

Welcome to





**At the foot of the Bavarian Alps**

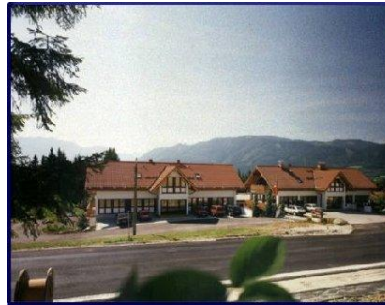
# KERN History



Founded 1962 in Martinsried as a Precision Parts Manufacturer

1983 start of the machine tool production

1987 move from Munich to Murnau



2007 two additional locations in Eschenlohe (Germany) and Webster (USA)



Precision





# Precision

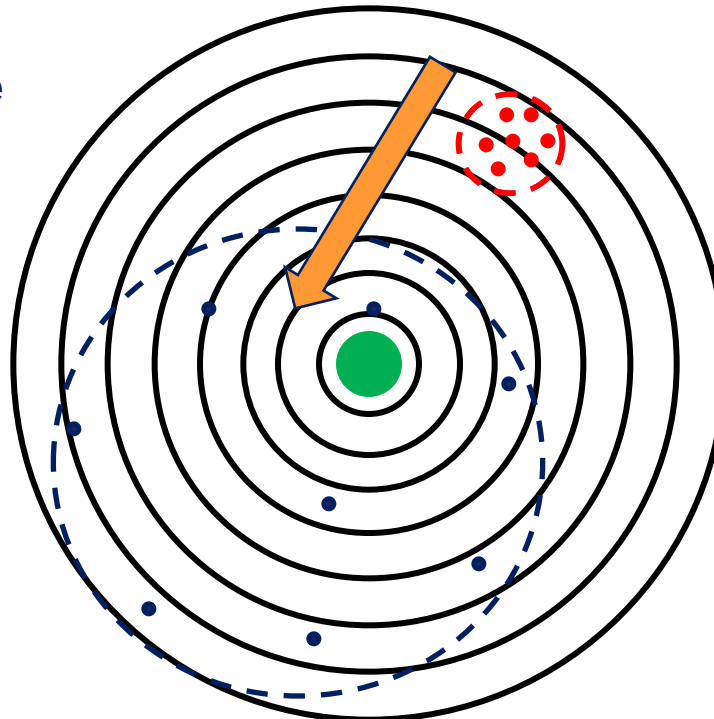


Target

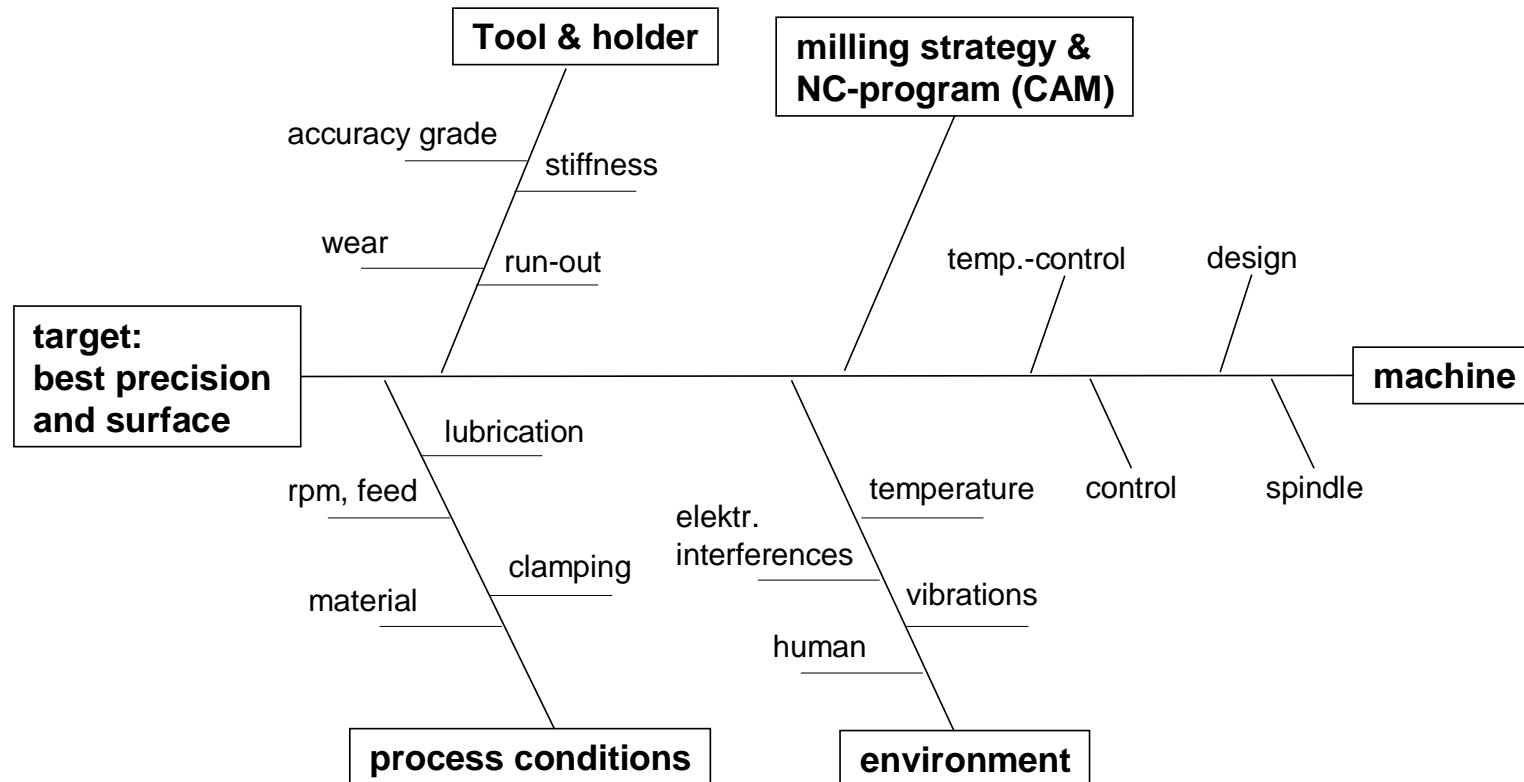
STANDARD - Machine

KERN - Machine

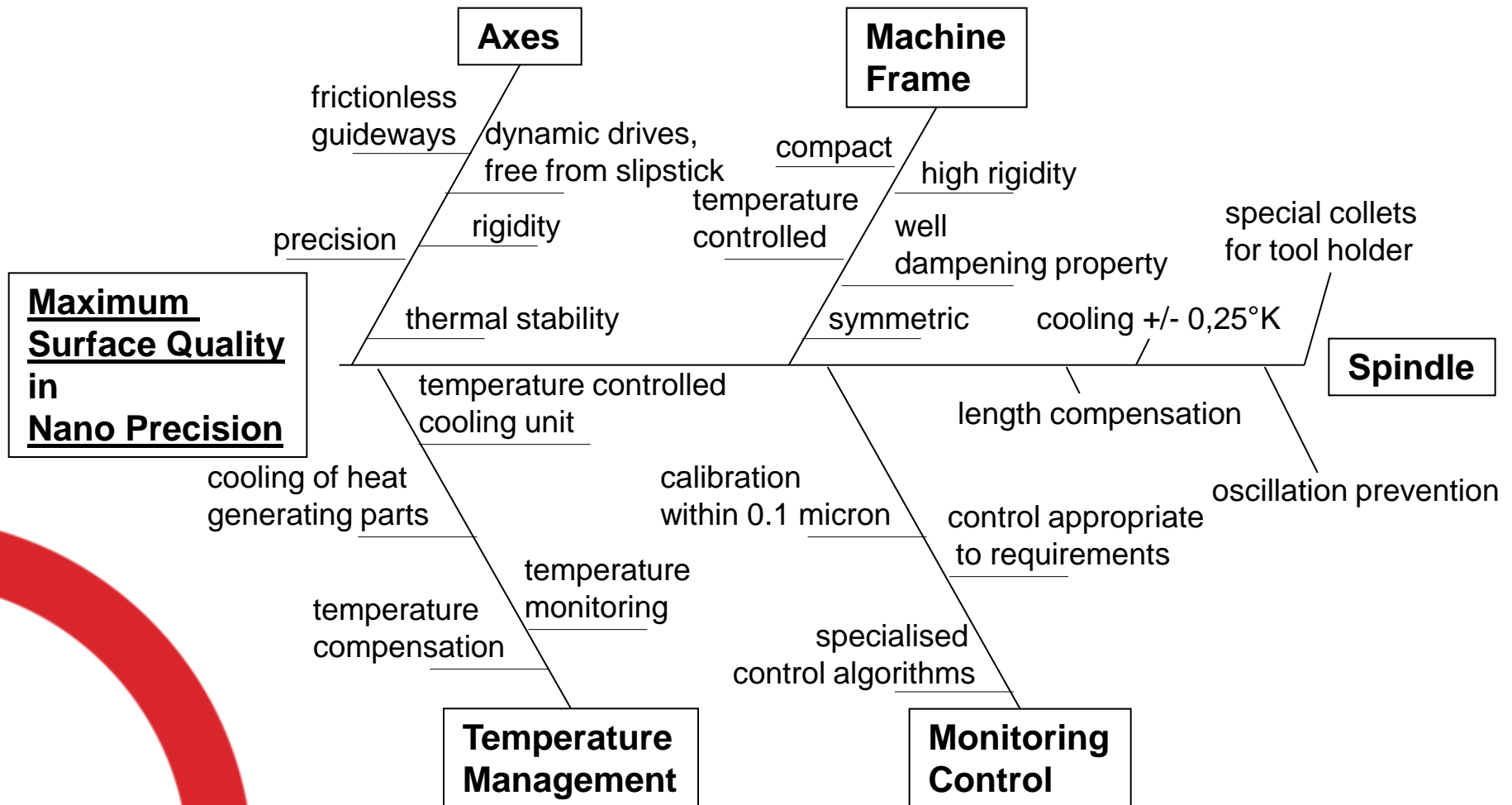
Customer Process



# Precision

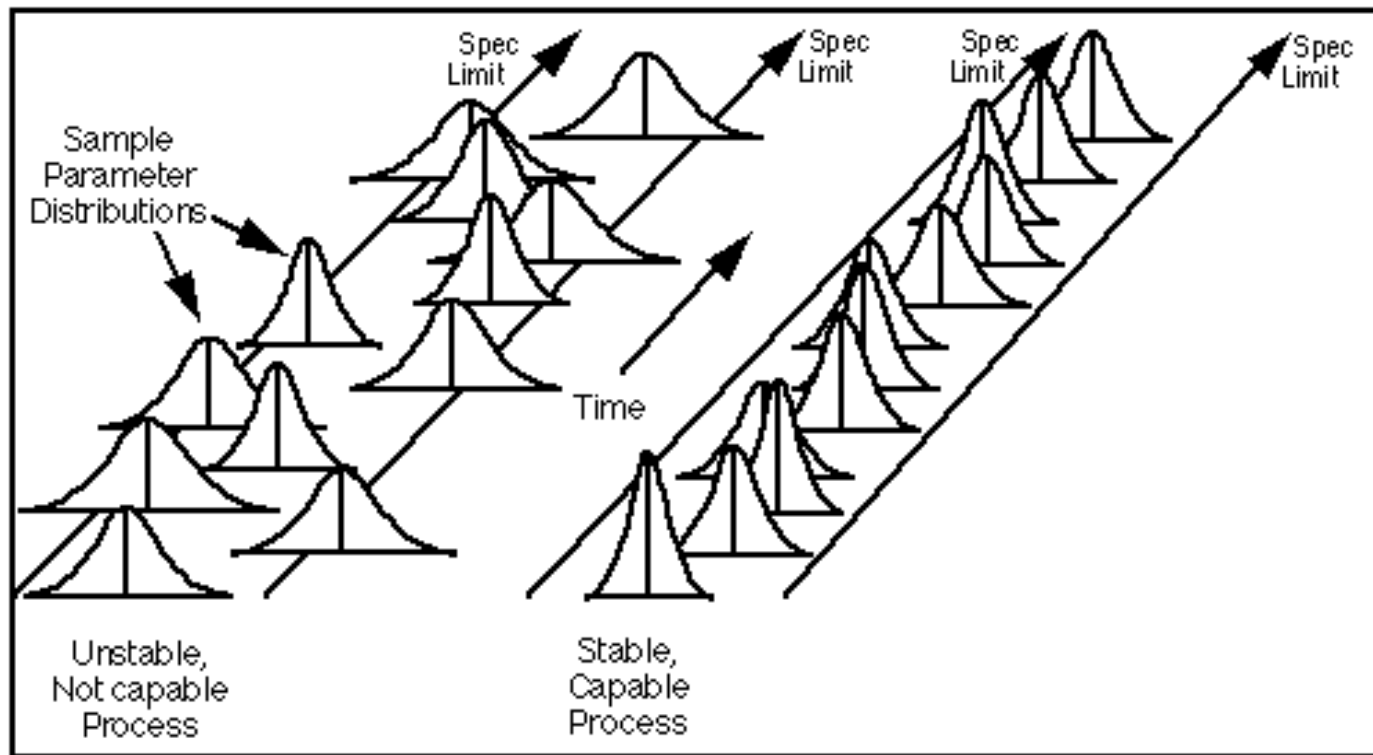


# Precision





## Precondition: Machine Capability



Contract Manufacturing



# High-Tech Contract Manufacturing



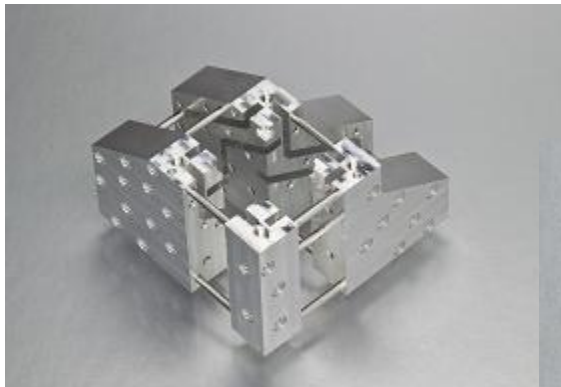
Our Location in Murnau



# High-Tech Contract Manufacturing



We manufacture  $\mu$  - precision parts for our customers using KERN machines



- Microparts manufacturing
- (Micro-) Mold and Die production
- Jig Grinding within the milling machine
- CNC- milling
- Wire cutting (EDM) and Die sinking
- Surface grinding
- Easy combination of different machining processes
- Development, construction, manufacturing and assembly
- Metrology, inspection, and documentation

# High-Tech Contract Manufacturing

## Micro Parts



- $\mu$ -exact contours
- Free form contours
- Form tolerance  $\pm 1\mu\text{m}$
- Same quality from the first to the last part
- Smallest caliber of tools (drills and mills from  $30\mu\text{m}$ )



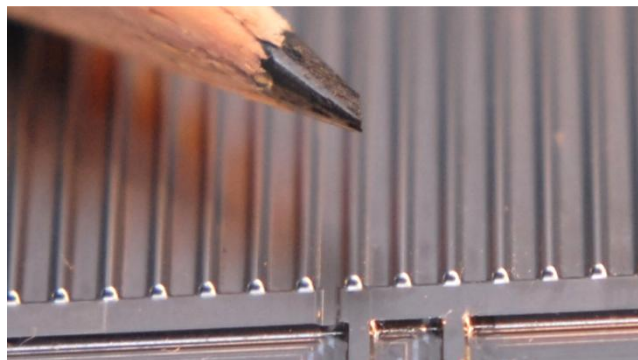


# High-Tech Contract Manufacturing

## Mold and Die



- No need for manual finishing due to milling with best surface quality
- Extremely even surface structure
- Highest contour accuracy
- Hard milling of mold inserts up to 62 HRC
- Direct milling of micro molds
- Milling of finest structures



# High-Tech Contract Manufacturing

## Jig Grinding with the Milling Machine

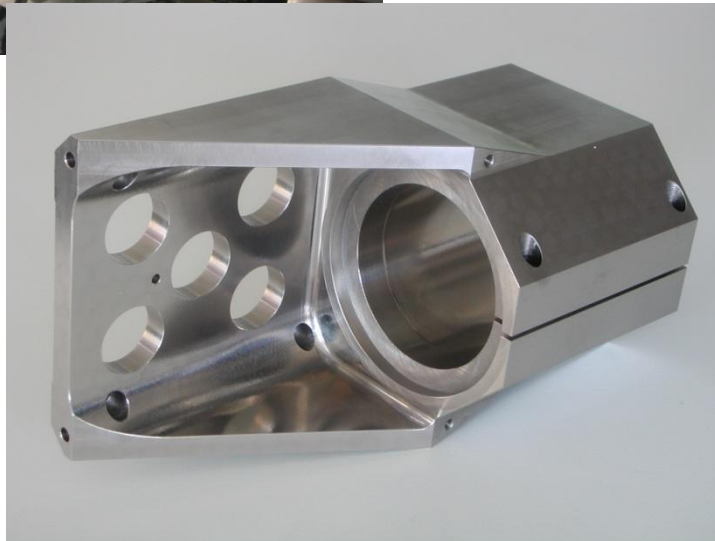
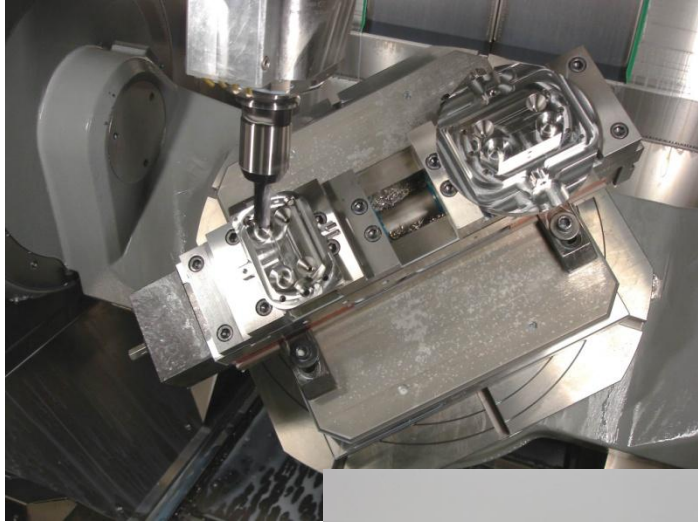


- Grinding and milling in **ONE** clamping/set up
- Cycle with hydrostatic axis
- No inaccuracy due to repeated clamping
- Advantages of grinding and milling are combined



# High-Tech Contract Manufacturing

## CNC Milling



- 5-axes simultaneous machining
- Processing of hard exotic materials such as Titanium, Invar, Kovar, and Inconel
- Length of parts up to 3m
- Deep hole drilling with internal tool cooling
- Integrated pallet changer for the parts

# High-Tech Contract Manufacturing

## EDM and Grinding

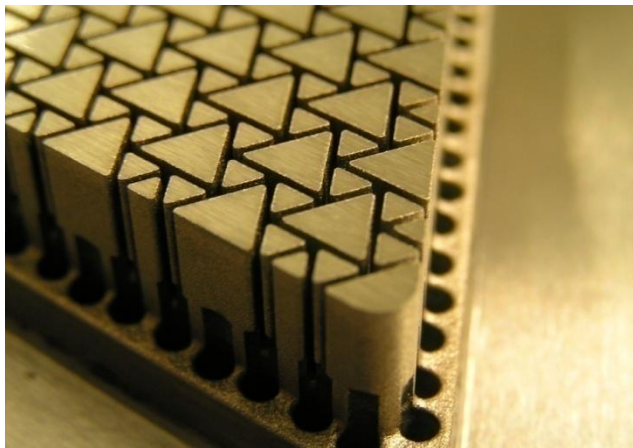


- Wire cutting with highest precision: surfaces with up to  $Ra\ 0,05\mu\text{m}$ , smallest wire  $30\mu\text{m}$ , contouring accuracy  $\pm 1,5\mu\text{m}$

- Die and micro sinking

- Surface grinding with best surface quality

flatness of  $2\mu\text{m}$  on a surface of  $500\text{mm} \times 200\text{mm}$



# High-Tech Contract Manufacturing

## Combination of different machining processes

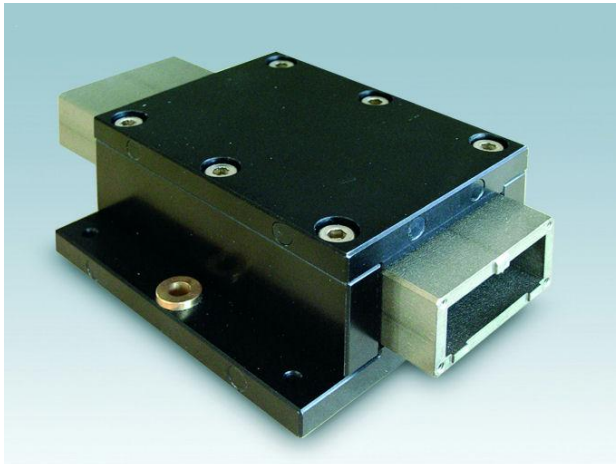
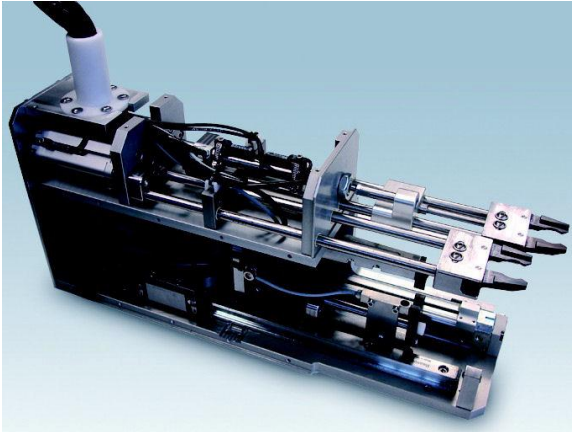


- Short lead time and consistent quality due to a broad in-house production depth
- Diverse technologies in-house
- Combination of CNC-milling, grinding, die sinking, wire cutting, and micro milling

Combination of milling and die-sinking  
5-Axis hard milling,  
Contouring accuracy < 5 $\mu$ m  
Excellent transitions in the radii

# High-Tech Contract Manufacturing

## Development, Construction, Manufacturing and Assembly



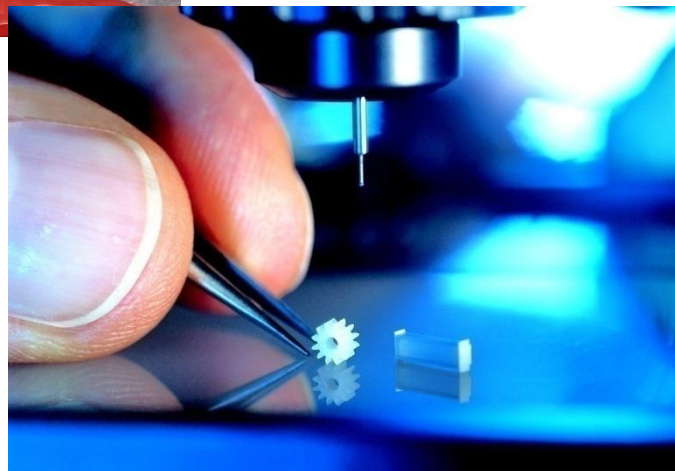
- Construction and development according to required specification
- Complete compilation of drawings and BOM's
- Mechanical assemblies with electrical and pneumatical control
- subassembly or assembly of the final product
- Certified final acceptance and inspection according to specification of the customer

# High-Tech Contract Manufacturing

## Metrology, Inspection and Documentation



- Optical and tactile measuring methods
- Measuring precision up to  $0,25\mu\text{m}$
- Probe diameter of  $0,12\text{mm}$  –  $5\text{mm}$
- Statistical interpretation of the measuring results
- Automatic archiving of the metrology reports





# High-Tech Contract Manufacturing Certifications



- DIN EN ISO 9001:2008
- DIN EN ISO 14001:2009

## Authorization for Aviation and Aerospace

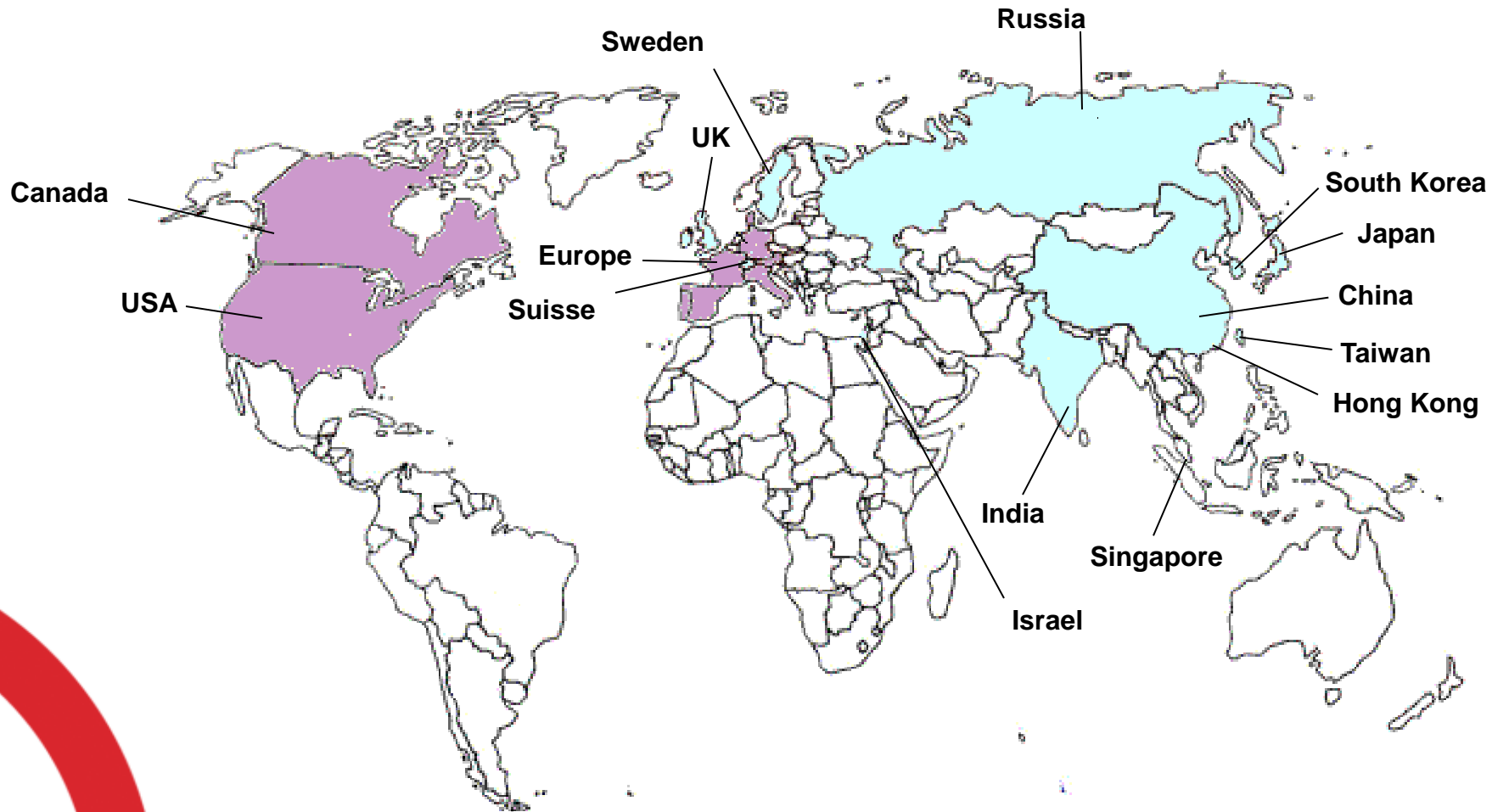
- QSF-A
- QSF-B



Service



# Service Worldwide Support












7 service engineers at **KERN** for worldwide support



# Service

## Representations with their own Service Departments



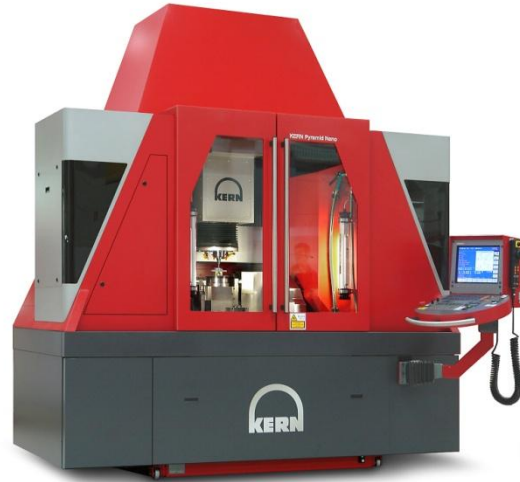
- USA  KERN-subsidiary
- Switzerland  3 engineers for service
- Sweden  2 engineers for service
- Great Britain  2 engineers for service
- Singapore  2 engineers for service
- Taiwan  2 engineers for service
- Israel  1 engineer for service
- China / HK  2 engineers for service
- India  1 engineer for service

# Service

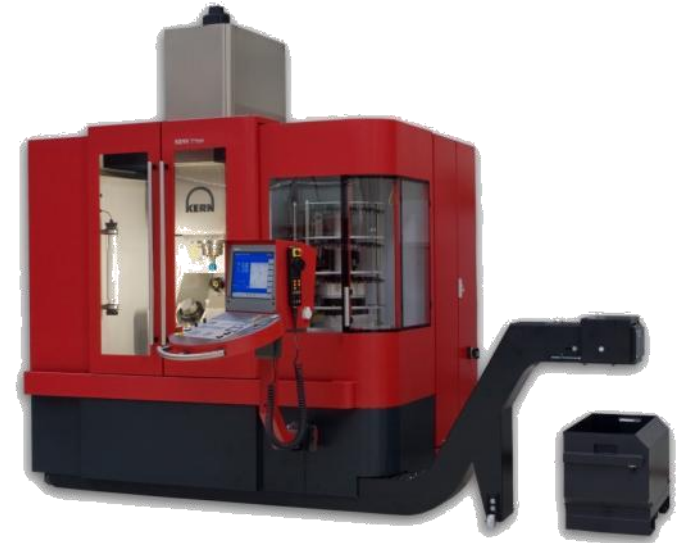
## KERN Service Range



**KERN** Evo



+ **KERN** Pyramid Nano



+ **KERN** Triton

**KERN** MMT year of manufacture 1984 until **KERN** Triton year of manufacture 2011

98% of the machines are still in operation

- Spare parts
- Maintenance repairs
- Still existing know-how

# Service

## Complaints solution



- Weekly quality control meeting at **KERN**
- Participants are the managers of the individual departments: General Manager, R&D, purchasing, production und service



Comprehensive consideration of the customer complaint



Discussion inside the quality meeting with the manager of the departments



Fast help for the customer based on management by objectives and weekly control of the activities



Conclusion only after complete solution

# Service

## Permanent quality control / accuracy of all critical components



### Prüfbericht / Final Inspection Report SD4084-S0002

<input checked="" type="checkbox"/> Neumontage / New Spindle	<input type="checkbox"/> Reparatur / Spindle renewal	Datum / Date	29.05.2007
Kunde / Customer	KERN	Serial-No:	0777
Max. Drehzahl / Max. Speed	50000 [1/min]	Kabellänge / Cable length	100 [cm]
Auslaufzeit / Running down time (Max --> 0)	[sec]	Kabel / Cable	[cm]
Elektrische Sicherheitsprüfung / Electrical security check	<input checked="" type="checkbox"/> OK	Stecker / Plug	Harting EMV 5 + 20
Leerlaufstrom / No load current	1,90 [A]	Stecker / Plug	Signalstecker 12-pol.
Sensor Test (1-2-3-4)	<input checked="" type="checkbox"/> OK	Distanz Spindelscheibe / Distance spindle disc	0,19 [mm]
Werkzeugwechsel / Tool change	<input checked="" type="checkbox"/> OK	Spannkraft / Clamping force	4000 [N]
Kühlmitteldurchfluss / Coolant flow	5,58 [L/min]	bei / at	0,51 [MPa]
max. Temperatur Gehäuse / max. Temperature housing bei / at 40.000 1/min	T1 25 [°C] T2 25 [°C]	Position der Temperatursensoren siehe Grafik rechts / Position of temperature sensors see drawing on the right	
Temperatur / Temperature PT100	Lager vorn / Bearing front 30,09 [°C] Stator 51,44 [°C]	Position der Schwingungssensoren siehe Grafik rechts / Position of vibration sensors see drawing on the right	
Schwinggeschwindigkeit / Vibration velocity bei / at 40.000 1/min	V1 0,8 [mm/s] V2 0,5 [mm/s]		
Planfläche Spindelwelle / Quill shaft face end A1 (<=1µm)	1 [µm]		
Konus / Taper R1	1 [µm]		
Am Messdorn 100 mm / Top of test arbor 100 mm R2 (<=4µm)	2 [µm]		
Bemerkungen / Remark	Produktions-Auftrag / Production-N 05714		
Montiert von / Assembled by	Deutscher, Uwe	Geprüft von / Checked by	Deutscher, Uwe

erstellt / issued 20.01.2004 R. Schmidt / Revision / Datum / Date Name Änderung / Change

- Test certificates for:
  - Axis / table systems
  - Spindles
  - Motors
- The spindle is manufactured according to special **KERN** specification

Planfläche Spindelwelle / Quill shaft face end A1 (<=1µm)	1 [µm]
Konus / Taper R1	1 [µm]
Am Messdorn 100 mm / Top of test arbor 100 mm R2 (<=4µm)	2 [µm]

# Service

## Fast and professional help

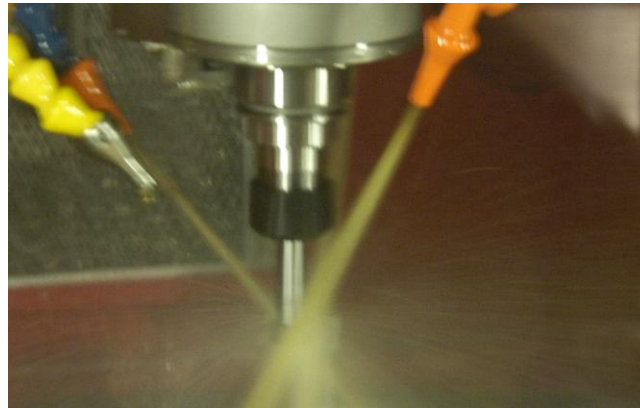


- At **KERN** the customer always has the “right of way”
- Service satellite stations located in-house and abroad
- Direct contact -> no hotline
- Short ways from service -> to the application engineers
- On request **KERN** can be at the customer site within 24-hours
- The service engineers are trained in machine building, pneumatic systems, hydraulic systems, electronics and software
- Remote diagnosis possible via analyses of customers machine

Machines



# Our Machine Models



# Microparts Machining



**KERN Micro**

- Intelligent temperature management
- Very compact in relation to the workpiece size
- Perfect ergonomics and automation options
- Plug & Play
- KERN Precision
- Tool cabinet with quick change pallets



**KERN Evo**

- Full automation possible
- High productivity
- Machining from graphite to hardened steel
- Spindles up to 160.000 rpm



# Hydrostatic Machining



- Hydrostatic guide ways in X, Y, Z
- Hydrostatic drives in X, Y, Z
- Milling and jig grinding in one setup
- Extreme precision and surface quality



**KERN Pyramid Nano**

- Hydrostatic guide ways in X and Y
- rapid changeover from 5-axis to 3-axis
- Symmetrical portal design
- Maximum flexibility



**KERN Triton**

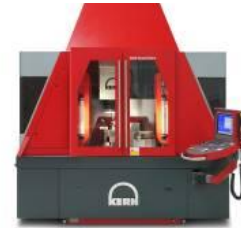
# Basic Data



**Micro**



**Evo**



**Pyramid Nano**



**Triton**

X	350	300	500	500
Y	220	280	500	500
Z	250	250	400	400
Clamping area	3ax 5ax $\Phi$ 350 x 200	350x230x300 $\Phi$ 72x170	600x600x400 $\Phi$ 150 x 120	600x600x560 $\Phi$ 220x220
max. kg 3ax		30	250	250
max. kg 5ax	50	2,5	15	60
PS	$\pm$ 0,5 $\mu$ m	$\pm$ 0,5 $\mu$ m	$\pm$ 0,3 $\mu$ m	$\pm$ 0,5 $\mu$ m
Ra	$\leq$ 0,2 $\mu$ m	$\leq$ 0,1 $\mu$ m	$\leq$ 0,05 $\mu$ m	$\leq$ 0,15 $\mu$ m

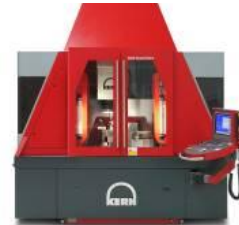
# Guide ways



**Micro**



**Evo**



**Pyramid Nano**



**Triton**

X	Roller bearing, Prism guided, KERN Design	Hydrostatic	Hydrostatic
Y			
Z			Roller bearing, Prism guided, KERN Design
B	Rollers		
C			

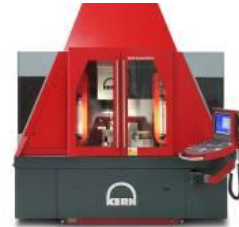
# Drives



**Micro**



**Evo**



**Pyramid Nano**



**Triton**

X	Ballscrew	Ballscrew	Hydrostatic	Ballscrew
Y	Ballscrew	Ballscrew	Hydrostatic	Ballscrew
Z	Ballscrew	Ballscrew	Hydrostatic	Ballscrew
B	Torque, cooled	Servo + gearbox	Torque, cooled	Torque, cooled
C	Torque, cooled	Servo + gearbox	Torque, cooled	Torque, cooled

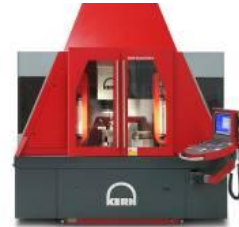
# Spindels



**Micro**



**Evo**



**Pyramid Nano**



**Triton**

rpm 500 – 36.000  
(HSK 25)

500 – 50.000  
(HSK 25)

500 - 50.000  
(HSK 25)

500 – 38.000  
(HSK 40)  
optional thru spindle coolant

rpm 500 – 50.000  
(HSK 25)

20.000 – 80.000  
(no HSK)

300 – 36.000  
(HSK 40)  
optional thru spindle coolant

rpm 500 – 42.000  
(HSK 40)

60.000 – 160.000  
(no HSK)



= vector controlled

no HSK = no tool changer



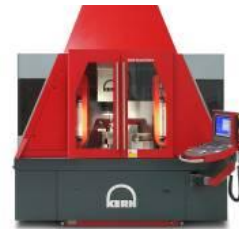
# Tool Changer



**Micro**



**Evo**



**Pyramid Nano**



**Triton**

HSK 25      20, 101, 209

32, 63, 95

32, 64, 96

HSK 40      18, 90, 186

25, 50, 75

25, 50, 75

# Additional Equipment



**Micro**

Touch Probe

Blum- Laser

Flood Coolant

MQL

Graphite



**Evo**

Touch Probe

Blum- Laser

Flood Coolant

MQL

Graphite



**Pyramid Nano**

Touch Probe

Blum- Laser

Flood Coolant

MQL

Graphite

Jig-Grinding



**Triton**

Touch Probe

Blum- Laser

Flood Coolant

MQL

Graphite

## Machine Details







Precision according to VDI/DGQ 3441:

**Positioning  $P_s \pm 0,5 \mu\text{m}$**

**Accuracy on the workpiece  $\pm 2,0 \mu\text{m}$  (3-axis)**

- X, Y, Z 350, 220, 250 mm
- B -110° to +110°  
optional -170° to +110°
- C 360° endless
- Clamping area 5 ax  $\Phi 350 \times 200\text{mm}$
- Acceleration 10 m/s<sup>2</sup>
- Feed rate 30 m/min
- Spindle (HSK25) 500 – 35.000 rpm (S1) 6kW
- Spindle (HSK25) 500 – 50.000 rpm (S1) 6kW
- Spindle (HSK40) 500 – 42,000 rpm (S1) 15kW
- max. work piece weight 50 Kg
- 5-axis simultaneous operation
- Central cooling management with 0,2K accuracy
- Polymer concrete machine frame
- ATC with up to 209 positions
- Optional integrated automatic work piece changer with 24 / 36 positions
- Plug & Play; one-box design



Precision according to VDI/DGQ 3441:

**Positioning  $P_s \pm 0,5 \mu\text{m}$**

**Accuracy on the workpiece  $\pm 2,0 \mu\text{m}$  (3-axis)**

- X, Y, Z 300, 280, 250 mm
- Clamping area 3 ax 350 x 230 x 300mm
- 5 ax  $\Phi 72 \times 170\text{mm}$
- Acceleration 8 m/s<sup>2</sup>
- Feed rate 16 m/min

### HSK25

- Spindle 500 – 50.000 rpm (S1) 3.4 kW
- Spindle 500 – 50.000 rpm (S1) 6,4 kW

### No HSK

- Spindle 20.000 – 80.000 rpm (S1) 1,0 kW
- Spindle 30.000 – 90.000 rpm (S1) 0,17 kW
- Spindle 60.000 - 160.000 rpm (S1) 0,5 kW

- max. work piece weight 3 Axis 30 Kg
- max. work piece weight 5 Axis 2,5 Kg

- 5-axes simultaneous operation
- Polymer concrete mono bloc machine frame
- ATC with up to 95 positions

# KERN Pyramid Nano – Hydrostatic Milling



Precision according to VDI/DGQ 3441:

**Positioning  $P_s \pm 0,3 \mu\text{m}$**

**Accuracy on the workpiece  $\pm 1,0 \mu\text{m}$  (3-axis)**

- X, Y, Z 500, 500, 400mm
- Clamping area 3 ax 600 x 600 x 400mm  
5 ax  $\Phi 150 \times 120\text{mm}$
- Acceleration 10 m/s<sup>2</sup>
- Feed rate 30 m/min
- Hydrostatic drives for X/Y/Z
- Hydrostatic guide ways for X/Y/Z
- HSK 25 Spindle 500 – 50.000 rpm (S1) 6,4 kW
- HSK 40 Spindle 200 – 36.000 rpm (S1) 11 kW
- HSK 40 Spindle 500 – 42.000 rpm (S1) 15 kW  
optional thru spindle coolant with HSK 40
- Max. work piece weight 3 Axis 250 kg
- Max. work piece weight 5 Axis 15 kg
- ATC with up to 96 positions
- Machine frame made of KERN ARMORITH®
- Integrated central temperature management in five separate cooling circuits for spindle, drives, axes, coolant, control cabinet
- Optional integrated automatic work piece changer
- Optional JIG Grinding

# KERN Triton – Hydrostatic Milling



Precision according to VDI/DGQ 3441:

**Positioning  $P_s \pm 0,5 \mu\text{m}$**

**Accuracy on the workpiece  $\pm 2,0 \mu\text{m}$  (3-axis)**

- X, Y, Z 500, 500, 400 mm
- Clamping area 3ax 600 x 600 x 560mm
- 5ax  $\Phi 220 \times 220 \text{ mm}$
- Acceleration 10 m/s<sup>2</sup>
- Feed rate 30 m/min
- Hydrostatic guide ways X/Y
- HSK 40 Spindle 500 – 38.000 rpm (S1) 37 kW  
optional thru spindle coolant
- Max. work piece weight 3 Axis 250kg
- Max. work piece weight 5 Axis 60 kg
- ATC with up to 75 positions
- Machine frame made of KERN ARMORITH®
- Integrated central temperature management in five separate cooling circuits for spindle, drives, axes, coolant, control cabinet
- 5-axis simultaneous operation while keeping the 3-Axis machining area

## Automation Examples

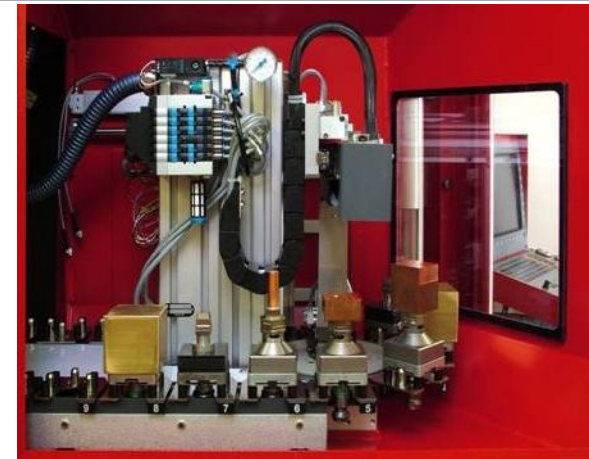
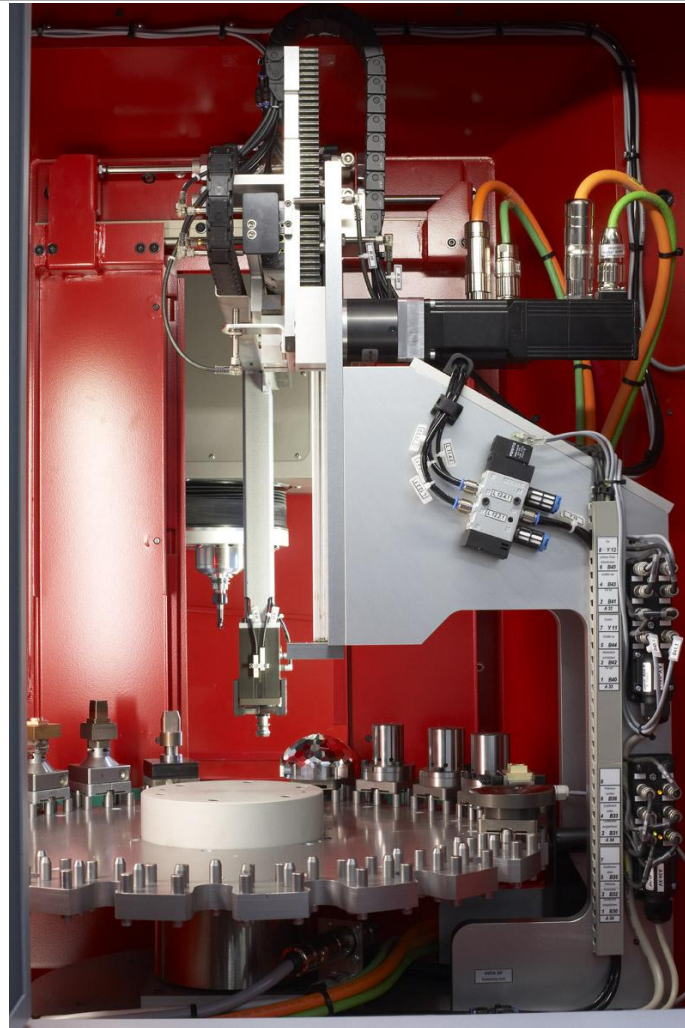




# Automation



# Automation



Know your tools





# KERN $\mu$ -view



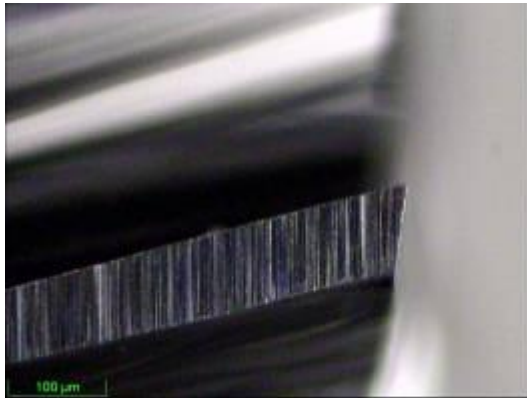
Visual check of tool wear

Visual check of new tools

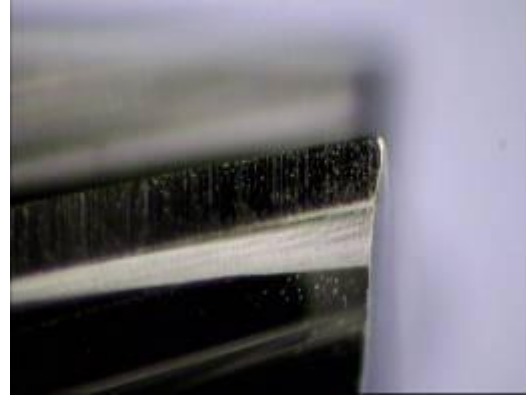
For Tools < 5mm



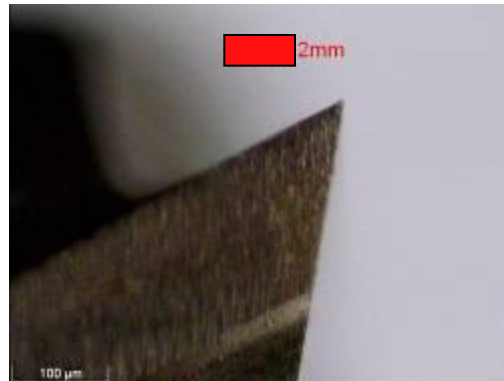
# KERN $\mu$ -view



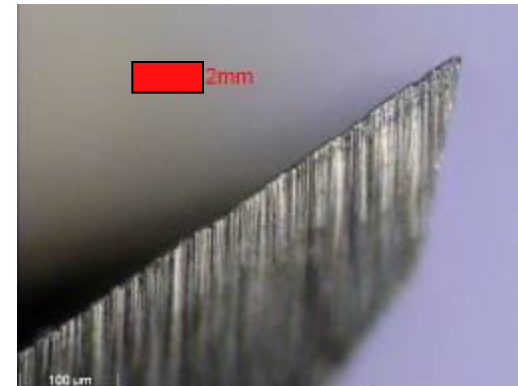
New



Worn



New



New



KERN Competence



## Application Examples



## The 4 $\mu$



# $\mu$ - drill

... are applications where  $\mu$ -precise holes are being drilled. The positioning and the diameter tolerances are within a few  $\mu\text{m}$ .

Important here are diameter, position (entry / exit), angle, surface quality.

A horizontal yellow bar containing the text " $\mu$  - drill".

$\mu$  - drill

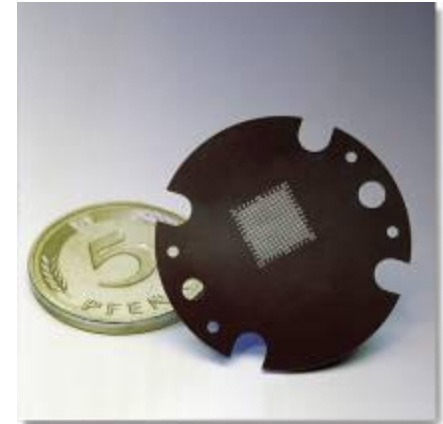
## >> 1982: entering a new dimension



**First CNC Micro-  
Milling and Drilling  
Machine KERN 1016**

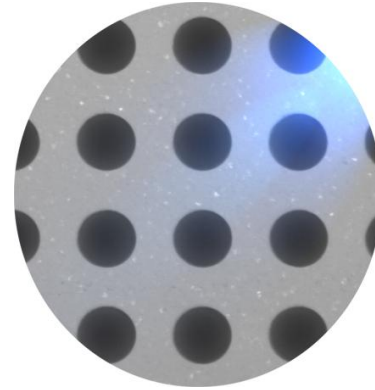
**approx. 300  
machines sold**

- Test membrane for electronic chips manufacture
- Material: Vespel
- 648 holes, smallest  $\varnothing$  0.06mm
- Thickness 0.5 mm
- Drilling from both sides to avoid burrs and to obtain accurate entrance and exit ports
- Web thickness 0.04 mm
- Drilling positioning tolerance  $\pm 2 \mu\text{m}$
- Machining time < 20 min
- Optical control with magnification 500-times



**$\mu$  - drill**

# 5 156 holes in Macor with a single tool



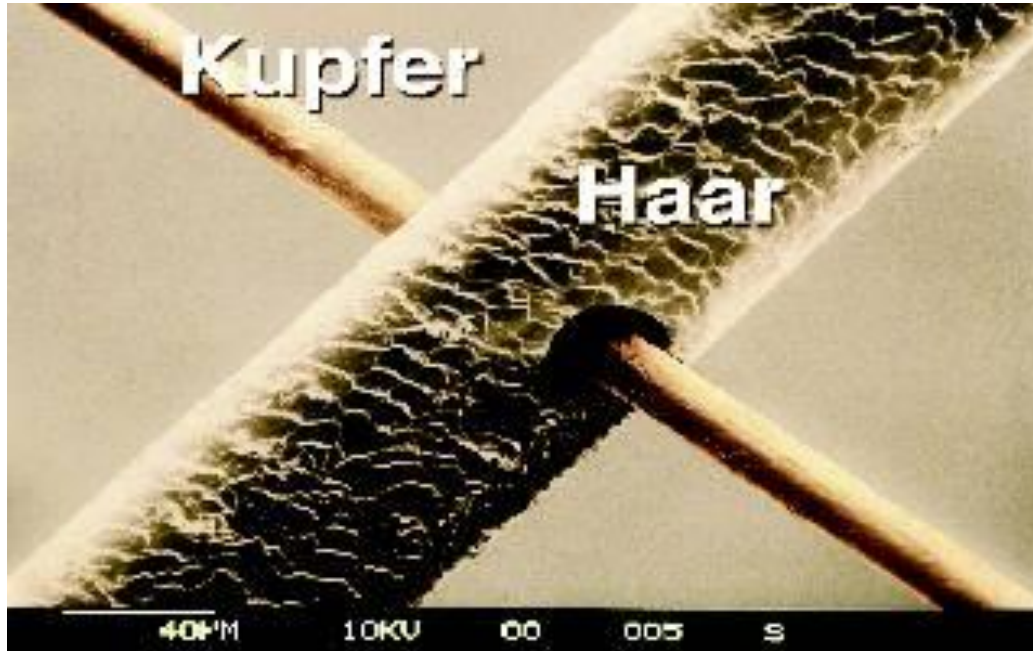
60 times magnification

**μ - drill**

- o Test membrane for computer chip manufacturing (probecard)
- o 5 156 holes with a diameter of 0,13 mm without tool change
- o Material: Macor
- o Drilling depth: 0.0315" (0,8 mm)
- o Positional tolerance  $\pm 2 \mu\text{m}$
- o Machining time for each hole: 7,8 sec



# Who needs to drill a hole in a hair ?



- o Hair diameter:  $\varnothing$  60  $\mu$ m
- o Drill diameter:  $\varnothing$  30  $\mu$ m
- o 5 holes set consecutively
- o Controlled by **KERN** Macro Video Monitoring system equipped with a 14" display screen

... are applications where  $\mu$ -precise electrodes in copper or graphite are made for EDM processing. More and more moulds are milled directly into hard steel.

Important here are tolerances of minimal  $\mu\text{m}$  and surface quality up to  $Ra < 0,1\mu\text{m}$ ; even in hard steel up to 60 HRC or more.

A thick red curved bar on the left side of the slide.A horizontal purple bar spanning most of the width of the slide.

$\mu$  - tool

## >> Electrodes for press tools



>> **Task:** 5-axes machining (4-axes simultaneously) of 5 identical consecutive electrodes

>> **Target:** surface better than  $Ra=0.12 \mu\text{m}$ , all 5 electrodes within  $\pm 2 \mu\text{m}$  contouring acc. measuring without any filters

>> **Machining:** < 110 min. per electrode

>> **Maschine:** **KERN** Evo with 4th and 5th axes



$\mu$  - tool

## >> Result of spindle optimization



- extreme running smoothness enables machining of a graphite electrode with fins (multi disc) of 0.004 inch thickness (0.1mm)
- distance 0.0079 inch (0.2mm)
- milled with a special saw-blade
- Processing time approx. 5 min
- The smallest vibration would destroy this piece

**μ - tool**

## >> Mould milling 5-axes



- >> **Material:** 416 stainless steel (14%Cr)
  - >> **Target:** best surface, very homogeneous look  
countouring accuracy better 5  $\mu\text{m}$
  - >> **Size:**  $\varnothing$  43 mm
  - >> **Smallest tool:**  $\varnothing$  0.5 mm  
34.000 rpm
  - >> **Machining:** 5h 50min
- >> **Maschine:** **KERN** Pyramid Nano  
4th and 5th axes with torque drives

$\mu$  - tool



## >> Challenge in mould and die making

- >> Work piece: Perlator
- >> Material: 1.2379
- >> Hardness: 56 HRC
- >> Groove width: 0,2 mm
- >> Groove depth: 0,5 mm
- >> Running time: 11h 30min
- >> Dimension: R=16,5 mm
- >> Tool: CBN-ball mill  
0,2 x 0,6 (DxL)
- >> Lubrication: oil mist

## >> Hard milling of a free form



>> **Target:** best surface quality with hydrostatic milling to minimize manual polishing

>> **Material:** Stavax HRC 54

>>**Result:**

- **KERN** Pyramid Nano
- surface finish Ra 0,103  $\mu\text{m}$ ,
- accuracy on the part  $\pm 1 \mu\text{m}$
- polishing reduced from 60 min. to 10 min.
- accuracy deviation due to polishing  $< 1 \mu\text{m}$

**$\mu$  - tool**



## >> Hydrostatic milling of moulds



- >> **Task:** hard milling of a 12-fold mould, nozzle and ejector side
- >> **Target:** best surface with maximum contouring accuracy  $\pm 2 \mu\text{m}$
- >> **Material:** 1.2767 (HRC 54)
- >> **Results:** accuracy better  $\pm 2 \mu\text{m}$
- >> surface finish minimizes manual polishing
  - >> past: 3 h per cavity
  - >> today: 10 min per cavity
- for a 12-fold mould reduction of one week manual work
- sharp edges will be preserved

**$\mu$  - tool**

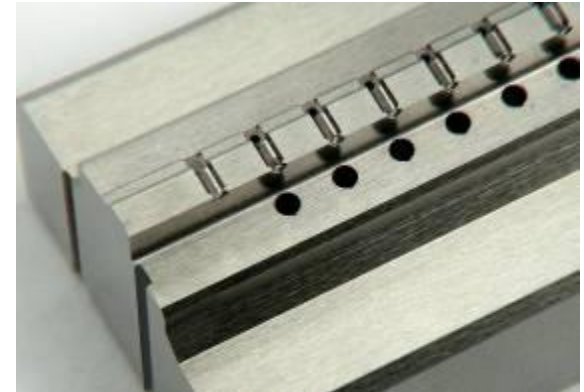


## >> Micro machining of electrodes

**Branch:** mould injection for automotive, micro technology and medical

**Challenge:**

- Contouring accuracy  $< 2 \mu\text{m}$
- machining of very small and accurate copper electrodes
  - inner radii  $< 0.1 \text{ mm}$ , surface better than Ra  $0.1 \mu\text{m}$



$\mu$  - tool

## >> Shining dentures



**$\mu$  - tool**

- Mould casting for plastic teeth
- Material: steel 56 HRC
- Highest surface quality:  $Ra < 0,2$
- 3 axes machining
- Spindle up to 35 000 rpm
- 5 tools
- Lubrication: special oil
- Machining time: 55 min

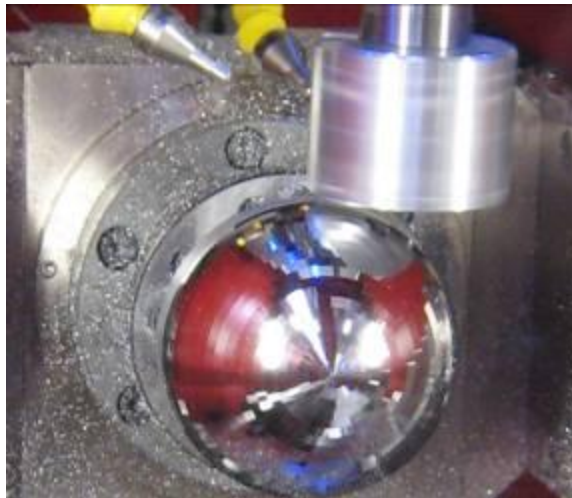
**... are applications where optical parts are machined in a big variety of materials.**

**Important here is the surface quality of the machined parts.**

A thick red curved bar on the left side of the slide.A thick blue horizontal bar spanning most of the width of the slide.

**μ - opt**

## >> Mirror surface



>> **Material:** Aluminium

>> **Machining time:** roughing 15, finishing 45 min.

>> **Spindle speed:** 9000 rpm

>> **Feed rate:** 7.9 inch/min

>> **Result:**

- mirror bright facettes
- surface finish Ra 0,0137  $\mu\text{m}$

**$\mu$  - opt**

# Mirror surface milling

Milling of mirror bright facettes in Aluminium

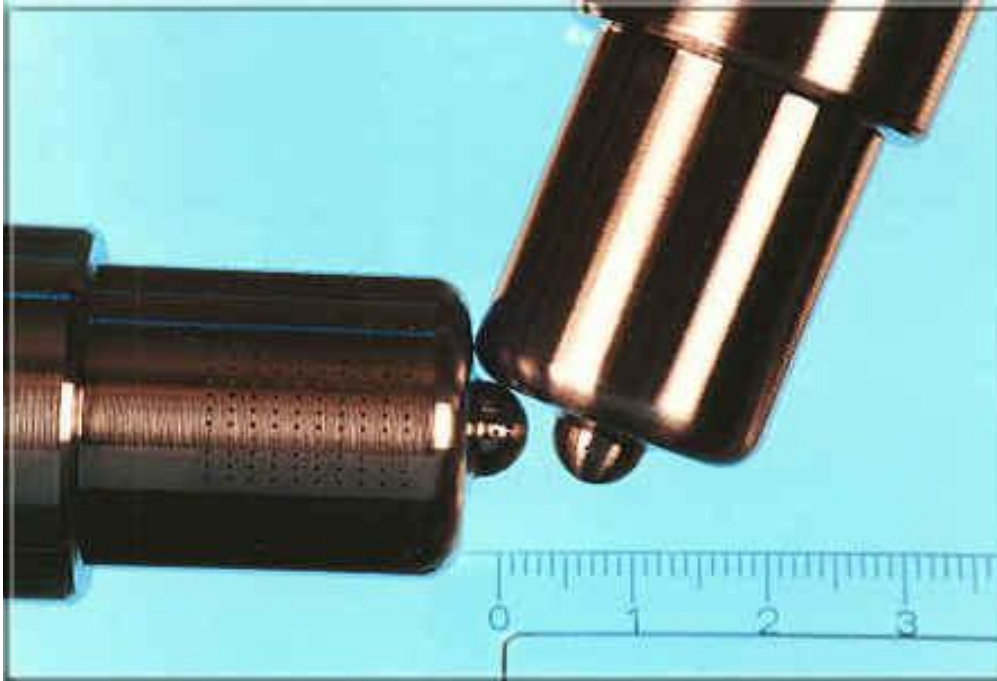


$\mu$  - opt

Circumference cutting of cataract lenses



# Atomisation at 2000 bar

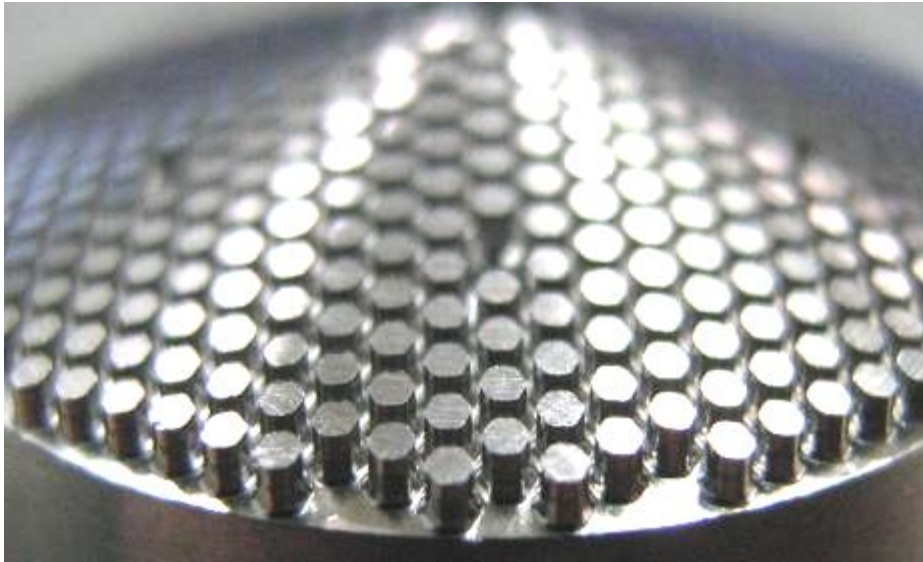


- Injection nozzles for diesel engines
- 5-axes machining
- Drilling holes  $\varnothing$  0,36 mm
- 3 tools for centering, pilot drilling and boring
- Additional de-burring from rear after pilot drill and boring
- Material: steel 53 HRC

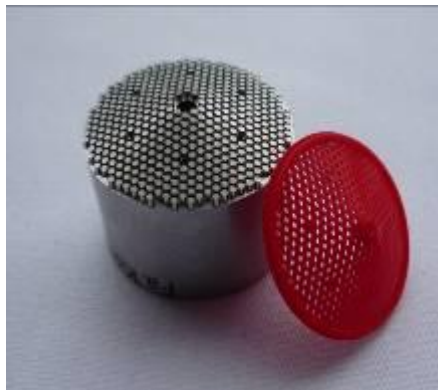
**$\mu$  - drill**



## >> Mould insert hard milled (stream shaper)



- >> **Material:** M340
- >> **Hardness:** 56 HRC
- >> **Groove width:** 0,2 mm  
Including draft angles of 0.5°
- >> **Groove depth:** 0,6 mm
- >> **Cycle time:** 30h
- >> **Smallest end mill:** Ball  $\varnothing$  0,2



**$\mu$  - tool**

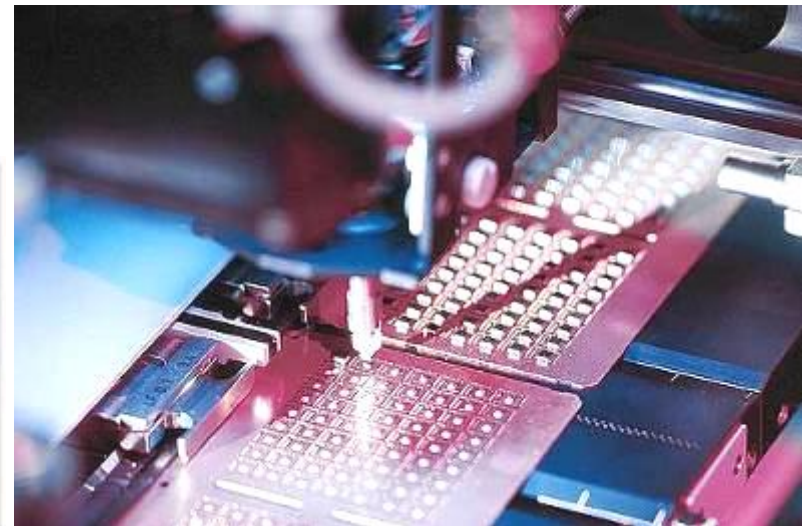
## >> Micro feed in parts production

**Application:** soldering tool for chip-assembly machines, soldering of chips into housing

**Machine:** **KERN** HSPC

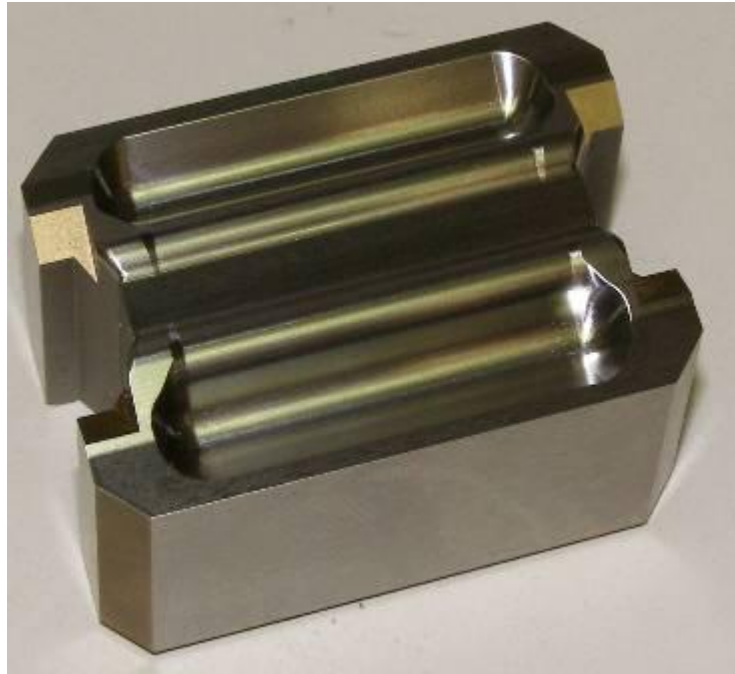
### **Task:**

- Machining of pockets on 3 different levels,
- difference of levels just 10  $\mu\text{m}$ , i.e. z-depth must be machined within  $\pm 1,5\mu\text{m}$
- hardened steel (56 HRC),
- smallest cutter  $\varnothing 0.3\text{mm}$





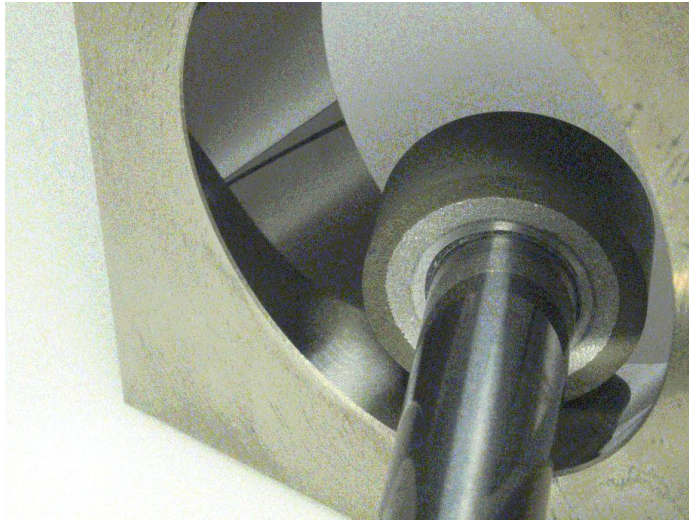
## >> Nano-Surface



- >> **Workpiece:** embossing tool
- >> **Material:** 1.2379 60+2 HRC
  - >> **smallest cutter:**  
ball nose 1,0 mm R 0,5 mm
- >> **machining time:** 90 Min.  
5-Axis machining
- >> **Accuracy:** 3  $\mu\text{m}$  at the bottom
  - >> **Surface:** Ra 0,2  $\mu\text{m}$

**$\mu$  - tool**

# >> Two in one – hard milling and grinding with hydrostatic accuracy



>> Nano precision in milling and grinding

>> no wear, no reversal backlash

>> dampening avoids any vibrations

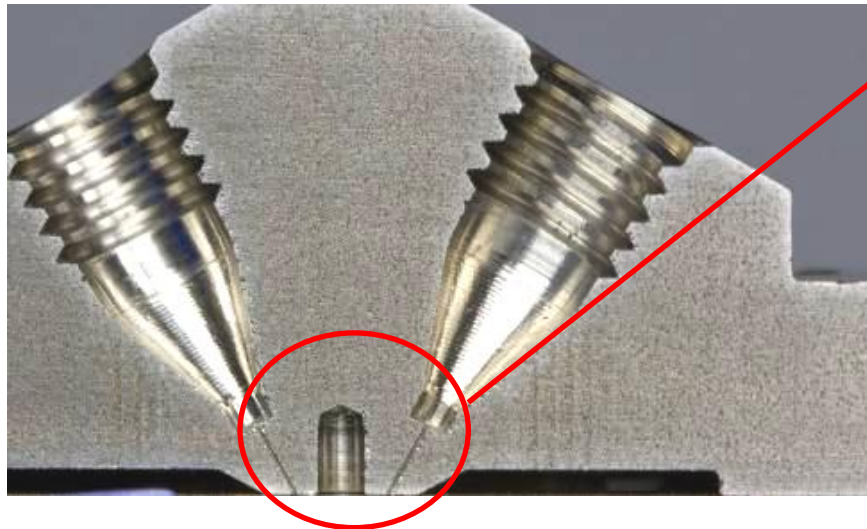
>> unrivaled surfaces

>> infeed of 0,1  $\mu\text{m}$  possible

## >> Micro drilling



- >> Material: Titanium grade 4
- >> Surface finish of cone Ra 0,2  $\mu\text{m}$  (RMS 8)
- >> 10 holes:
  - smallest diameter at outlet 0.1mm
  - depth 1.7 mm (17 x D)
  - angle at hole exit: 20° und 45°
  - all machining from top



**$\mu$  - drill**

# **μ - part**

**... are applications where μ-precise single and series parts up to 10.000 pieces per year have to be machined.**

**Important here are tolerances  $\pm 1 \mu\text{m}$  and surface qualities of  $Ra < 0,2\mu\text{m}$ . At the same time high productivity and automatic production is requested.**

A horizontal orange bar with the text "μ - part" in black.

**μ - part**

# Fast flying turbines (150.000 rpm)



- Turbine wheels for micro fluid pumps
- Material: vespel and ceramic
- Diameter: 0.276" (7 mm) / 0.157" (4 mm) / 0.0787" (2 mm) / 0.0276 (0,7 mm)
- Circumference tolerance 2  $\mu\text{m}$
- 5 axes machining

**$\mu$  - part**

# Titanium: 5 axes unmanned machining



- o Complete machining with one single clamping
- o Material: Titanium
- o 5 axes machining
- o Machining time: 25 min
- o Mass production with automatic palletizing unit in shift operation
- o Tolerances  $\pm 10 \mu\text{m}$  for mass production

**$\mu$  - part**

# Mechanical miracle



- Watch base plate produced fully automatically
- Material: brass
- Accuracy between holes, pockets and various heights:  $\pm 3 \mu\text{m}$
- Rigid tapping M 0,35 mm

**$\mu$  - part**



# Home sweet home right after operation



- Tissue removal tools for endoscopy
- 5 axes machining at 1 mm width
- Material: Cr Ni
- 12 tools required
- Machining time: 14 min
- Precise cutting required, best surface quality imperative

**μ - part**





Quality is never an accident,  
it represents the wise choice of many alternatives.

*Willi A. Foster*