# Nano Analytical and Testing (NAT) Laboratory Services

Exponential Business and Technologies Company (Ebatco™) is an international technology service and development company. Ebatco specializes in providing high-quality products and services for worldwide clients in the areas of testing instruments and equipment, advanced materials, and micro/nanotechnology. Ebatco is fully committed to provide you with world-first-class services that will satisfy your business and technology needs.

Ebatco's Nano Analytical and Testing Laboratory (NAT Lab) is established to perform a wide spectrum test and analysis of advanced materials and miniaturized devices, root-cause determination of failed parts, system and part performance verification, industrial and regulatory compliance tests. NAT Lab's expertise spans from material property testing and measurement to failure analysis. We have worked with a majority of material types such as steel, metal, ceramic, glass, polymer, existed in nanostructure, thin film, coating, composite, or bulk format. We are strong and have been recognized in data processing, analysis, interpretation, and correlation. In addition, NAT Lab has ready accesses to numerous advanced techniques and equipment within its own lab and through strategic alliances and partnerships, long-term contracts with many commercial, research, and national labs worldwide.

NAT Lab strives to provide you thorough and satisfactory solutions for your material related challenges in a timely and professional manner, and at market competitive prices.

## Contract Lab Services

| Lab Service Category | Services and Techniques |
|---|---|
| Chemical | EDS (Energy Dispersive X-Ray Spectroscopy) |
| Contact Angle | Contact Angle<br>Dynamic Contact Angle<br>Interfacial Tension<br>Micro Contact Angle<br>Powder Contact Angle<br>Surface Free Energy |

| | |
|---|---|
| Liquids | CMC (Critical Micelle Concentration)<br>Density<br>Refractive Index<br>Surface/Interfacial Tension<br>Viscosity |
| Mechanical | Microindentation<br>Microscratch<br>Modulus Mapping<br>NanoDMA (Nano Scale Dynamic Mechanical Analysis)<br>Nanoindentation<br>Nanoscratch |
| Microscopy | SEM (Scanning Electron Microscopy)<br>SPM (Scanning Probe Microscopy)<br>Optical Microscopy |
| Particle Size | Coulter Principle (Electric Sensing Zone Technique)<br>Dynamic Light Scattering (Photon Correlation Spectroscopy)<br>Laser Diffraction |
| Pore Size | Pore Size (Capillary Flow Porometry) |
| Thermal | DMA (Dynamic Mechanical Analysis)<br>DSC (Differential Scanning Calorimetry)<br>Specific Heat<br>STA (Simultaneous Thermal Analysis)<br>TGA (Thermal Gravimetric Analysis)<br>TMA (Thermal Mechanical Analysis) |
| Tribological | Friction<br>Lubrication<br>Wear |
| Zeta Potential | Particle Zeta Potential<br>Solid Surface Zeta Potential |

**Chemical Analysis**

- Back Scattered Electron Imaging
- Characteristic X-Rays
- Coating and Film Thickness
- Critical Dimension Measurement
- Composition Distribution and Mapping
- EDS (Energy Dispersive Spectrometer)
- Elemental Composition
- Elemental Profiling
- Low Vacuum SEM/EDS
- Fractography
- Particle Size and Distribution
- SEM (Scanning Electron Microscopy)
- Surface Contamination
- Surface Morphology and Topography
- Variable Pressure SEM/EDS

**Contact Angle Measurement**

- Advancing and Receding Angle
- Contact Angle Hysteresis
- Captive Bubble Contact Angle
- Droplets in Micron Size
- Drop Size Effect
- Dynamic Contact Angle
- Hydrophilicity of Microfluidics
- Hydrophobicity of MEMS Beams
- Interfacial Adhesion
- Liquid Absorption
- Liquid Repellence
- Liquid Permeability
- Liquid Solid Interfacial Phenomena
- Liquid Vaporization
- Lotus Effect
- Nano/micro Patterned Surfaces
- Oleophobicity and Oleophilicity
- Permeability of Ink to Its Medias
- Roll Off Angle
- Self-Cleaning Paint
- Sliding Angle
- Stain Resistant Fabrics
- Super Hydrophobicity
- Super Wetting
- Surface Chemistry
- Surface Cleanness
- Surface Contamination
- Surface Free Energy
- Surface Roughness Influence
- Surface Uniformity
- Surfactant Efficiency
- Wettability of Color Resists to Each Cell of Flat Panel Displays
- Wettability of PCB Traces
- Wettability of Single Fiber, Wire, Catheter, and Small Tube

**Liquid Testing**

- Aqueous Solutions
- Degree Brix Measurement
- Dip Coatings
- du Noüy Ring
- Evaporation Rate
- High Viscous Materials
- Interfacial Tension
- Interfacial Tension Over Time
- Lamella Length
- Liquid Density
- Liquid Refractive Index
- Newtonian Fluids
- Non-Newtonian Fluids
- Oil Mixtures
- Printer Inks
- Pycnometer
- Refractive Index as a function Temperature
- Sedimentation
- Surface Tension
- Surface Tension Over Time
- Surfactants
- Temperature Control
- Viscosity
- Wilhelmy Plate

**Mechanical Testing-Micro Scale**

- Brinell Hardness
- Coating Adhesion
- Creep
- Fatigue
- Knoop Hardness
- Mar Resistance
- Microhardness
- Microindentation
- Microscratch
- Scratch Resistance
- Stress Relaxation
- Tensile Testing
- Vickers Hardness

**Mechanical Testing-Nano Scale**

- Nanocompression
- Nanofatigue
- Nanohardness
- Nanoimpact
- Nanoimprint
- Nanoindentation
- Nanolithography
- Nanomachining
- Nano pull off force
- Nano pull on force
- Nanoscale Creep Test
- Nanoscale Stress Relaxation Test

- Nanoscratch
- Nanotensile
- Nanotribology
- Nanowear
- Biological Sample Testing
- Correlation between Nanoindentation and Other Analytical Analysis
- Fracture Toughness Determined through Nanoindentation
- Friction under Extremely Low Load
- Mechanical Test on Micro Cantilever and MEMS Beam
- Nanoindentation in Liquid
- Nanoindentation under Environmental Control
- Nanoindentation under High/low Temperature
- Nanomechanical Property Depth Profile
- Nano/micro Feature Testing
- Nano Particle Testing
- Nanoscale Dynamic Mechanical Analysis
- Quantum Dot Testing
- Test and Evaluation of Miniaturized Devices
- Thin Film Interfacial Adhesion Measured using Nanoscratch
- Ultra-Thin Film Testing
- Young's Modulus

**Microscopy-Optical and SEM**

- Back Scattered Electron Imaging
- Bright Field
- Coating and Film Thickness
- Critical Dimension Measurement
- Corrosion
- Crystallization and Recrystallization
- Crystallography
- Dark Field
- Etched Materials
- Failure Analysis
- Failure Location
- Fatigue
- Fractography
- Grain Count
- Grain Structure
- Grain Boundary
- Heat Treatment
- Ion Implantation
- Laser Alloying
- Laser Cladding
- Low Vacuum SEM/EDS
- None Conductive Samples
- Optical Microscopy
- Oxidation
- Phase Diagram
- Phase Transformation
- Particle Size and Distribution
- Sample Grinding, Polishing and Other Preparation

- Scanning Electron Microscopy (SEM)
- Secondary Electron Image
- Scratch
- Surface Contamination
- Surface Hardening
- Surface Morphology and Topography
- Variable Pressure SEM/EDS
- Wear

**Microscopy-SPM**

- 10 Peak Height
- Average Surface Roughness
- Crack Length
- Critical Dimensions
- Density of Summits
- Line Profile
- Material Finishing
- Material Removal
- Morphology
- Nano Features
- Nano Wear
- Particle Counts
- Peak to Peak
- Peak to Valley
- RMS Roughness
- Scanning Probe Microscopy (SPM)
- Scanning wear
- Surface Features
- Surface Roughness

**Particle Sizing**

- Abrasives
- Air Contamination
- Bacteria
- Beverages
- Biomedical Industry
- Biotechnology
- Brownian Motion
- Cell Biology
- Ceramics
- Chemical-Mechanical Polishing
- Chromatographic Material
- Clays
- Coffee Grounds
- Construction Industry
- Cosmetics
- Contamination of Solution
- Coulter Counter
- Dry Powders
- Dynamic Light Scattering
- Effect of Additives
- Electric Sensing Zone Technique
- Electronic Industry

- Electrophoretic Light Scattering
- Emulsion
- Environmental Filtration & Filter Efficiency
- Food Industry
- Fraunhofer Method
- Fuel
- Hydraulic Fluids
- Laser Diffraction Particle Analysis
- Liquid Suspension
- Marine Biology
- Metals
- Mie Theory
- Microspheres
- Mixture Purity
- Motor Oils
- Organic Mixtures
- Paints & Pigments
- Paper Industry Pesticides
- Particle Concentration
- Particle Size Distribution
- Particle Sizing
- Particle Surfactants
- Particle Suspensions
- Petrochemical Industry
- pH Analysis
- pH Titration
- Pharmaceuticals
- Photo Industry
- Photon Correlation Spectroscopy
- Polarization Intensity Diffraction Scattering
- Polishing Slurries
- Powder Metallurgy
- Sedimentation
- Soil
- Temperature Testing
- Toners
- Vaccines
- Water Contamination

**Pore Sizing**

- Biomedical Porous Materials
- Bubble Point Flow Rate
- Bubble Point Pressure
- Capillary Flow Porometry
- Fabrics
- Filtration Membranes
- Gas/Liquid Permeability
- Maximum Pore Size
- Mean Flow Pore Size
- Meshes
- Minimum Pore Size
- Papers
- Polymeric Membranes
- Pore Density
- Pore Number
- Pore Volume
- Porofil Wetting Fluid
- Sintered Materials
- Through Pore Size

**Thermal Analysis-DMA**

- 3-Point Bend
- Complex Modulus
- Complex/Dynamic Viscosity
- Compression
- Controlled Force/Strain Rate
- Creep Compliance
- Dynamic Mechanical Analysis
- DMA
- Equilibrium Recoverable Compliance
- Film Analysis
- Frequency Effect
- Glass Transition
- Isostrain
- Loss Modulus
- Multi-Frequency
- Multi-Stress/Strain
- Relaxation Modulus
- Sample Stiffness
- Secondary Transitions
- Shear Sandwich
- Static/Dynamic Force
- Storage Modulus
- Storage/Loss Compliance
- Stress Relaxation
- Stress/Strain Behavior
- Submersible Clamps
- Tangent Delta
- Tension
- Viscoelastic Characterization

**Thermal Analysis-DSC**

- Adsorption
- Catalytic Reactions
- Compositional Analysis
- Corrosion/Oxidation
- Crystallization
- Curing
- Decomposition Reactions
- Differential Scanning Calorimetry
- Evaporation
- Glass Transition Temperature
- Magnetic Transitions
- Mass Changes
- Phase Diagrams
- Phase Transition Temperatures
- Purity Determination
- Reaction Kinetics
- Residual Mass
- Simultaneous Thermal Analysis
- Solid-Gas Reactions
- Solid-Liquid Reactions
- Solid-Solid Reactions
- Specific Heat Determination
- Sublimation
- Synthesis Reactions
- Thermal Stability

- Transition Enthalpies

**Thermal Analysis-TGA**

- Adsorption
- Corrosion/Oxidation
- Decomposition Reactions
- Dehydration
- Desolvation
- Desorption
- Evaporation
- Mass Changes
- Residual Mass
- Solid-Gas Reactions
- STA
- TGA
- Thermogravimetric Analysis
- Volatiles Determination

**Thermal Analysis-TMA**

- 3-Point Bending
- Compression
- Contraction
- Creep Analysis
- Distortion Temperature
- Dynamic TMA
- Expansion
- Fiber Testing
- Film Penetration
- Film Tensile Testing
- Glass Transition
- Isostrain Shrinkage Force
- Mechanical Characterization
- Modulated TMA
- Multilayer Film Analysis
- Softening Point
- Stress/Strain Behavior
- Stress Relaxation
- Tension
- Thermal Expansion
- Thermal Mechanical Analysis
- TMA
- Viscoelastic Characterization

**Tribological Testing and Analysis**

- Abrasive Wear
- Adhesive Wear
- Bio Materials
- Bulk Metals
- Ceramics
- Coatings
- Contact Lenses
- Delamination Wear

- Engineered Surfaces
- Fatigue Wear
- Fabrics
- Fretting Wear
- Friction Coefficient
- High Temperature Test
- Kinetic Friction
- Lifetime Cycle
- Liquid Lubrication
- Load Effect
- Lubrication Film
- Lubricity
- Material Removal Rate
- Metals
- Oxidation Wear
- Papers
- Pin-on-Disk
- Plastics
- Printed Surfaces
- Printer Rollers
- Reciprocating Motion
- Reciprocating Wear
- Rubbing and Wear Testing
- Scuffing
- Scratching
- Scratch Resistance
- Solid Lubrication
- Static Friction
- Surface Condition
- Thin Films
- Tribochemistry
- Variable Cycles
- Variable Load
- Variable Speed
- Various Contact Types
- Wafers
- Wear
- Wear Rate
- Wear Resistance
- Wear Volume
- Wet and Dry Friction

**Zeta Potential Analysis**

- Effect of Additives
- Electroosmotic Flow
- Electrophoretic Light Scattering
- Isoelectric Point
- Oil Suspensions
- Organic Mixtures
- Particle Agglomeration/Coagulation
- Particle Mobility
- Particle Suspensions
- Particle Zeta Potential
- pH Analysis
- pH Titration
- Photon Correlation Spectroscopy
- Polishing Slurries
- Sedimentation
- Solid Surface Zeta Potentials
- Surface Charge
- Surface Coatings

- Suspension Stability and Shelf Life
- Temperature Effects
- Zeta Potential of Flat Surface
- Zeta Potential of Membranes

## Technical Consulting Services

Ebatco makes every effort to provide its customers one-stop-shop solutions for their challenges through nano/microscale analytical lab services, expert-level consultation and first-class scientific instrumentation products. Ebatco offers both business and technical consulting to benefit its client who is looking for business and technical guidance, support or simply a second opinion. Ebatco's technical consultants could be contracted by clients on assigned tasks and duties individually or on a leading or participating role in a team. Depending on the customer needs, they can provide advices based on their expertise on a subject matter, conduct specialty technical research, problem solving and solution finding activities, advanced level data analysis and result interpretation, presentation at an international conference or to management, or project, program or team management.

### Materials Systems

- Steel, Metals, Ceramics, Glass, Polymers
- Nanostructures, Nanotubes, Nanoparticles, Nanowires, Nanobelts, Nanocomposites
- Surfaces, Grain Boundaries and Interfaces
- Thin films, Coatings, Composites

### Industrial Fields and Applications

- Advanced Characterization Instruments and Techniques
- Mechanical, Physical, Thermal and Tribological Property Measurement
- Surface and Interfaces
- Tribology, Friction, Wear, Lubrication
- Metallurgy, Metallography, Phase Diagrams

### Micro and Surface Analysis

- AES (Auger Electron Microscopy)
- AFM (Atomic Force Microscopy)
- TEM (Transmission Electron Microscopy)
- XPS (X-ray Photon Spectroscopy)

- XRD (X-ray Diffraction)

**Root Cause and Failure Analysis**

- Corrosion
- Creep
- Erosion
- Fatigue
- Fracture
- Fretting
- Stress Relaxation
- Oxidation
- Wear

## The Chief Materials Scientist

Dr. Dehua Yang is the Founder and President of Ebatco. He holds a Ph. D. in Physical Chemistry. He is an internationally well-known nanotechnology expert and an award-winning materials scientist. Prior to founding Ebatco, he was the Vice President of Hysitron, Inc., a world-leading nanomechanical testing instrument designer and manufacturer.

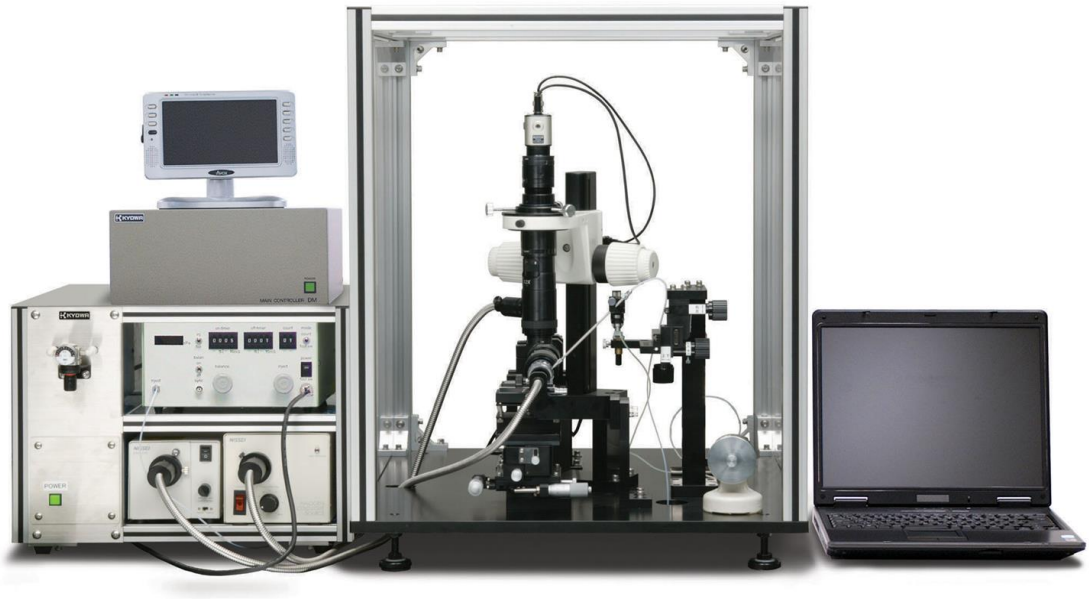
- 2011 Best of Business Award
- 2009 Best of Business Award
- 2007 Micro/Nano 25 Award
- 2005 Nano 50 Award
- 6 Issued US Patents
- Over 100 publications and Presentations
- US NSF Grant Proposal Review Panelist
- International Conference Organizer and Session Chair
- ASM International, MRS, ASME, TMS, STLE Member

**The Representative State-of-Art Testing and Measurement Instruments**

**Automatic Micro Contact Angle Meter**

The micro contact angle meter is specially designed for the pioneers in the micro/nano fields. The instrument is equipped with a unique capillary liquid dispensing system that has an inner diameter of 5-50μm, for making a liquid drop <30μm in size and picoliter in volume. In addition, the instrument comes with high magnification optics for accurately placing and measuring such small drops on micrometer features, and CCD cameras with a high capturing speed of 60 frames per second for studying dynamic characteristics of interaction of micron size liquids with solid surfaces. The technique is sensitive and capable of detecting monolayer molecules.

The unmatched instrument capabilities and usefulness for contact angle measurement at microscale have been exemplified through results obtained on fibers, medical guide wires, patterned organic light emitting display and microcircuits. Its advantageous high speed capturing capability is demonstrated by measuring the strong dependency of contact angles on time at millisecond intervals. The recorded feature-rich dynamics of contact angles of micron size drops is deemed valuable for investigating sensitive surface chemistry, vapor evaporation, wettability, and hydrophilicity/hydrophobicity changes at micro/nano scales.



Automatic Micro Contact Angle Meter.

**Full Feature, Multi-technique Nanoindenter**

Nanoscience and nanotechnology accelerate the proliferation of novel materials and devices possessing small sizes and low dimensions such as nanomaterials and ultra thin films. Mechanical testing and characterization of these materials have exposed challenges to the traditional hardness and tensile testing and measurement tools. Nanoindentation, also referred to as instrumented or depth-sensing indentation, is a promising technology for measuring nanomechanical properties of materials and miniaturized devices. To date, nanoindentation has been expanded to encompass a whole spectrum of testing techniques, well beyond the narrow indication of its name. While quasi-static nanoindentation has been broadly accepted as a method for determination of nanohardness and elastic modulus of materials, dynamic mechanical analysis of visco-elastic materials at nanoscale has seen steadily increasing interest. The nanoscale pulling and compression tests have also become a choice of tests.

The NAT Lab nanoindenter is a full-feature, multi-technique nanomechanical and nanotribological test system. It performs closed-loop controlled nanoindentation,

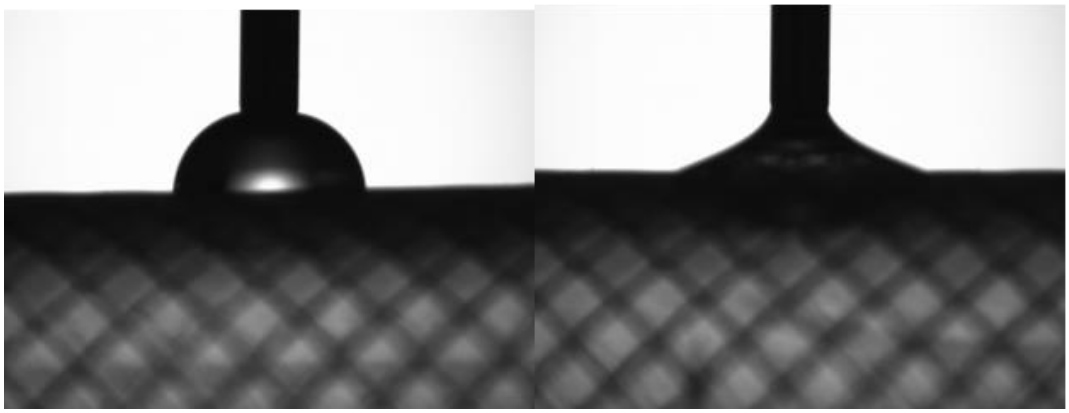
nanoscratch, nanowear, nanopulling, nanocompression tests with sub-nanometer and nanoNewton resolutions. Experiments can be conducted at room, elevated or reduced temperature, submerged in liquid, or under humidity control. The in-situ scanning probe microscopy (SPM) capability of the instrument enhances the nanoindentation function by enabling SPM imaging of the surface and positioning the indenter tip with nanometer precision over the feature to be studied. Examples of materials and devices that can be tested include thin films, coatings, nanoparticles, nanowires, bulk material surfaces and interfaces, MEMS, and electronic and biomedical devices.

The full-feature, multi-technique nanoindenter; Left: main unit; Right: transducers mounted on a granite platform inside the environmental enclosure.

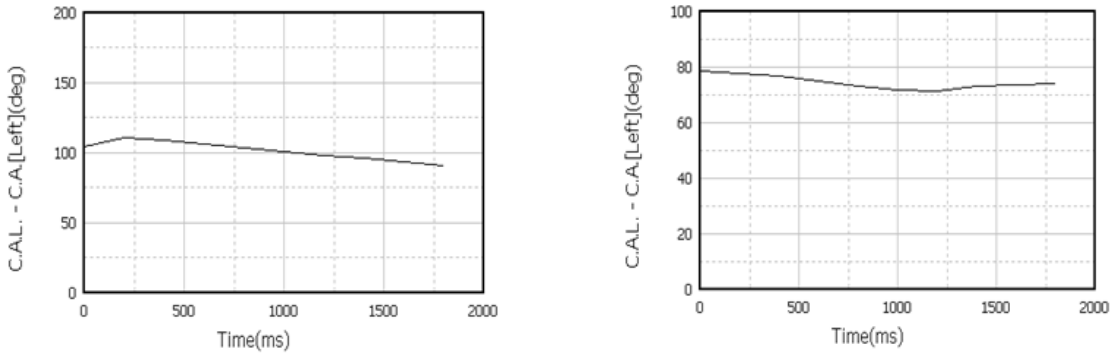
**Exemplary Testing Results**

**Contact Angle Measurement**

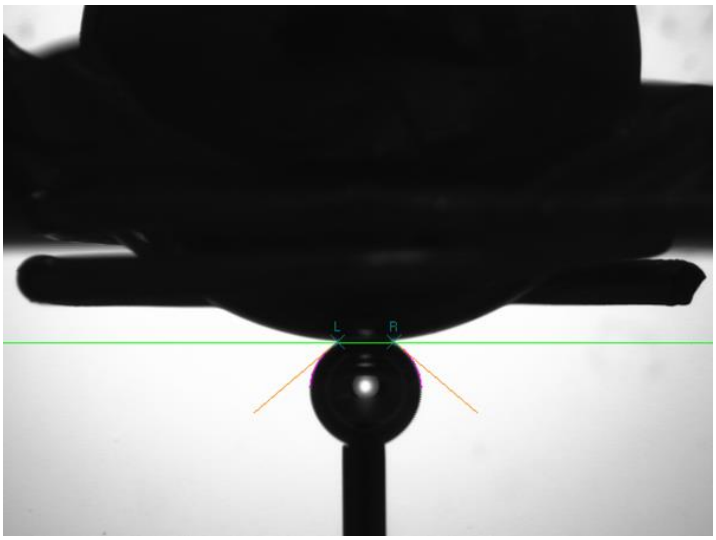
Contact Angle Measurement has been employed in numerous industries for measurement of surface wettability, hydrophobicity, hydrophilicity, surface energy, adhesion, surfactant efficiency, biocompatibility, etc. Microscale contact angle meter is designed to work with small or patterned surfaces such as fibers, small diameter tubes, micro-patterned surfaces, hairs, etc.



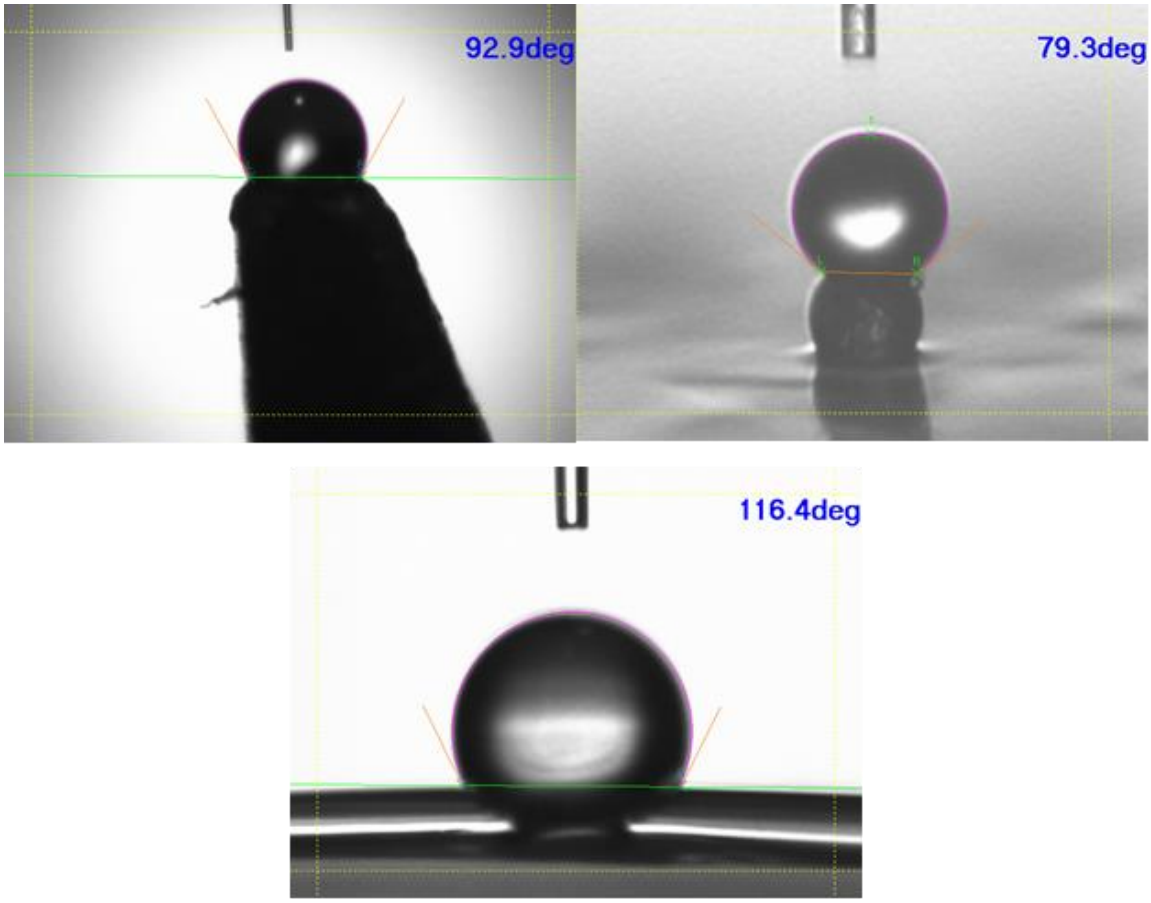
Images captured during advancing (left) and receding (right) angle measurements on the biomedical polymer catheter surface.




Contact angles measured over time through extension and contraction methods for advancing (left) and receding (right) angle determination of a biomedical polymer catheter.



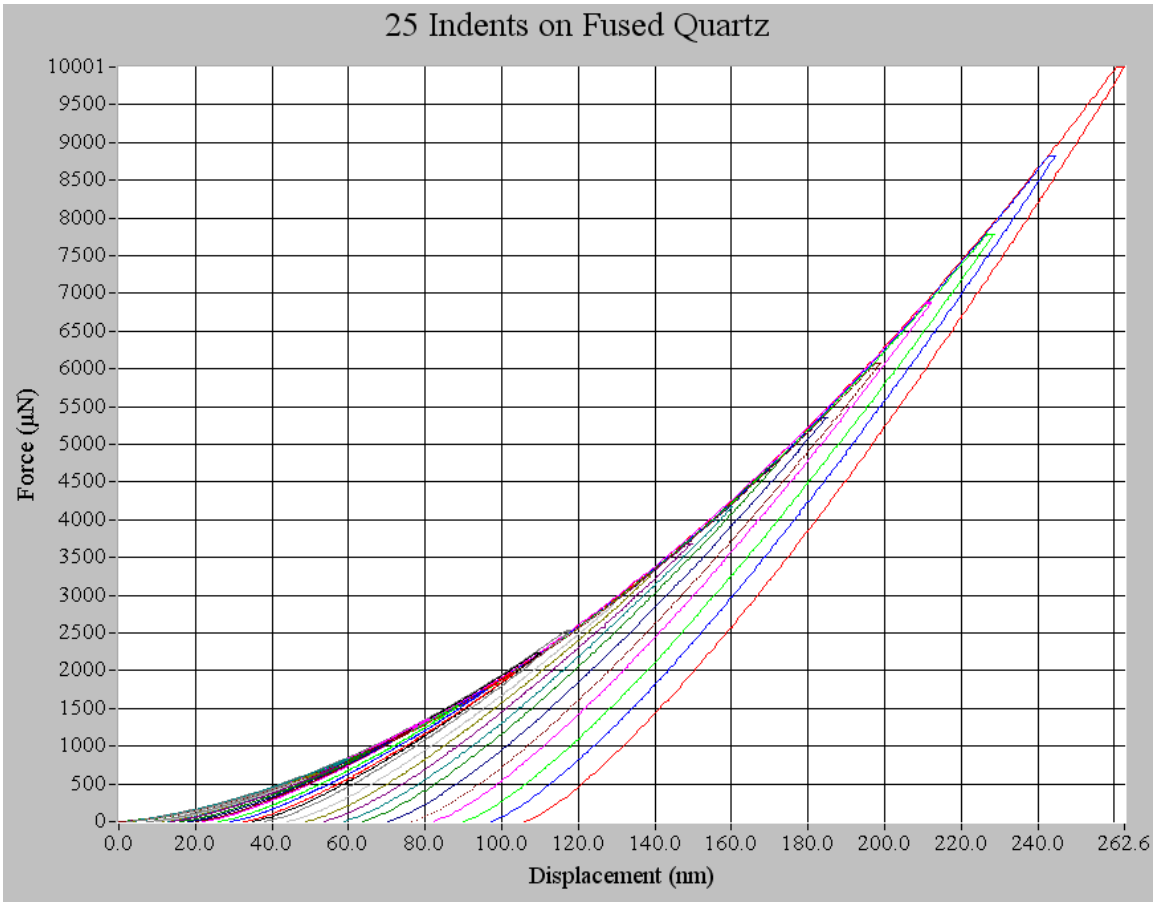
Captive bubble contact angle measurement on a disposable contact lens in saline solution.



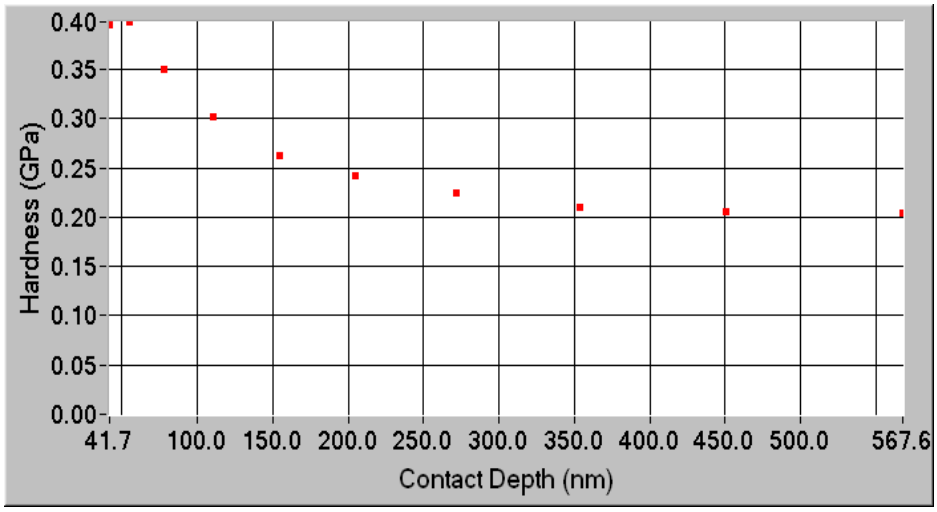

Captured droplets used for micro contact angle analysis on a 140 µm hydroxyapatite coated Ti post (top left), 30µm $Al_2O_3$ particle (top right) and 20µm polymer fiber (bottom).

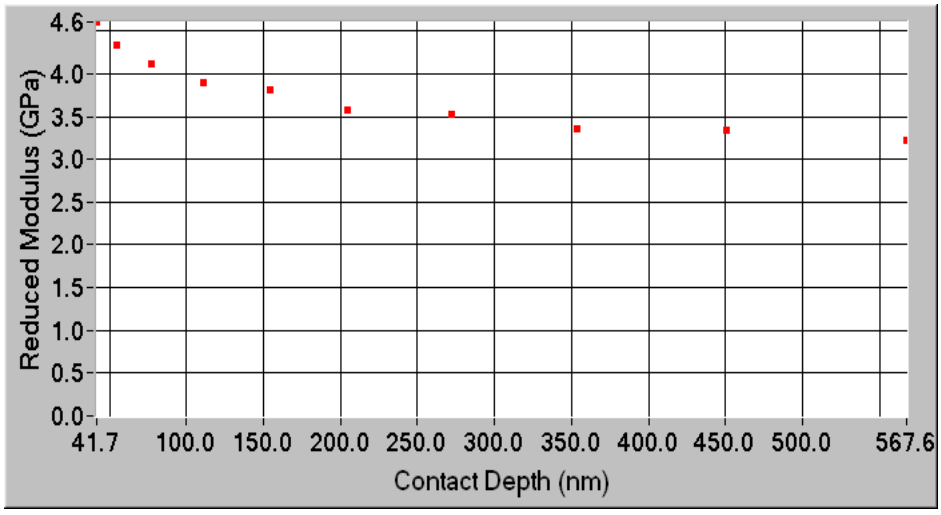
**Nanomechanical and Nanotribological Measurement**

Nanoindentation measures the hardness and Young's modulus at nano/micro scale. It has broad applications in testing and evaluation of thin films, coatings, miniaturized devices and small volume bulk material such as single phases or grain boundaries.

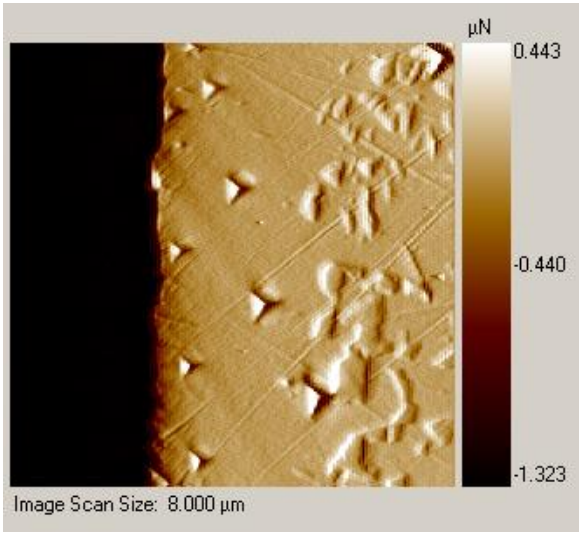



Load versus displacement curves from 25 load-controlled indents on fused quartz using a Berkovich indenter probe. These indents show excellent repeatability.




Hardness and reduced modulus as a function of contact depth from the partial unload indent performed on a CD ROM disk specimen.




In-situ Scanning Probe Microscopy (SPM) image of nanoindents on the surface of a metallic specimen after a cross-section profile test.

## Specimen Submission

In order for us to assist you in a more effective way, we request you to discuss with us on your testing and measurement needs in-depth. Sometimes we may ask for specimen submission prior to commitment and promise. When submit the specimens please fill out the Contract Lab Services Request Form completely and submit it with your specimens. Information on applications and other analyses that you have performed on the specimens may be helpful in selecting optimal testing methods and conditions. Please provide this kind of information as much as possible. If a non-disclosure agreement is required, please arrange it to be fully executed before submission.

## Service Charge Rates

Contract lab service fees are charged based on the scientist/engineer and instrument time spent on customer's project at predetermined hourly rates. The total time includes initial evaluation and planning of the project, test method development, specimen preparation and mounting, instrument calibration, experiments, data processing, result analysis, and report generation. The fee schedule is:

**Standard Schedule** (report due two weeks after receiving specimens): $260/hour
**Expedite Schedule** (report due one week after receiving specimens): $350/hour
**Priority Schedule** (report due three days after receiving specimens): $390/hour
**Rush Schedule** (report due one day after receiving specimens): $520/hour

Consulting services fees are charged based on the scientist/engineer time spent on customer's project at predetermined hourly rates. The total time includes initial evaluation and planning of the project, data gathering and background investigation, experiments and analysis, discussion, communication, meeting, solution conceiving and proposing, and final report generation. The fee schedule is:

**Metro Schedule** (same rate applies for travel time from office to customer site and back to office): $198/hour
**Outside Metro Schedule**: $198/hour (50% rate for travel time, travel expenses extra)

**Testing Results and Analysis Report**

Specimen testing and analysis report will be generated based the experiments. The report summarizes specimen characters as received, specimen preparation, testing method, testing instruments, testing conditions, testing data, testing results and analysis. Each report will be given a report number with finishing date and testing scientist/engineer name listed.

An electronic copy of the report will be sent via email and a hard copy via first class mail to customer on the due date. The report and testing results will be archived for record. Retrieval of the report within three month of testing finishing date can be arranged free of charge. After three months, an extra service charge may be applied.

**Quotation, Purchase Order, Payment and Invoice**

After receiving the specimens and requirement of test and analysis from a customer, NAT Lab will issue a formal quotation specifying the tests, project scope and estimated cost. Normally a purchase order is required to commence the experiments for contract lab services or a consulting project.

After finishing a project, an invoice will be sent together with the analysis and test report. A prompt payment made to Ebatco will be expected and highly appreciated.

**Specimen Return and Disposal Policy**

In general, customer's specimens submitted for test and analysis will not be returned after the tests are performed. The specimens will be stored in the normal lab environment for three months before disposal. Customers that want their specimens returned are required to specify this need clearly at specimen submission. Bulky, special, and expedited specimen shipment cost will be borne by customers.

**Contact Information**

NAT Lab is proud to be able to support you in putting all the puzzle pieces together through our professional, thorough and satisfactory analytical, testing and consulting services. Your technical expert and solutions are only a phone call away. For more information about the NAT Lab, or to start a project with us, please contact:

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