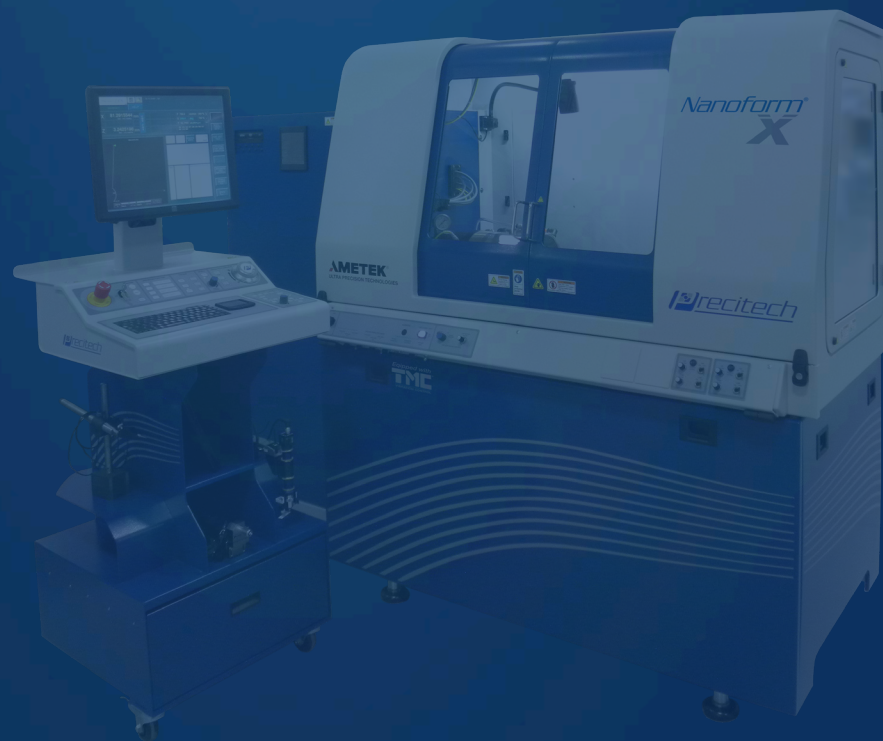




*Global Manufacturer of Innovative Ultra Precision Machining Solutions*

## ***Solutions for Aerospace and Defense***



**AMETEK<sup>®</sup>**  
ULTRA PRECISION TECHNOLOGIES

[www.precitech.com](http://www.precitech.com)

Precitech's unique technologies enable many of the key ultra precision applications in the aerospace and defense markets.

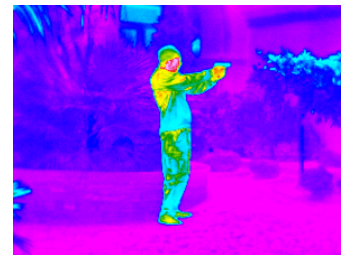
If you are looking to manufacture Head-up Displays (HUDs) for aerospace applications, the Nanoform® 700 ultra and Nanoform® L 1000, are uniquely positioned to meet your needs.

The Nanoform X and Nanoform X Ultra Grind can be used to make parabolic and diffractive lens molds for visible and infrared applications like surveillance cameras, thermal imaging, and targeting systems.

The Nanoform X and Nanoform X Ultra Grind are the number one choices for manufacturers of aspheric infrared (IR) optics worldwide. Aspheric IR lenses are used in defense applications such as surveillance and night vision cameras, and portable missile and thermal image firing systems.

In addition to the Nanoform X the revolutionary Nanoform Xtc with MicroLAM technology brings a new level of efficiency and productivity when working with hard to machine IR materials like silicon (Si), calcium fluoride (CaF), and zinc sulfide (ZnS).

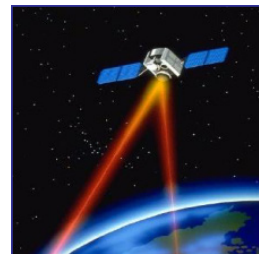
For customers in the aerospace and defense industry Precitech is ideally positioned to provide ultra-precision machining solutions to meet your needs.



Night vision



Portable missile systems



Satellite communications



Head-up displays (HUDs)



Thermal image firing systems



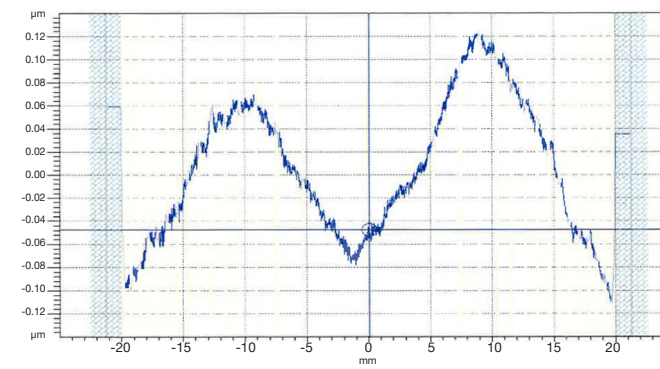
Surveillance cameras

### Application: Infrared Silicon Diffractive Machining

Machining a 15 zone Silicon Diffractive lens and meet surface finish, form accuracy, and absolute radius specifications

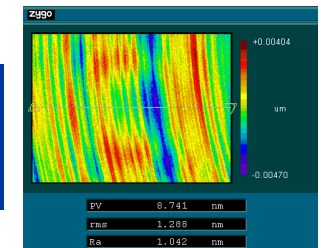


Part photo on Taylor Hobson Form Talysurf

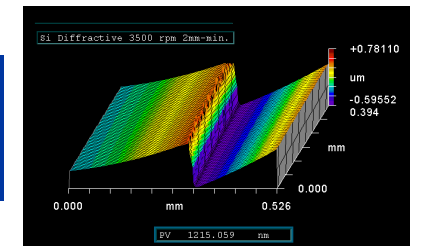


Analyzed using AAU diffractive analysis utility from Taylor Hobson

**Surface Finish:**  
1.04 nm Ra



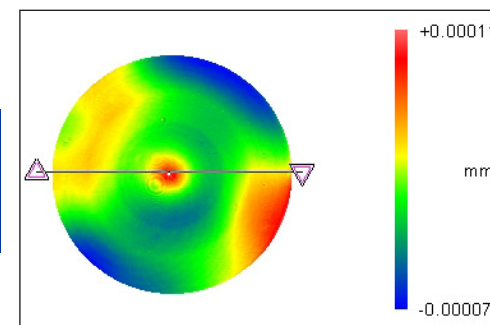
**Diffractive Step:**  
1.2 µm



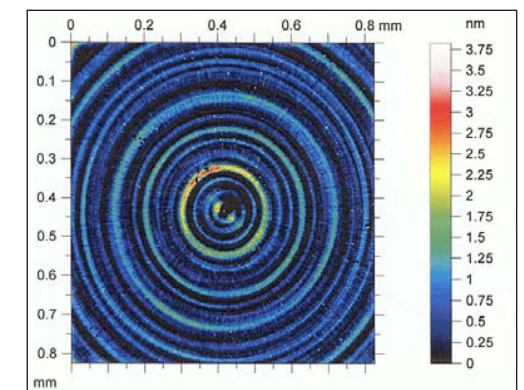
### Application: High Speed Germanium Machining

Using a Hydroround oil hydrostatic B axis and HS150 work holding spindle to machine Germanium at 3 times typical part cutting times

**Form Accuracy**  
0.197 µm PV



**Surface Finish**  
0.3674 nm Sa  
0.4845 nm Ra



## Enabling Technology: Nanoform X and Nanoform X Ultra Grind



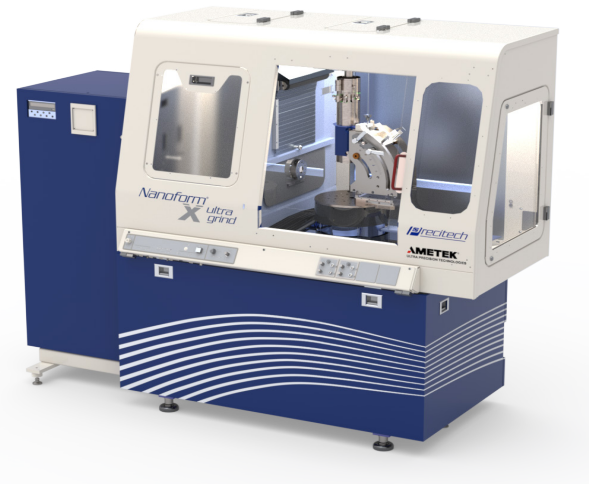
The Nanoform X is designed to increase productivity and ease of use in the diamond turning, milling, and grinding of optical lenses, mold inserts, mirrors, and precision mechanical components. The machine can be configured from 2 to 4 axis to produce spherical, aspherical and freeform surfaces of up to 440 mm diameter.

- ▶ **Fully-opening upper enclosure and lower work envelope allows easier access for setup and cleanup**
- ▶ **Unique inner compartment design improves Swarf containment**
- ▶ **Operator console enhancements lead to greater ease of use**
- ▶ **Innovative suite of productivity tools reduces part and tool setup time**
- ▶ **HS 150 spindle provides for 5x improvement in thermal stability**
- ▶ **Dual frame design with TMC MaxDamp® isolation reduces sensitivity to vibration**
- ▶ **Industry leading surface finish less than 1 nm Sa**

### Key Specifications

Turning performance	Surface roughness < 1 nm Sa Form accuracy < 0.1 μm P-V (tested and measured on one surface upon request)
Programming resolution	0.01 nm linear / 0.0000001° Rotary
Ultimate load capacity	136 kg (300 lbs) @ 100 PSI
Swing capacity	Max swing 440 mm dia., w/ 100 mm riser block (250 mm dia. standard swing)

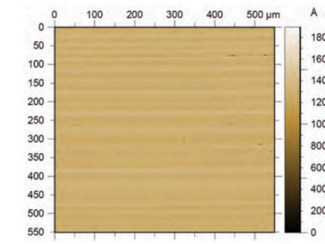
The Nanoform X Ultra Grind is the next generation of the Nanoform 250 Ultra Grind. With many installed in the field, the 250 Ultra Grind is an ideal solution for diamond turning materials that benefit from the use of water based coolants.



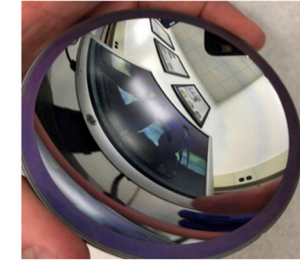
### Key Specifications

Turning performance	Surface roughness < 1 nm Sa Form accuracy < 0.1 μm P-V (tested and measured on one surface upon request)
Grinding performance	Surface roughness < 5 nm Sa Form accuracy < 0.2 μm PV
Programming resolution	0.01 nm linear / 0.0000001° Rotary
Ultimate load capacity	136 kg (300 lbs) @ 100 PSI
Swing capacity	Max swing 440 mm dia., w/ 100 mm riser block (250 mm dia. standard swing) 220 mm over B-axis

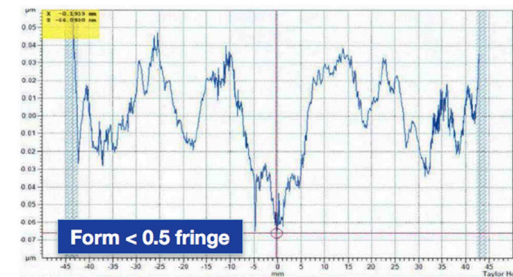
## Application: Micro-LAM on Silicon



Finish Parts 1-5: 20-40 Å  
6-10: 40-60 Å  
11-15: 45-65 Å



Part Diameter: 90 mm  
Time to machine 1 part: 4.8 minutes



### Micro-LAM Advantages on Si

- Faster part machining  
Higher rpm  
Higher feed rate (2-5x)
- Improved surface finish (2-4x)
- Minimal or no spoke pattern
- Improved tool life (3-7x)
- Better part accuracy (form)
- Less rainbow effect

## Enabling Technology: Nanoform Xtc with Micro-LAM technology

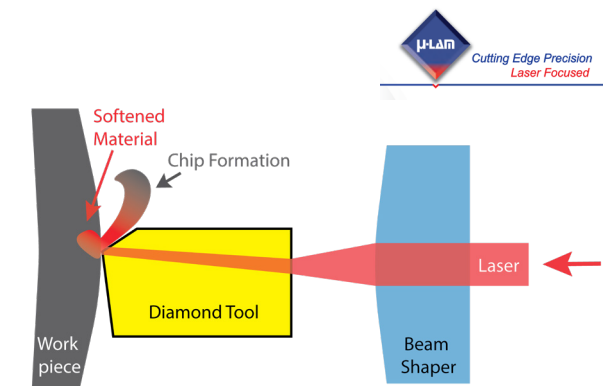


Certain infrared (IR) materials have historically been challenging to diamond turn. In some cases, such as with silicon (Si), this is due to excessive tool wear. In other cases, such as zinc sulfide (ZnS) and calcium fluoride (CaF), it's due to part quality issues.

The Nanoform Xtc is an advanced method for diamond turning hard to machine IR materials with greater productivity and part quality than traditional diamond turning.

## The μ-LAM patented solution

- The laser beam passes through an optically transparent diamond tool
- Innovative solution proven through extensive research & development
- Laser delivered precisely at tool-workpiece interface
- Issued patent with 20 claims



## Application: Head-Up Display Mold

### Goal:

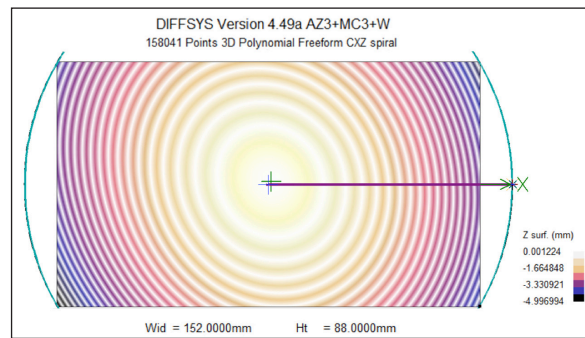
Demonstrate the surface finish and form accuracy achievable when machining a Head-Up Display (HUD) mold on either the Nanoform® 700 ultra or the Nanoform® L 1000 machine platform using Adaptive Control Technology (ACT) and an HD160 high capacity work holding spindle.

### Process:

Freeform XZC diamond turning with Adaptive Control Technology to eliminate errors in X and Y that repeat with spindle position

### Part Details:

- Material:** Brass

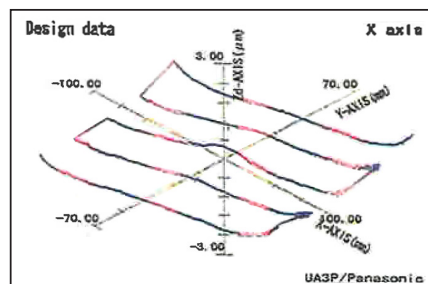


### Process Details:

- Tool:** Single point diamond tool
- Tool radius:** 1.5 mm
- Spindle speed:** 200 rpm
- Feed rate:** 2.5 µm/rev
- Coolant:** Odorless mineral spirits (OMS)
- Finishing pass duration:** 176 minutes
- Z axis excursion:** 1.5 mm (twice per revolution)
- Diagonal width:** 192 mm

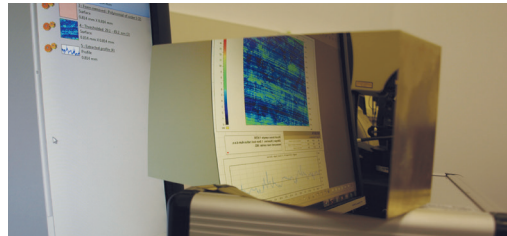
### Results:

- Surface finish near center:** 0.744 nm Ra
- Surface finish near edge:** 1.31 nm Ra
- Form error:** 0.79 µm PV

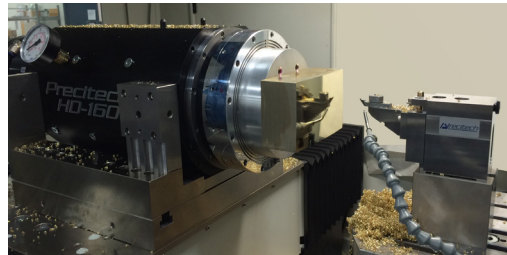


Status R.M.S. = 0.1127 (µm) P-V = 0.7869 (µm)

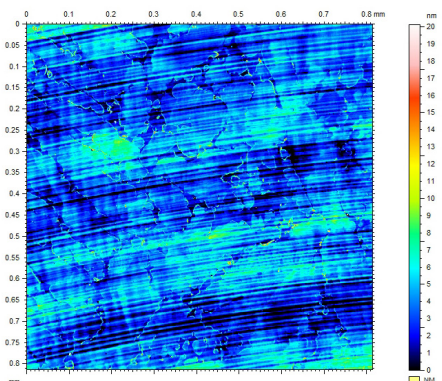
Part Photo



Setup Photo



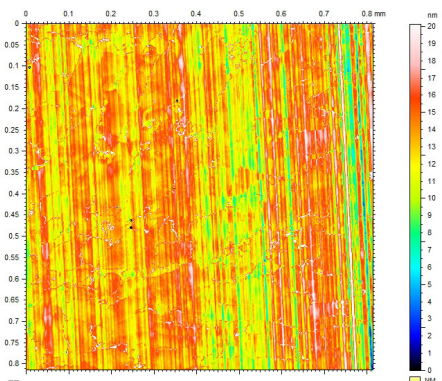
Sample 1- near center



ISO 4287			
Amplitude parameters - Roughness profile			
Ra	0.744 nm	Gaussian filter, 0.08 mm	Arithmetic Mean Deviation of the roughness profile.
Rz	5.07 nm	Gaussian filter, 0.08 mm	Maximum Height of roughness profile.
Rq	0.974 nm	Gaussian filter, 0.08 mm	Root-Mean-Square (RMS) Deviation of the roughness profile.

TelyMap Platinum 6.2.6746

Sample 1- outside edge



ISO 4287			
Amplitude parameters - Roughness profile			
Ra	1.31 nm	Gaussian filter, 0.08 mm	Arithmetic Mean Deviation of the roughness profile.
Rz	8.44 nm	Gaussian filter, 0.08 mm	Maximum Height of roughness profile.
Rq	1.70 nm	Gaussian filter, 0.08 mm	Root-Mean-Square (RMS) Deviation of the roughness profile.

TelyMap Platinum 6.2.6746

## Enabling Technologies: Large Frame Machines, High-Capacity Spindle, C Axis, and Adaptive Control Technology (ACT)

*If you are looking to manufacture Head-up Display molds for automotive or aerospace applications, the Nanoform® 700 ultra or Nanoform® L 1000, are uniquely positioned to meet your needs.*



Nanoform<sup>®</sup> 700 ultra      Nanoform<sup>®</sup> L 1000

- ▶ Accommodate large and heavy parts HS 160 spindle
- ▶ Manufacture non-rotationally symmetric freeform shapes Rotary C axis
- ▶ Improve form and reduce machining time Adaptive Control Technology (ACT)

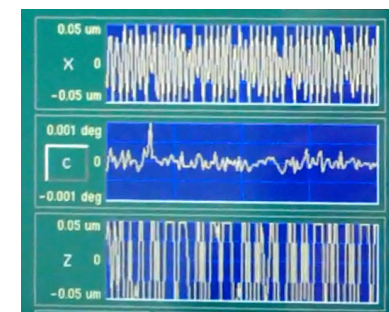
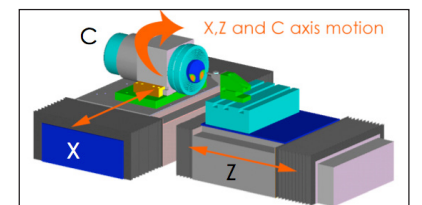
*When equipped with an HD-160 spindle with a C axis and Adaptive Control Technology (ACT) there is no better solution in the market today for this application.*

The stiffness and dampening of the HD-160 results in improved surface finish and the capacity for large parts and fixtures. The HD-160 has an ultimate load capacity of 170 kg (375 lbs.)

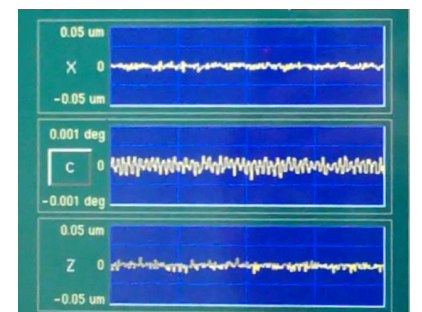
Precitech's C axis and high resolution encoder, with feedback resolution of 0.010 arc-sec, and servo tuning algorithms allow for tight control of the rotary position of the spindle. The result is the capability to manufacture high accuracy freeform shapes with superior surface finish using XZC machining.

Finally, Adaptive Control Technology (ACT), exclusively offered by Precitech, utilizes a unique learning algorithm to eliminate errors in X and Z that repeat with spindle position. This allows you to increase the spindle speed, reducing manufacturing time while improving form error.

Key Machine Specifications	Nanoform 700 ultra	Nanoform L 1000
Swing capacity	700 mm (27.5 in.) dia.	Max swing 1 m (39 in.) dia.
Surface finish	< 1.0 nm Sa	< 1.25 nm Sa
Form accuracy	< 0.125 µm P-V	< 0.125 µm P-V



Following error without ACT active



Following error with ACT active



*Global Manufacturer of Innovative Ultra Precision Machining Solutions*



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