Optical Polishing
High Precision Lapping
Single Point Diamond Machining
High Precision, Low Stress Grinding
High Precision Honing
Metrology & Consulting Services

www.surfacefinishes.com
E-Mail: info@surfacefinishes.com
Phone: 630-543-6682
about surface finishes

Prototyping & Manufacturing with State-of-the-Art Technology

• Industry leading precision since 1949
• Fabrication, finishing & metrology services
  – Lapping
  – Polishing
  – Grinding
  – Honing
  – Single point diamond machining
• Subsidiary of Cabot Microelectronics Corporation (NASDAQ:CCMP)
  – The global leader in Chemical Mechanical Planarization (CMP) slurries
  – Over 1000 employees & $400M revenue
  – R&D, manufacturing, and engineering in NA, EU and Asia
  – Over 200 world class scientists and engineers with more than 450 patents
• Leveraging CMP to enable high precision surfaces for demanding applications
Tomorrow’s Precision Technology Available Today

- Chemical Mechanical Polishing (CMP)
- Optical quality polishing
- High precision lapping
- Single point diamond machining
- Precision low-stress grinding
- Large bore, long length honing
- Metrology & design consulting services
- Metals, ceramics, single crystal materials, coatings, glass, plastics
- ITAR registered (#0049272)

History of Fine Craftsmanship

Experts in Precision Fabrication
CMP of Specialty Metals & Alloys
400+ Patents on Chemical Mechanical Polishing, Slurries & Pads

Materials:
• Niobium, Molybdenum, Titanium, Tungsten, Tantalum, Glidcop, Stainless Steel

Applications:
• Mirrors, targets and substrates
• SRF cavities
• Air bearings
• High energy research
• Vacuum chambers

Resulting Benefits:
• Nano-scale surface roughness
• Improved surface purity and cleanliness
• Low subsurface damage

Leveraging global leadership in CMP consumable technology
Optical Quality Polishing
Enabled for Multiple Materials, Shapes and Sizes

Typical Applications:
- Flat, OD/ID Cylindrical, Spherical
- Optical flats
- Mirrors - low scatter, light weighted, interferometric and positioning
- Optical Windows
- CD/DVD ROM molds
- Novel substrates

Precision Quartz Cylinder

Typical Results:
- $R_a < 10 \, \text{Å}$ on specific materials
- $\lambda/20$ Flatness
- Scratch dig down to 10/5

ScatterStop™ Al Mirror
High Precision Lapping
Very Large Surface Areas and Thermal Stability

Typical Applications:
- Flat, OD/ID cylindrical, spherical
- Wafer & FPD chucks
- Air bearing and reference surfaces
- Locating & positioning fixtures
- Pumps, gears, seals
- Novel substrates
- Precision masters & gauge tooling
- Precision spacers

Typical Results:
- 25 nm flatness
- 50 nm size accuracy
- Surface roughness < 25 nm Ra
- 125 nm parallelism and perpendicularity

Optical Reference Cubes

(Image courtesy of Azores Corp.)

FPD Litho Stage < 0.5 microns PV

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Single Point Diamond Machining

Unsurpassed Flatness on Many Materials & Designs

Typical Applications:

• Scan mirrors
• IR optics
• Reticle transfer cases
• Heat sinks
• Plastics and soft metals

Typical Results:

• $R_a$ 50 – 100Å typical
• $\lambda/4$ flatness
• Perpendicularity < 0.000050”
High Precision, Low-Stress Grinding
Over 60 Years of Experience

Typical Applications:
- Flat, ID/OD Cylindrical, Taper
- Compression Rollers
- Spherical and Cylindrical Air Bearings
- Bearing Journals
- Shafts and mandrels
- Nozzles
- Gauge masters

Typical Results:
- 125 nm roundness
- 250 nm straightness
- 250 nm cylindricity
- Common sizing within 125 nm
High Precision Honing

Unique Large Bore, Long Length Capabilities

Typical Applications:
- ID range – 3/4” to 48”
- Length up to 36’
- Blind cylinders
- Hydraulic cylinders
- Waveguides
- Chrome, Steel, SS, Nickel Boron, Iron, Copper
- Metal/ceramic composites
- WC and Nickel Boron HVOF coatings

Typical Results:
- Accuracy:
  - ¾” ≤ ID ≤ 6”: +/- 0.001”
  - 6” < ID ≤ 48”: +/- 0.002”
- Surface Finishing Capabilities
  - > 10 μ-inch Typical
  - 8 -10 μ-inch R_a for many industrial materials
  - 2 μ-inch R_a on specialty materials
Metrology & Consulting Services

Design in Superior Quality and Manufacturability

- Surface Roughness
- Flatness
  - Contact measurements up to 34”
  - Laser Interferometry up to 6” CA
- Dimensional to < 0.000005”
- Perpendicularity
- Parallelism
- Roundness
- Straightness
- Cylindricity
- NIST Certifications

Zygo New View 6300 - White Light Interferometer

Zygo GPI - Laser Interferometer

Mikrocator 0.000002” Indicator Gauge

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How can surface finishes help you?

• Bringing precision to the surface since 1949
• Advanced capabilities in CMP, optical polishing, lapping, single point diamond machining, precision grinding, and honing
• Metrology and design consulting services
• Prototype through production
• ITAR registered

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www.surfacefinishes.com
Cleanroom Matrix™ Technologies

Access to Class 1 Cleanrooms and Metrology

• State-of-the-Art Polishing and Metrology
• Critical Cleaning and Cleanroom Packaging
• Surface and thin film analysis
• Defect characterization
Wafer Chucks
Technology for Highest Precision Specifications

Offerings:
- Electrostatic, RTP, Pin, Vacuum
- SiC, aluminum, alumina, anodized, Ni plated, silicon
- Custom fabrication and refurbishment services

Resulting Benefits:
- Reduced Cost of Ownership
- Increased Yield
- Improved Quality
- Reduced Variability

Anodized Aluminum
Silicon Carbide
FPD Vacuum Chuck Applications
Flatness < 0.5 microns On Very Large Surfaces

Offerings:
- Precision Lapping
- Custom fabrications and reconditioning services
- SiC, aluminum, alumina, anodized, Ni plated, PTFE coated

RESULTING BENEFITS:
- Reduced local slope
- Improved resolution
- Improved thermal stability

Segmented SS Litho Chuck

(Image courtesy of Azores Corp.)

FPD Lithography Stage < 0.5 microns PV

(Image courtesy of Azores Corp.)
Air Bearings
Large and Small Spherical, Cylindrical & Flat Surfaces

Offerings:
• Precision Lapping < 0.000020”
• Optical Polishing
• Reconditioning Services
• Large Surfaces > 5 ft long

Resulting Benefits:
• Extreme Tolerance Control
• Durability/Lifetime Extension
Interferometric & Positioning Mirrors
Superior Finishes via Advanced Technologies

Offerings:
- Single point diamond machining $< \lambda/4$
- Precision Lapping $< \lambda/10$
- Optical Polishing, $R_a < 10 \text{ Å}$
- Aluminum, SS, SiC, anodized, Si, other
- Highest reflectivity gold coatings

Metal Spin Mirrors for Scanning System Cubes

Resulting Benefits:
- Reduced Scatter
- Figure & Flatness
- Surface Roughness
- Thermal stability
Optical Reference Surfaces

Very Large and Small Cylindrical & Flat Surfaces

Offerings:

- Precision lapping
- Custom optical flats, $\lambda/10$ up to 16” diameter
- Reconditioning services with certification
- Large Reference Surfaces, up to 1 m$^2$

Resulting Benefits:

- Global Flatness
- Dimensional tolerance control
- No subsurface damage
Specialty Substrates
Exceed Critical Specifications on all Types of Materials

Materials:
• Non-metals -- AlN, SiC, Al₂O₃, CVD Diamond, Polyimides, Glass, Quartz, other
• Metals -- Mo, Nb, W, Cu, SS, Si, Cu-W, Mo-Cu, Au-Cu, Al, other

Applications:
• Compound semiconductors
• High power LED’s & electronic devices
• Test structures
• Microfluidic structures
• MEMS, sensors & RF devices
• Other
ScatterStop™ Precision Mirrors

Superior Performance Compared to SPDT

Materials:
- Non-metals – Silicon Carbide, Coated Glass
- Metals -- Molybdenum, Niobium, Tungsten, Copper, Stainless Steel, Silicon, Copper Tungsten, Molybdenum - Copper, Gold-Copper, Aluminum, Glidcop, other

Applications:
- FLIR
- Remote Sensing
- Airborne and Space Surveillance
- Hyperspectral Imaging
- Laser Marking and Cutting
- Other
Cartrilamp™ – Newton Interferometer
Quick, Accurate Flatness Measurement on the Shop Floor

Offerings:
• 8”, 10”, 12” or 16” flats are standard
• Custom sizes and shapes available
• $\lambda/4$ (0.000005”) or $\lambda/10$ (0.000002”) precision

Resulting Benefits:
• Low-cost flatness measurement
• Ease of use
• In process or final QC
Hydraulic Cylinders
3/4” to 48” ID – Up to 36’ Long

Offerings:
- Internal, blind hole, thin walled cylinders, large bore
- Metals, composites, hard coatings
- Accuracy
  - ¾” ≤ ID ≤ 6”: +/- 0.001”
  - 6” < ID ≤ 48” +/- 0.002”
- Finish Capabilities
  - > 10 μ-inch Rₐ typical
  - 8 -10 μ-inch Rₐ for many industrial materials
  - 2 μ-inch Rₐ on specialty materials

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Wafer Mounting Blocks
Custom Fabrication and Reconditioning Services

Offerings:
• Concave or convex up to 6 light bands
• Flatness to < 0.000010”
• Optical quality finish
• Re-application of registration marks

Resulting Benefits:
• Uniform flatness
• Reduced TTV
• Lower variability
• Improved yield

Source: kyocera.com

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Wafer Mounting Blocks
Custom Fabrication and Reconditioning Services

Typical Reconditioning Specifications:

• Surface Roughness ≤ 0.5 μm Rₐ
• Global Flatness ≤ 0.2 μm
• Local Flatness ≤ 0.63 μm in any 150 mm sub-aperture of the polishing plate
• Surface to be clean and smooth (no waviness)
• The plate surface will be free of imbedded particles per visual inspection
• Reappplication of the registration mark
• Certificate of Analysis that includes test data for roughness and flatness by individual plate number
• Plates to be shipped between locations in a “Plate Safe” specifically designed for the plates’ transport and storage

Custom Plate Safe Transport Case Available from Surface Finishes

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Shafts, Journals and Gear Faces

Exceed Demanding Specifications

• Typical Applications:
  – Matched rollers
  – Tapered shafts
  – Precision shaft and bearing assemblies
  – Polished journals

• Typical Results:
  – Roundness to < 0.000005” (125 nm)
  – Straightness to < 0.000010” (250 nm)
  – Cylindricity to < 0.000010” (250 nm)
  – Common sizing to < 0.000005” (125 nm)
  – Perpendicularity < 0.000010” (250 nm)
  – $R_a < 0.0000001$” (2.5 nm)
Medical Devices & Pharmaceutical
Highly Controlled Precision Fabrication and Finishing

Applications:
• Surgical mirrors
• Tableting molds
• Pumps
• Substrates for microfluidics
• Replicated optics

Materials:
• SS, tool steel, titanium, cobalt chrome, other
Gauge Tooling and Fixtures
Custom Fabrication and Reconditioning Services
Make complete or finish;
also certification services:
• Bluing gauges
• Calibration bars
• Check plates
• Custom alignment and assembly fixtures
• Custom masters
• Gauge standards
• Optical reference cubes to 0.2 arc-second accuracy
• Reference platens
• Sine bars
• Other

Source: www.adcole.com
Camshaft Master
Angularity Measurement
Reference Cubes
High Energy Physics & Research
Prototype Development and Fabrication

Typical Applications:
• Low scatter mirrors
• Sub-atomic Particle Targets
• SRF cavities
• Substrates
• Vacuum chambers
• Other

Typical Materials:
• Niobium Molybdenum, Titanium, Tungsten, Tantalum Glidcop, Stainless Steel, Aluminum, other

University of Wisconsin, Madison Beam Line with 12 Laser Beams
Semiconductor Tooling and Parts

Global Infrastructure & Industry Leading Technology

Offerings:

• Wafer chucks
  – Electrostatic, RTP, pin, vacuum, ceramic, other

• Wafer mounting blocks
  – Alumina, SiC

• CMP retaining rings
  – PPS, PET, Delrin, PEEK

• Polishing head and platen refurbishment

• Reticle holders for lithography systems

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ScatterStop™ Mirrors
Advanced Nanoscale Surface Technology™

Offerings:
• 1” to 6” Plano mirrors, 90% CA
  – Round, elliptical, rectangular
  – Larger sizes on case-by-case basis
• Components made to order
• High precision finishing services also available

Results:
• < 20 Å rms on monolithic 6061-T6 Al
  – Other alloys on case-by-case basis
• Isotropic surface
• Better than λ/10 rms surface figure

Typical Diamond Turned Al
77.7Å rms finish

vs.

ScatterStop™ Al Mirror
5.3Å rms finish
Power Spectral Density

ScatterStop™ Al Mirrors Yield Superior Performance

ScatterStop™ Reduces Errors Across Spatial Frequencies

- Comparable performance to Al on glass without the issues of weight and mounting complexity
- Better performance than Ni on Al without the bimetallic effects
- Superior performance compared to traditional single point diamond turned Al

Note: PSD measurement with Veeco NT-2200

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Reflectivity

ScatterStop™ Mirrors Overcome Limitations of Nickel

Scatterstop™ Benefits:

- Higher reflectance of Al
- Use 6061-T6 Al for VIS and UV applications
- Eliminate bimetallic stresses from CTE mismatches
Many ScatterStop™ Applications
Superior Performance compared to SPDT

Typical Applications:
- FLIR
- Targeting and fire control
- Image stabilization
- Remote sensing
- Printing and scanning
- Microscopy
- Airborne and space surveillance
- Semiconductor inspection

- Hyperspectral Imaging
- Laser Beam Delivery
- Laser marking and cutting
- Machine Vision/Sorting
- Medical Imaging
- Spectrometers
- Free space laser communication
High Reflectivity Gold Coatings
Custom Designed to Meet Your Specific Needs

Protected Gold Average Reflectivity

SF Protected Gold Coating Performance

Typical Industry Performance
Chemical Mechanical Polishing (CMP)
An Enabling Technology for Precision Applications

MECHANISM

pad

slurry →
oxidized metal →

Metal substrate

Abrasive particle

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Design Consulting & Prototyping

Experts in Precision Fabrication Since 1949

Typical Areas:

- Coatings
- Dimensions and tolerancing
- Fabrication methods
- Materials selection
- Measurement techniques
- Packaging
- Part identification for traceability
- Process flows
- Prototyping and high volume manufacturing
- Stress relief and thermal stabilization
- Supplier selection
- Other
Refurbishment and Certification
Significantly Reduce Costs by Extending Service Life

Typical Applications:
- Calendaring rolls
- CD and DVD molds
- Check & reference plates
- Gauge tooling & masters
- Hydraulic cylinders
- Optical reference surfaces
- Pin & vacuum chucks
- Seals
- Slitter knives
- Tableting molds
- Valve components
- Wafer mounting blocks
- Wobblers

Cam Shaft Gauge Master

Wobbler Before & After Refurbishment

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Metals and Alloys
Precise Tolerances and Fine Finishes on Hard and Soft Materials

Some Typical Materials:
• Aluminum
• Brass & bronze
• Cast iron
• Cobalt chrome
• Copper
• Hastelloy C
• Inconel
• Molybdenum
• Nickel
• Niobium
• Stainless steels
• Titanium
• Tool steels
• Tungsten
• Tungsten carbide
• Other

Examples of Applications:
• Air bearings, Gears, Seals, Valves, Shafts, Pump Components, and Hydraulic Cylinders
• Calendaring Rolls and Slitter Knives
• Molds, Reference Plates
• Vacuum Chambers, Mirrors, Targets, Substrates, Heat Sinks and Wave Guides
Coatings

High Performance on Finishes, Tolerances and Reflectivity

Some Typical Coatings:

• Protective & Wear Resistant
  • Aluminum
  • Anodize
  • Copper
  • Diamond-like-carbon (DLC)
  • Hard chrome
  • Nickel & nickel boride
  • Silicon carbide
  • Silicon dioxide
  • Silicon nitride
  • Titanium nitride
  • Tungsten carbide
  • Other

• Reflective
  • Aluminum
  • Gold
  • Nickel

Examples of Applications:

• Air bearings
• Hydraulic Cylinders
• Mirrors and Optical Reference Surfaces
• Molds
• Seals, Valves, Shafts and Pump Components
Glass

High Precision Surfaces on a Variety of Shapes and Sizes

Some Typical Materials:

- Borosilicate
- Fused silica
- Polysilicon
- Pyrex®
- Quartz
- Zerodur
- Other

Examples of Applications:

- Imprint Lithography Cylinders
- Mirrors
- Optical Reference Surfaces
- Sensors and MEMS
- Windows

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Ceramics

Finishes and Tolerances that Exceed Specifications

Some Typical Materials:
- Alumina
- Aluminum
- Aluminum nitride
- Aluminum oxynitride
- Silicon carbide
- Spinel
- Other

Examples of Applications:
- Armor
- Mirror substrates
- Mounting Blocks
- Optical Windows and Domes
- Pin Chucks, Vacuum Stages
- Valves, Seals and Pump Components

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Polymers
Surface Precision for Many Materials, Shapes and Sizes

Some Typical Materials:
- Acrylic
- Corian®
- Delrin®
- PEEK
- Polypropylene
- Polycarbonate
- PPS
- PVC
- Teflon®
- Other

Examples of Applications:
- CMP Retaining Rings
- Custom Fixtures
- Light Tubes
- Optical Windows
- Seats, Seals and Spacers
Single Crystal Materials
Surface Roughnesses < 10 Å

Some Typical Materials:
• Aluminum Nitride
• Germanium
• Niobium
• Silicon Carbide
• Silicon
• Zinc Selenide
• Zinc Sulfide
• Other

Examples of Applications:
• Compound Semiconductor Substrates
• Optical Components
  • Windows
  • Gratings
  • Mirrors
  • Other
• Sensors
• Superconductor Substrates

Specialty Substrates