *R*esearchers
- The 'green flash' occurs
  - when people close their eyes quickly
  - at sunset due to refraction and scattering of the atmosphere
  - when a naked Irishman runs across a soccer field
  - with your fifth mint julep
- 'Scratch and dig' is
  - a method to measure hardness of optical materials
  - measurement of surface quality of an optical part
  - procedure to examine composition of Martian rocks
  - how a dog finds his buried bone

Conclusion
Technician Gap

- Losses in skilled technician workforce
- Who will replace them?
- Can skilled replacements be found in time?
- Photonics is moving target, requiring
  - new tools
  - new skills
- No end in sight for Photonics
  - new platforms
  - new spectral regions

Conclusion
How To Implement Technician Training

- Obtain Dedicated Lab Space
- Determine Local Industry Technician Needs
  - Focus groups
  - Industry Advisory Committee
  - College Advisory Committee
- Seek Local Industry Support
  - Employees as students
  - Student industry tours
  - Speakers and instructors
  - Equipment donations
- Join Regional Optics & Engineering Societies

Conclusion
Support Resources

- **NSF OP-TEC Support**
- **Professional Conferences: Exhibits Free**
  - **Optical Society of America (OSA) www.osa.org**

    Conf. Lasers & Electro-Optics (CLEO), San Jose on May 4-9
  - **SPIE www.spie.org**

    Optics+Photonics Conference, San Diego on Aug. 10-14

    SPIE Photonics West, San Jose on Jan. 24-29, 2009
  - **IEEE www.ieee.org/leos**

    Lasers & Electro-Optics Society, Newport Beach on Nov. 9-13

    Optical Fiber Comm. (OFC), San Diego on Mar. 23-27, 2009
- **Short Courses**
- **Internet Websites for Optics+Photonics**

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Q & A