GESELLSCHAFT FÜR DIAMANTPRODUKTE

Diamond Nanocoatings

Applications and success factors

P. Gluche

Outlook

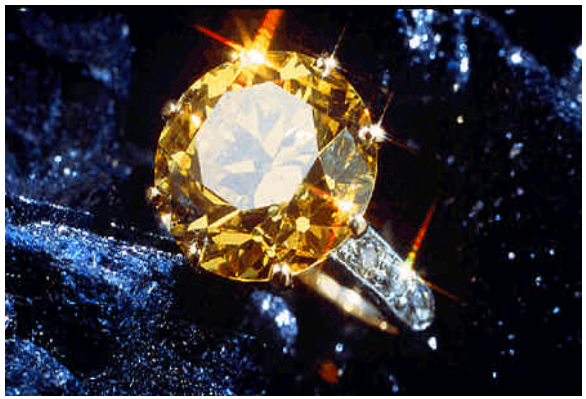
- Who is GFD?
- Why diamond?
- How to make diamond
- Business approach
- Products
- Success factors

Who is GFD?

- Founded by Dr. André Flöter and Dr. Peter Gluche in March 1999 in Ulm, as a Spin-off of the University of Ulm and DaimlerChrysler Research
- Headquarter and production facility at Science Park II, Ulm, Germany
- Profitable company since 2004
- 6 employees (January 2007)
- First introduction of Diamaze-scalpels in 2001
- First introduction of Diamaze PSD-Blades in 2003
- First introduction of Diamaze Microparts in 2004

GFD Headquarter Ulm, Germany

Why Diamond?



Diamond is extreme...

- Highest mechanical strength of all materials
- Chemically inert
- Bio compatible
- Low coefficient of friction
- Highest thermal conductivity of all materials
- Insulating, semiconducting and metal-like
- Optical transparent from infrared to deep ultra violett
- Valuable material for customers
- ...

Diamond is potentially suited for many applications

How to make diamond

Diamaze

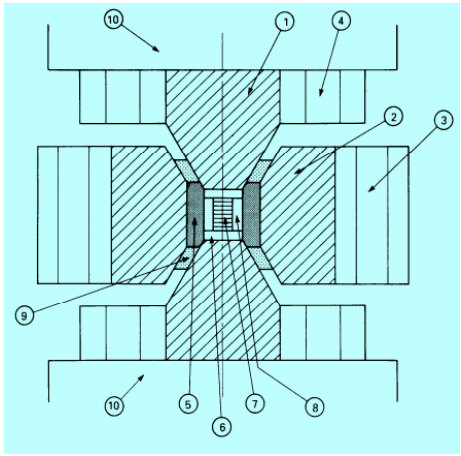
Diamond fabrication

Nature

Single crystals

HPHT

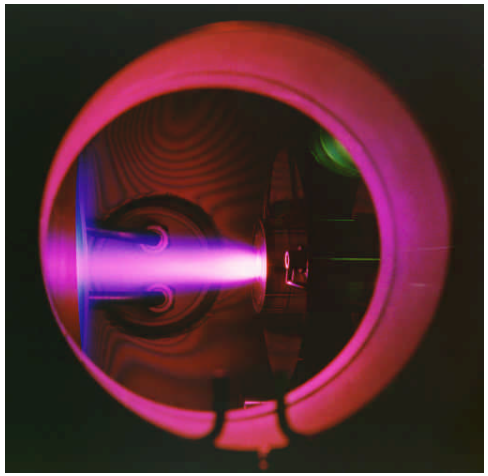
Belt Apparatus



Wedlake, In *The Properties of Diamond* (ed. J. Field) Academic Press, London, 1979

Single crystals
Diamond powder

CVD



Single crystals
Polycrystalline diamond films
Nanocrystalline diamond films

Technology

CVD Diamond roadmap

Improved mechanical properties

heteroepitaxy
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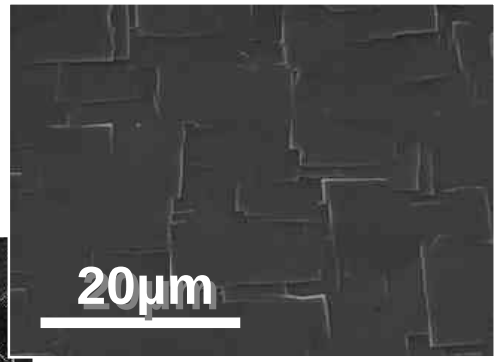

statistically orientiented
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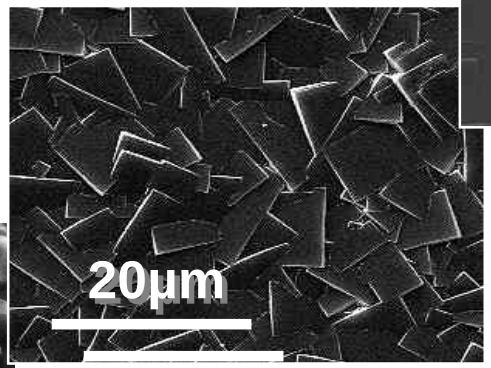

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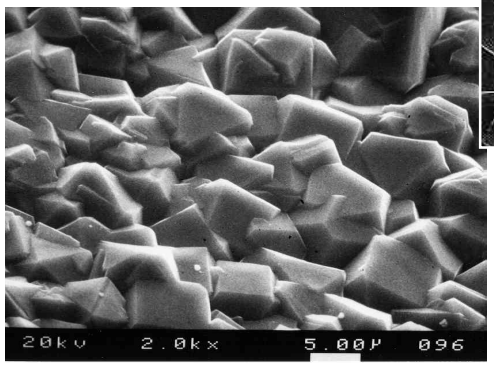

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- **good mechanical properties**
- **acceptable surface roughness**
- **small area deposition**
- **very expensive**

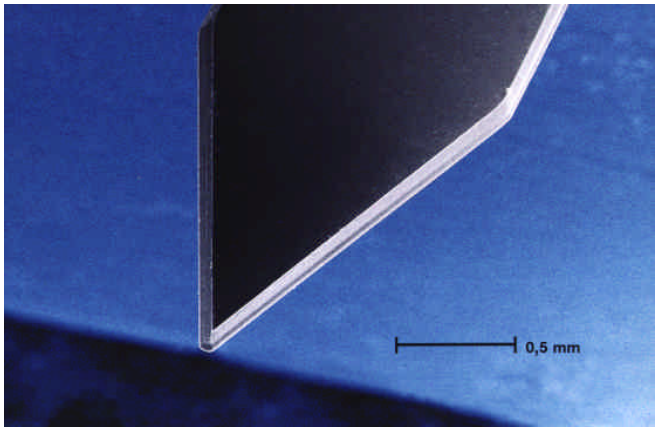
Business approach

Diamaze

- Niche markets, high value - low quanitity
- Products requiring a „low“ but reproducible technological base
- First product scalpel
- Early stage funding by university and venture capital investors
- High R&D expenses (product development/production processes)

Product stopped in 2003

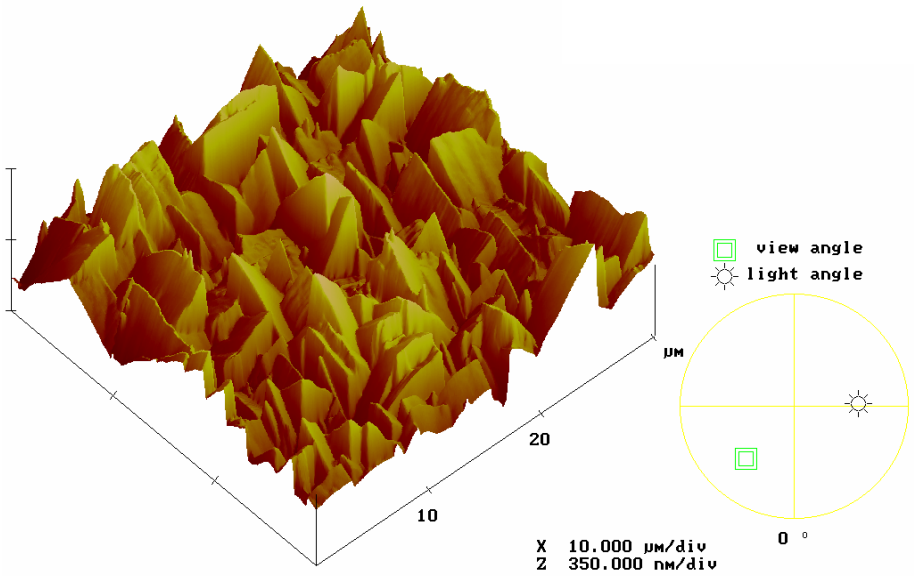
- Changed capital market situation
- High production costs
- Lack of distribution channels
- Progress in CVD diamond



Technology

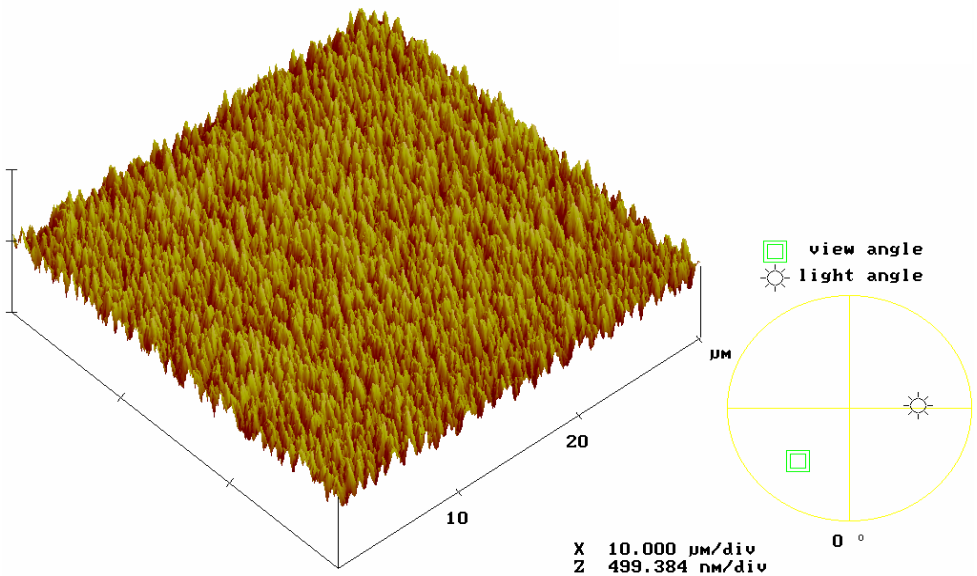
Surface topography (AFM)

Polycrystalline Diamond film



RMS: >> 100 nm

Nanocrystalline Diamond film



RMS: approx. 20 nm

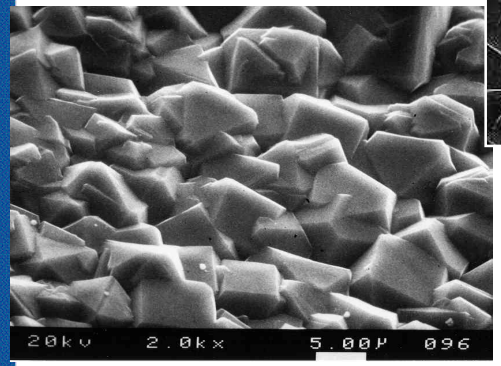
(film thickness: 12µm)

Technology

CVD Diamond roadmap

Improved mechanical properties

statistically orientiented



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statistically orientiented
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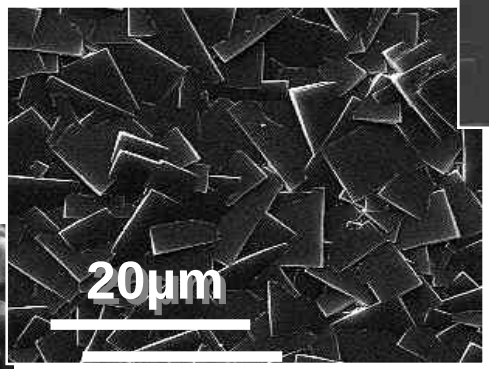

heteroepitaxy
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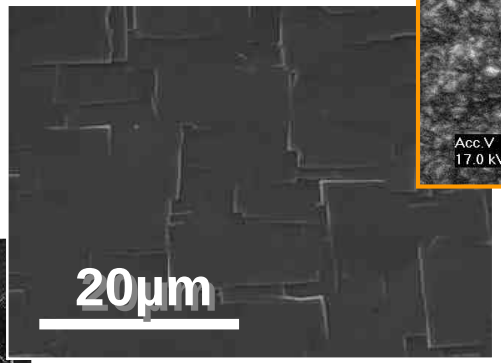
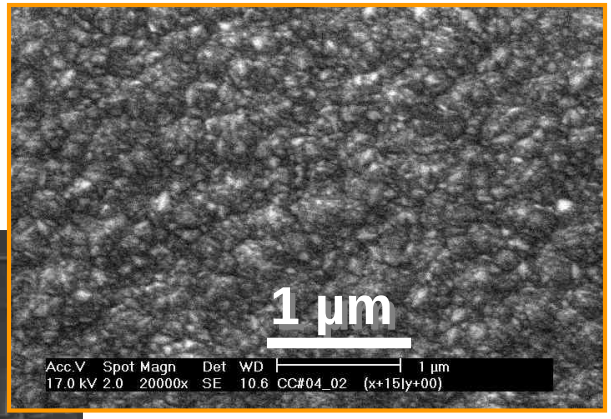


New: Nano-Diamond



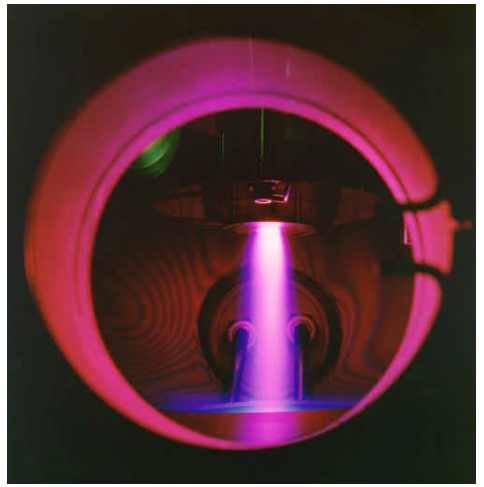
Excellent mechanical properties
Very low surface roughness
Large area deposition
Reduced production costs

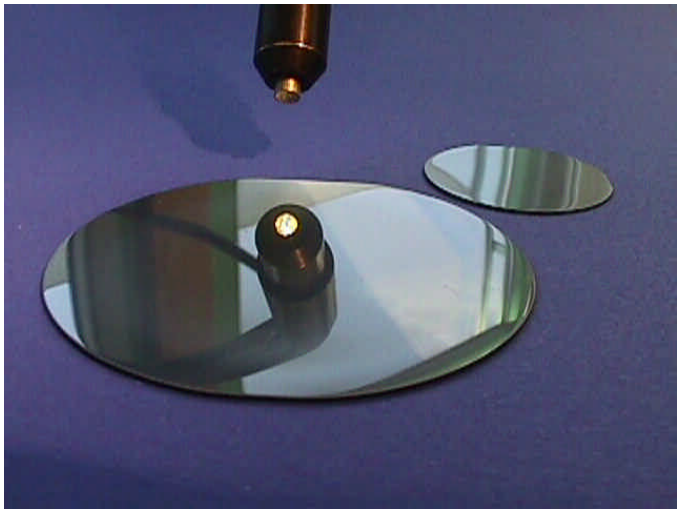
Enabling new products

Technology

Chemical vapor deposition (CVD) of nanocrystalline diamond on:

- Sillicon (up to 3” diameter) (✓ ✓ ✓)
- Tungsten carbides (✓ ✓ ✓)
- Silicon carbides (✓ ✓)
- Titanium (✓)





Diamaze

Diamaze

Micro-Parts

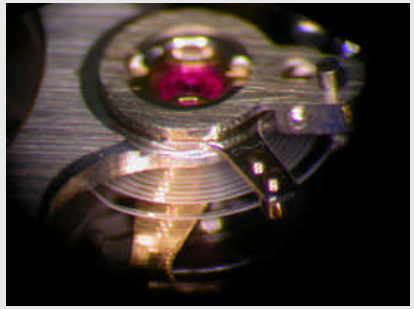
- Watch industry
- Medical industry
- Tool industry

PSD-Blades

- Plastic industry
- Pharmazeutical industry
- Automotive industry
- Glass industry
- Aircraft industry
- Food industry

R&D-Activities

- 3-D Tools
- Improved diamond films
- Elastic microparts



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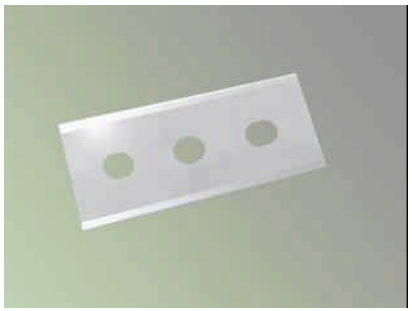

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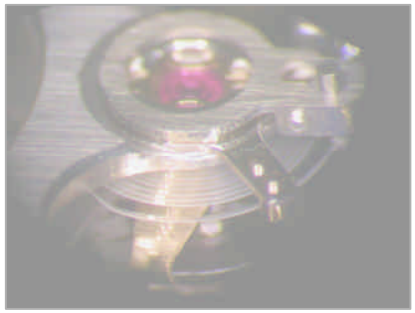
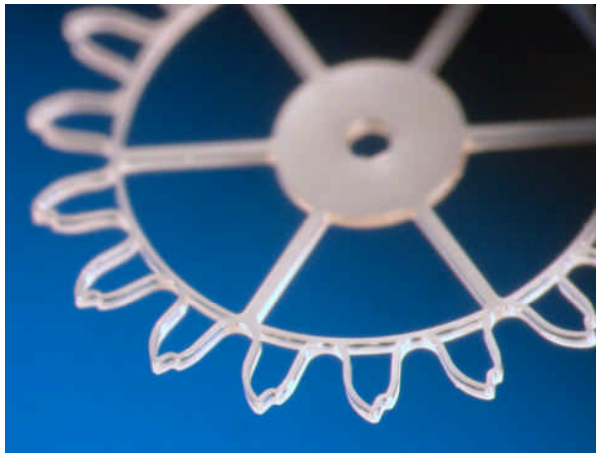


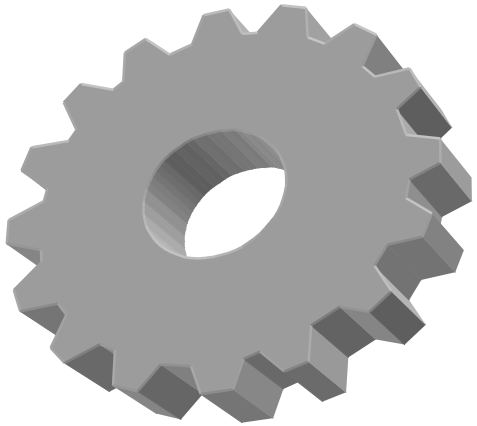
Technology

Structuring of diamond by anisotropic plasma treatments:

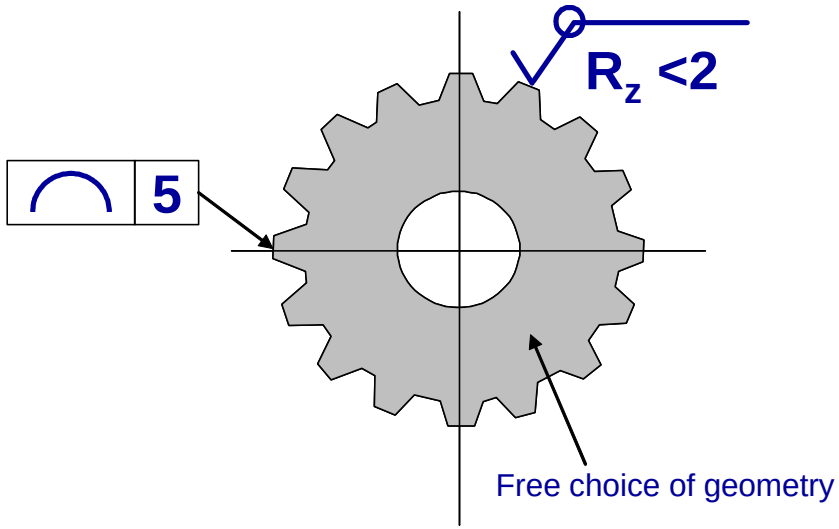
- Up to 150µm thickness
- Verticality better than 2°
- Side wall surface roughness <1µm
- General shape tolerance 5µm



3D-view

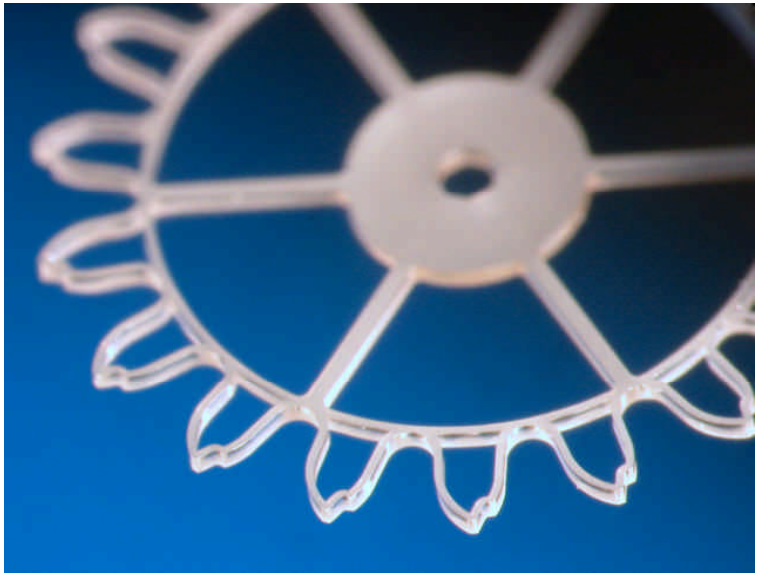


Top view



Products

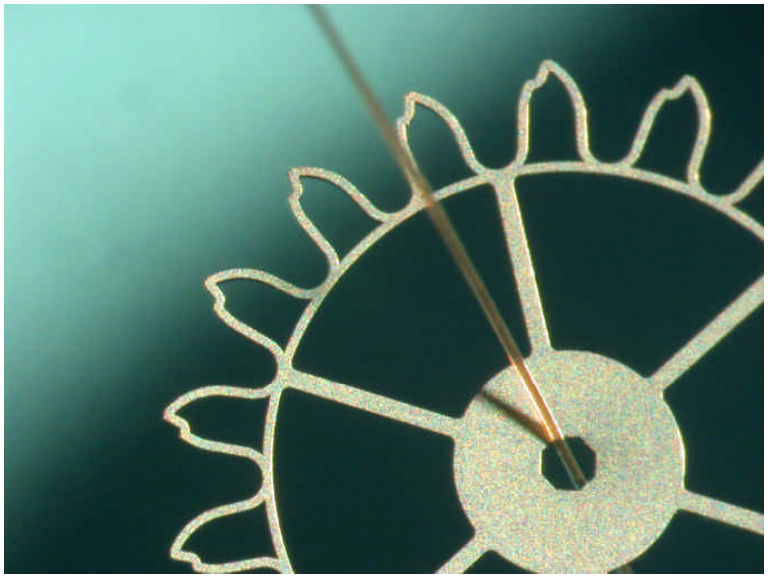
All diamond (AD)



Premium product:

- Limited editions
- Exclusive movements

Diamond coated silicon (DCS)



Economy product:

- Large scale production
- Potential mass product

Products

Diamaze

Wristwatch with diamond escapement

Freak 28‘800 V/h Diamond Heart

ULYSSE NARDIN
SINCE 1846 LE LOCLE - SUISSE

- **No lubrication**
- **Higher mainanance intervals**
- **Higher accuracy**
- **Higher power reserve**
- **Exclusive design**
- **Valuable product**

Diamaze

Diamaze

Micro-Parts

- Watch industry
- Medical industry
- Tool industry

PSD-Blades

- **Plastic industry**
- **Pharmazeutical industry**
- **Automotive industry**
- **Glass industry**
- **Aircraft industry**
- **Food industry**

R&D-Activities

- 3-D Tools
- Improved diamond films
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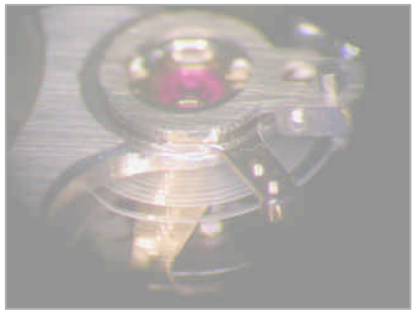
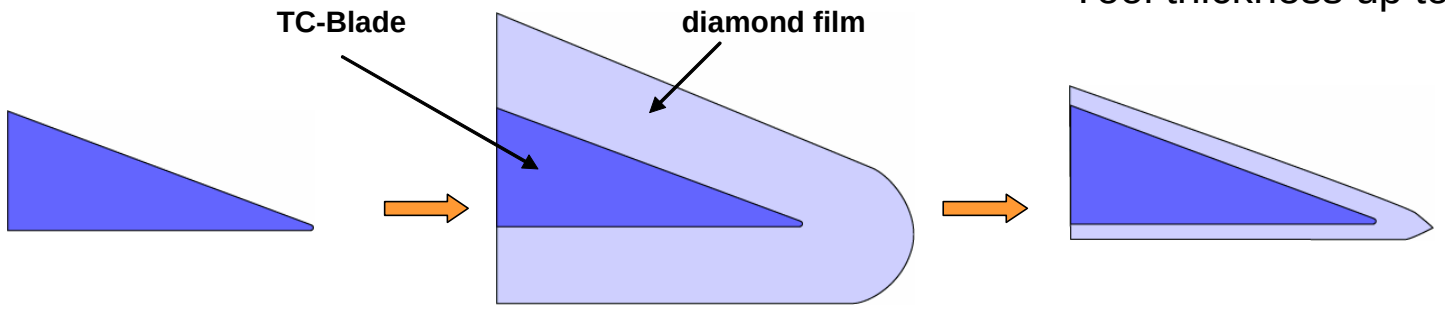


Products

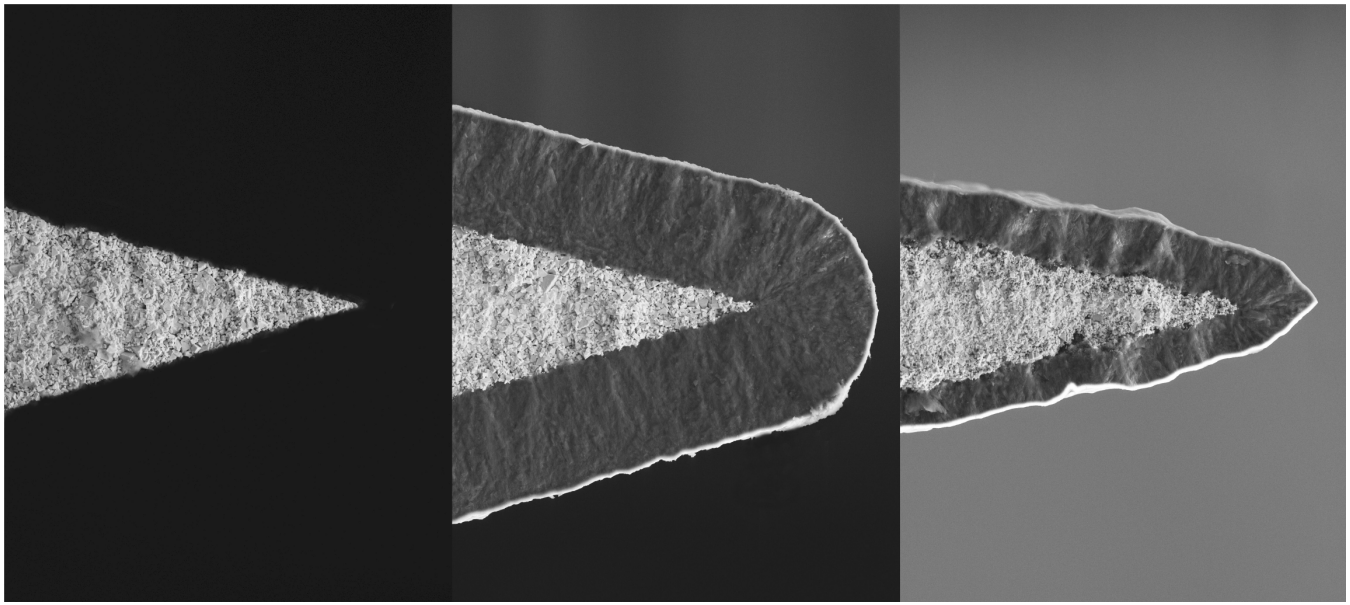
Plasma sharpening of diamond (PSD)

Tungsten carbide (TC) carrier

- Blade length up to 100mm
- Wedge angles between 10 and 90°
- Radii of curvature <500nm
- Tool thickness up to 10mm



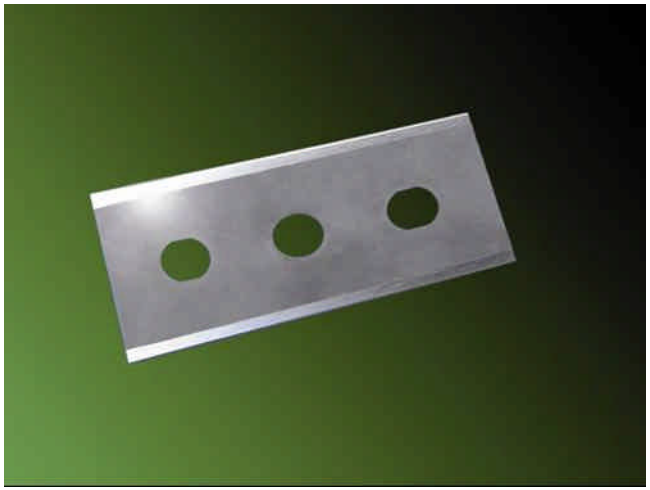
TC blade without coating | Diamond coated TC blade | Plasma sharpened TC-blade (real)

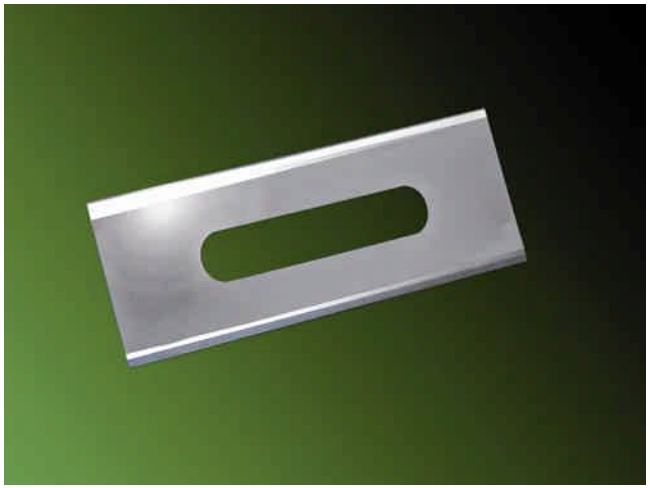


Products

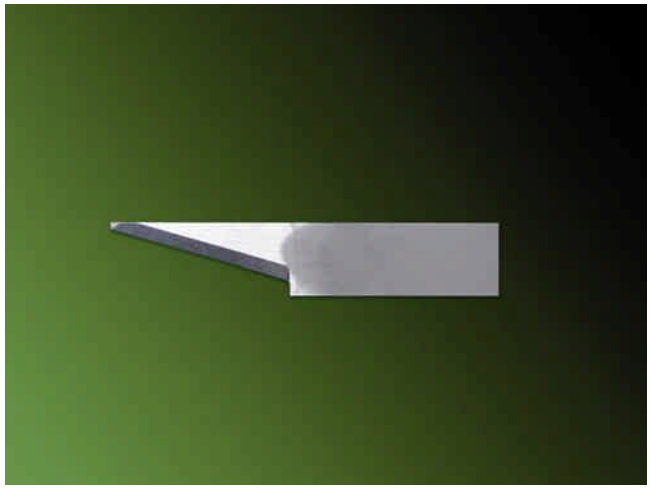
Diamaze

Foil blades



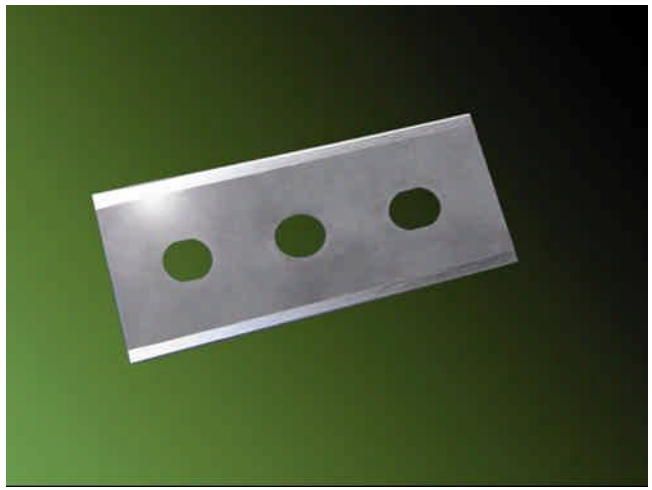


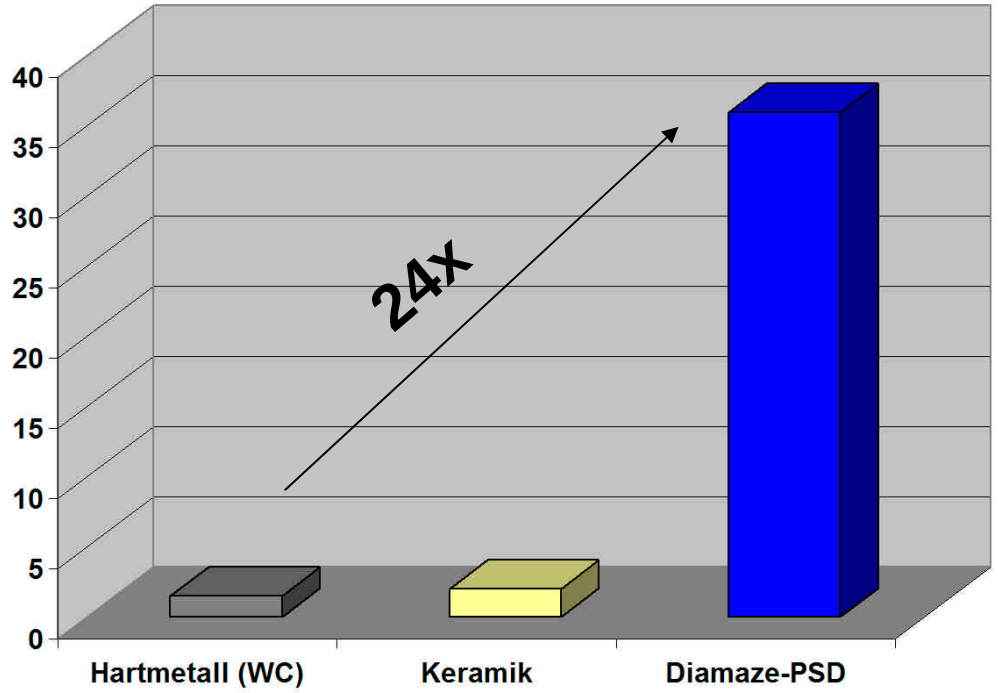
Plotter blades



Products

Plastic foil containing TiO_2 addititves





- **High cutting quality (reduced quality insurance cost)**
- **Significantly increased life time**
- **Higher speed of operation**
- **Reduction of production cost**

Success factors

Diamaze

High level research
•Governmental founding

Bundesministerium für Bildung und Forschung

Human resources
•Motivated management team willing to take risks

Ulm Gründerverbund

Consultancy/Information
•Financial concept
•Market strategy
•IP rights

- University of Ulm
- University of applied science Ulm
- Chamber of industry and commerce

Finance
•Early stage support by government and university
•Availability of seed capital
•Availability of „growth“ capital

- State Baden-Württemberg
- Program „Junge Innovatoren“

Success factors

Diamaze

Time

- Quick transfer from R&D to production
- Quick availability of prototypes

ulm university universität ulm

WMtech

Infrastructure

- Availability of adequate infrastructure
- Availability of necessary analysis support

- University of Ulm
- Well equipped transfer center
- Analysis equipment
- Skilled, experienced staff

Market

- Product ideas
- Feasability studies
- Presence of niche market
- Early customer contact

- Innovative companies
- Long term relationship

GESELLSCHAFT FÜR DIAMANTPRODUKTE

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