„Microcrystalline Diamond Coated Seal Faces for strong challenging Multiphase Pump Application“

24th Pump User Symposium

presented by:

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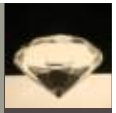
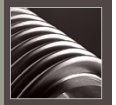
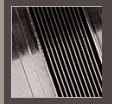
Outline

- The Location
- The Process
- The Application
- The Problem
- Sealing technology
- The Solution
- The technology
- The Result

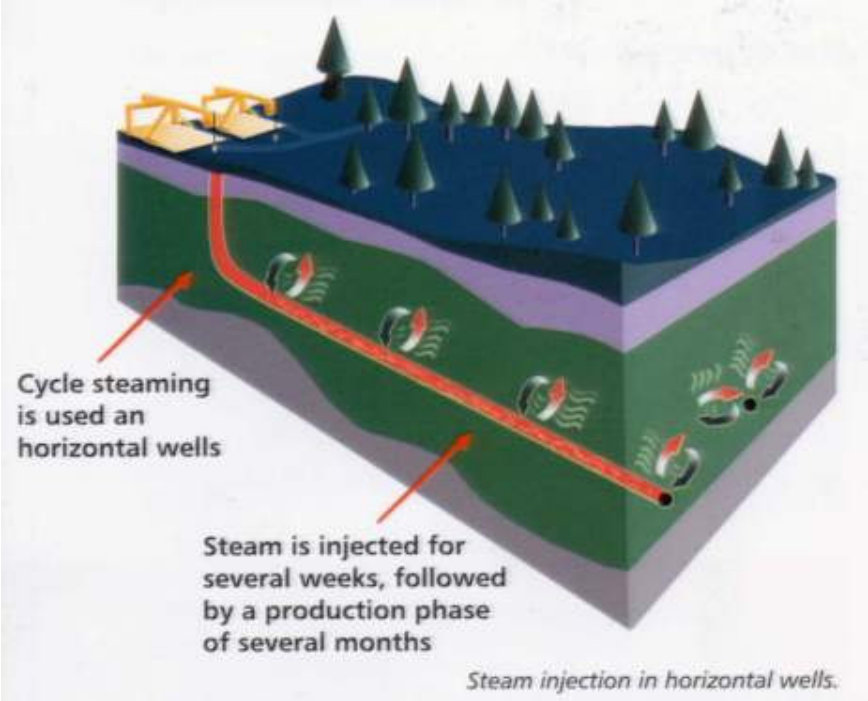



The Location

- Canada, Primrose, Deer Creek
- End user „Total“
- Twin Screw Multiphase Pump

The Process

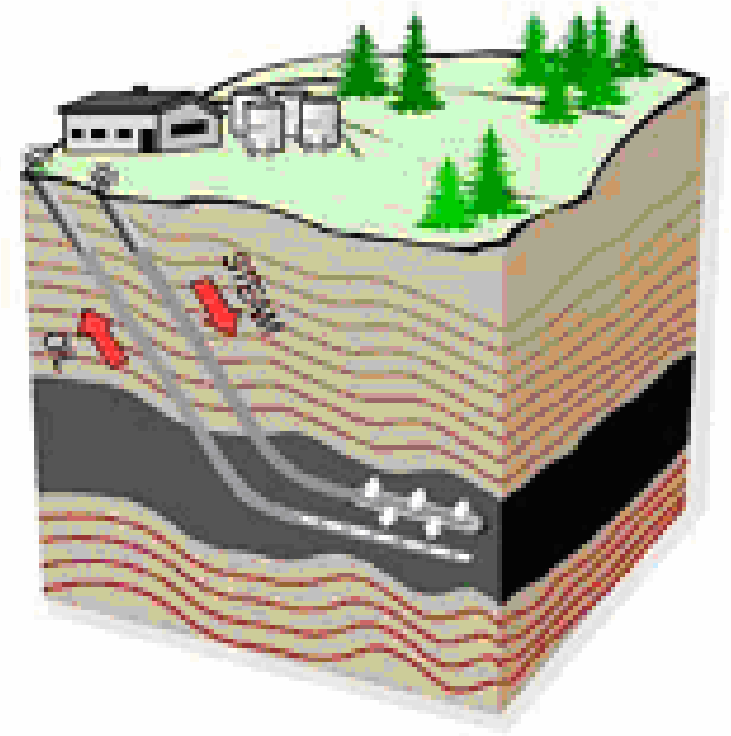
- Heavy oil recovery by steam injection processes
- CSS-process (Cyclic Steam Stimulation) requires only one wellbore. Steam is injected for several weeks to heat the oil, then oil flows into the wellbore and get lifted to the surface.



Steam injection in horizontal wells.

The Process

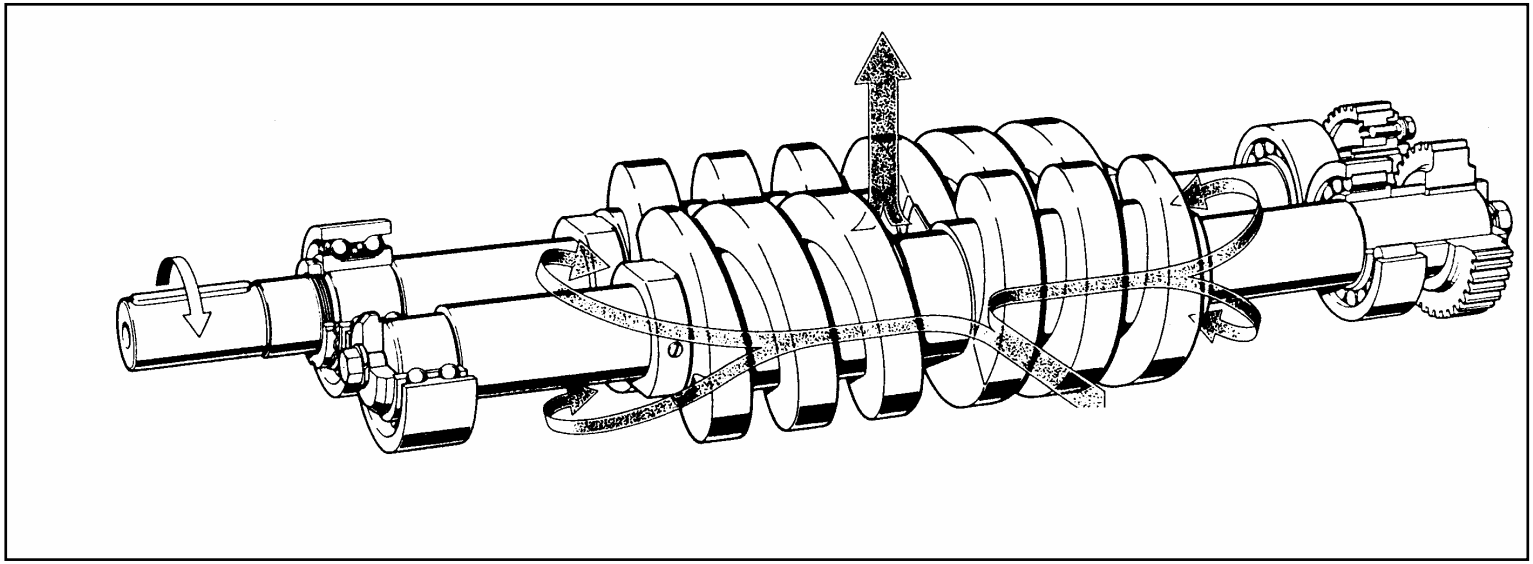
- SAGD-process (Steam Assisted Gravity Drainage) requires two horizontal wellbores. Steam is injected continuously into the upper wellbore, mobilizing the oil to drain to the lower wellbore and get pumped to the surface



Courtesy of Petro-Canada

The Application: Twin Screw Multiphase Pump

In the annulus vapor recovery service multiphase boosting systems are used



- Single Mechanical Seals installed at suction side
- A simple unpressurized buffer fluid system supports the seal lubrication at high gas volume fractions (GVF), API-Plan 52

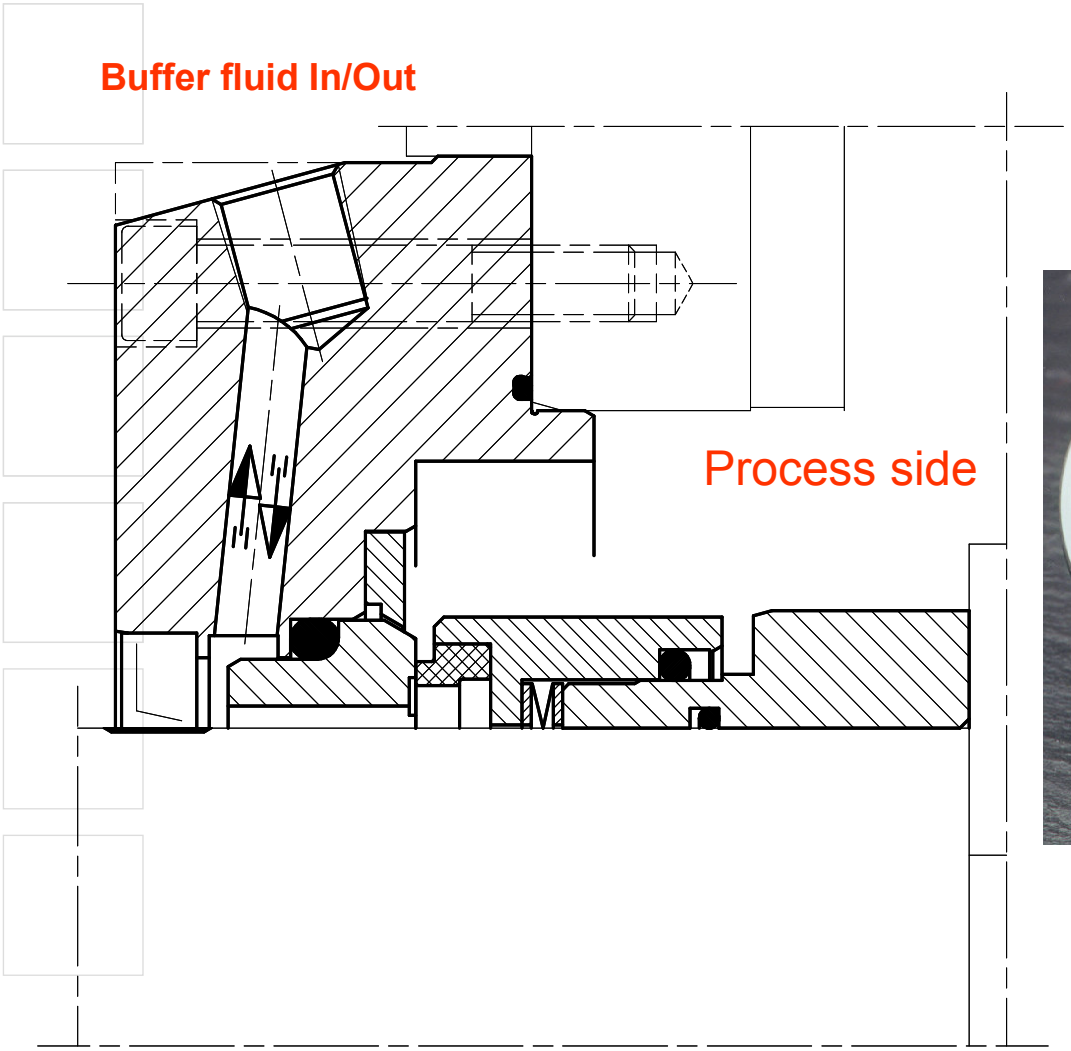
The Application: Multiphase Twin Screw Pump

Operating conditions for the mechanical seals:

Product media	**Saturated steam and condensed water, small amounts of bitumen and sand; gas including methane, CO2 and H2S**
Product pressure [p / bar(abs)]	**approx. 1**
Product temperature [T / °C]	**up to 130**
Rot. speed [rpm]	**up to 1800**

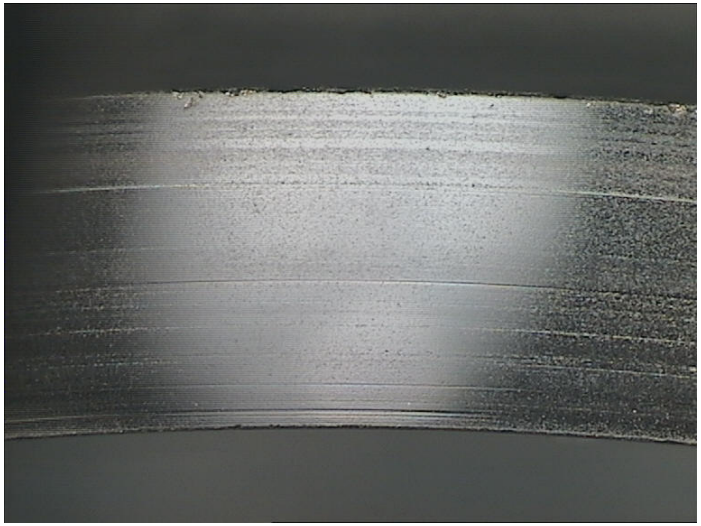
The Problem: former installation – failed every 2 weeks due to heavy wear of seal faces

Single Seal with unpressurized buffer fluid system – API-Plan 52

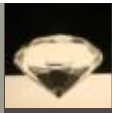


Seal face materials:
antimony impregnated carbon versus
silicon carbide (soft – hard)

- Increased dry-running risk requires soft-hard seal face material combination
- Abrasive particles require hard-hard seal face material combination with the ability to run without lubrication and cooling for an unpredictable period of time



The Solution:



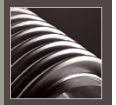
Seal faces

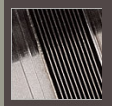
- in a hard material in order to handle solids

and

- can run dry for a specific period of time

→ crystalline diamond coated seal faces






The Solution: Mechanical Seals with two diamond coated seal faces

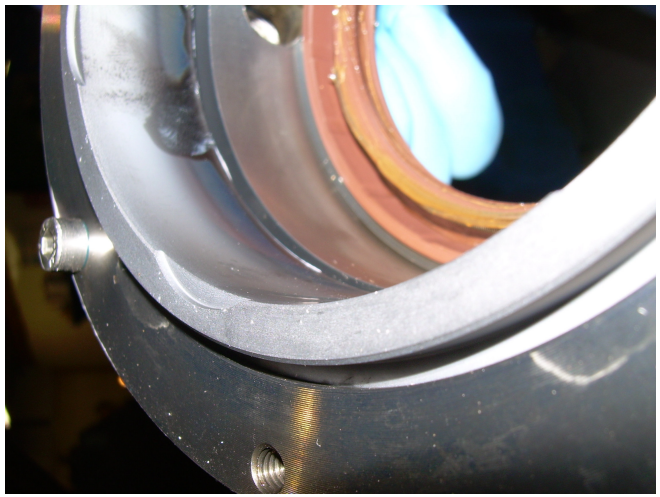
Installation in
December 2006
on site

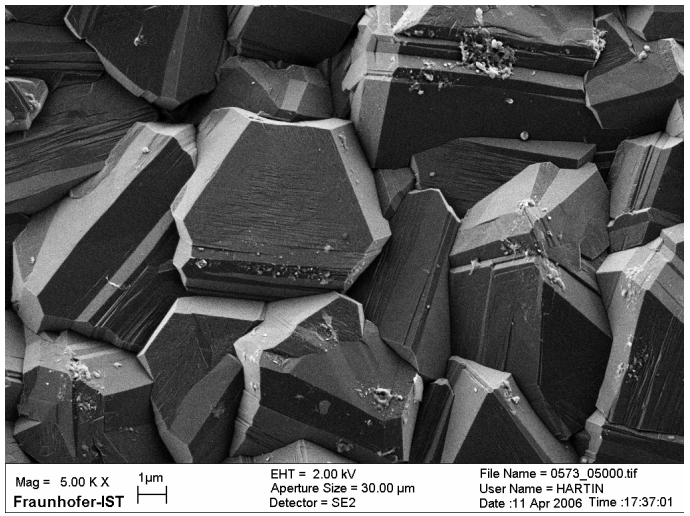
The solution – Mechanical Seals with two diamond coated seal faces

Diamond Seal Faces properties:

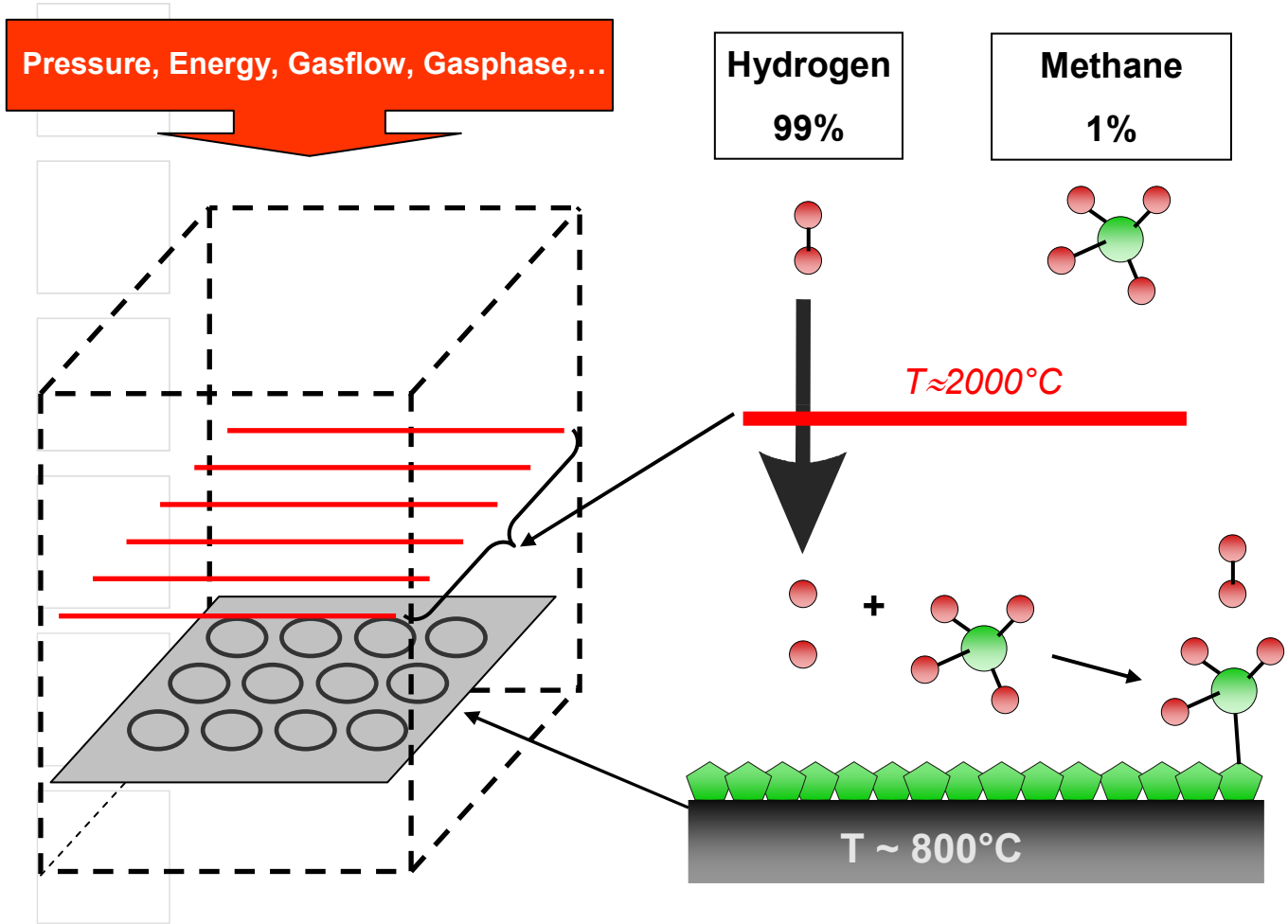
- Unique hardness
- Excellent thermal and chemical resistance
- low friction coefficient
- Dry running capability!!

→ **Thus mechanical seal faces can handle solids and dry running!**





The manufacturing process



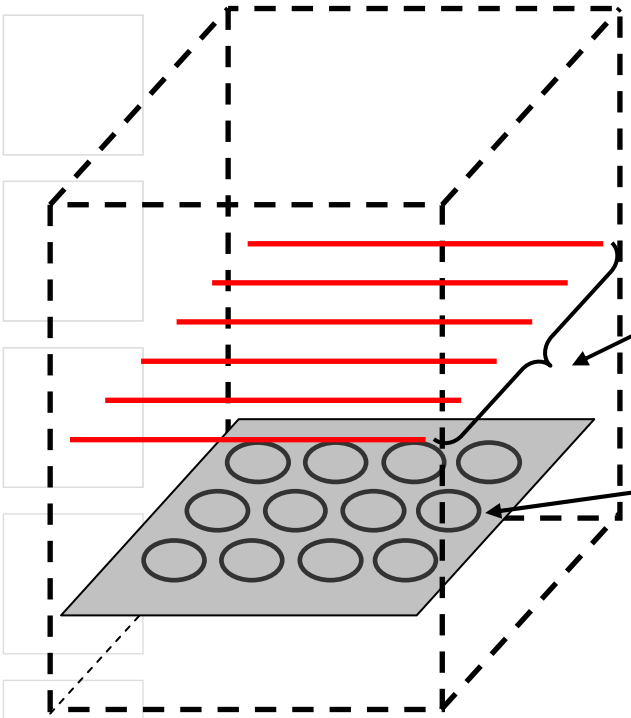
Gas atmosphere
at vacuum

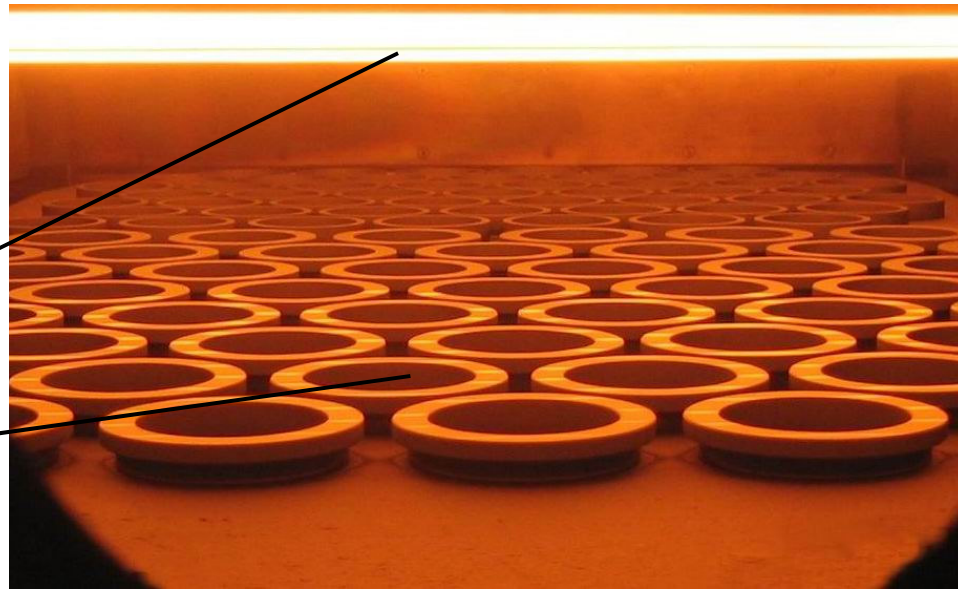
Activation due
to hot filament

Deposition of
Diamond

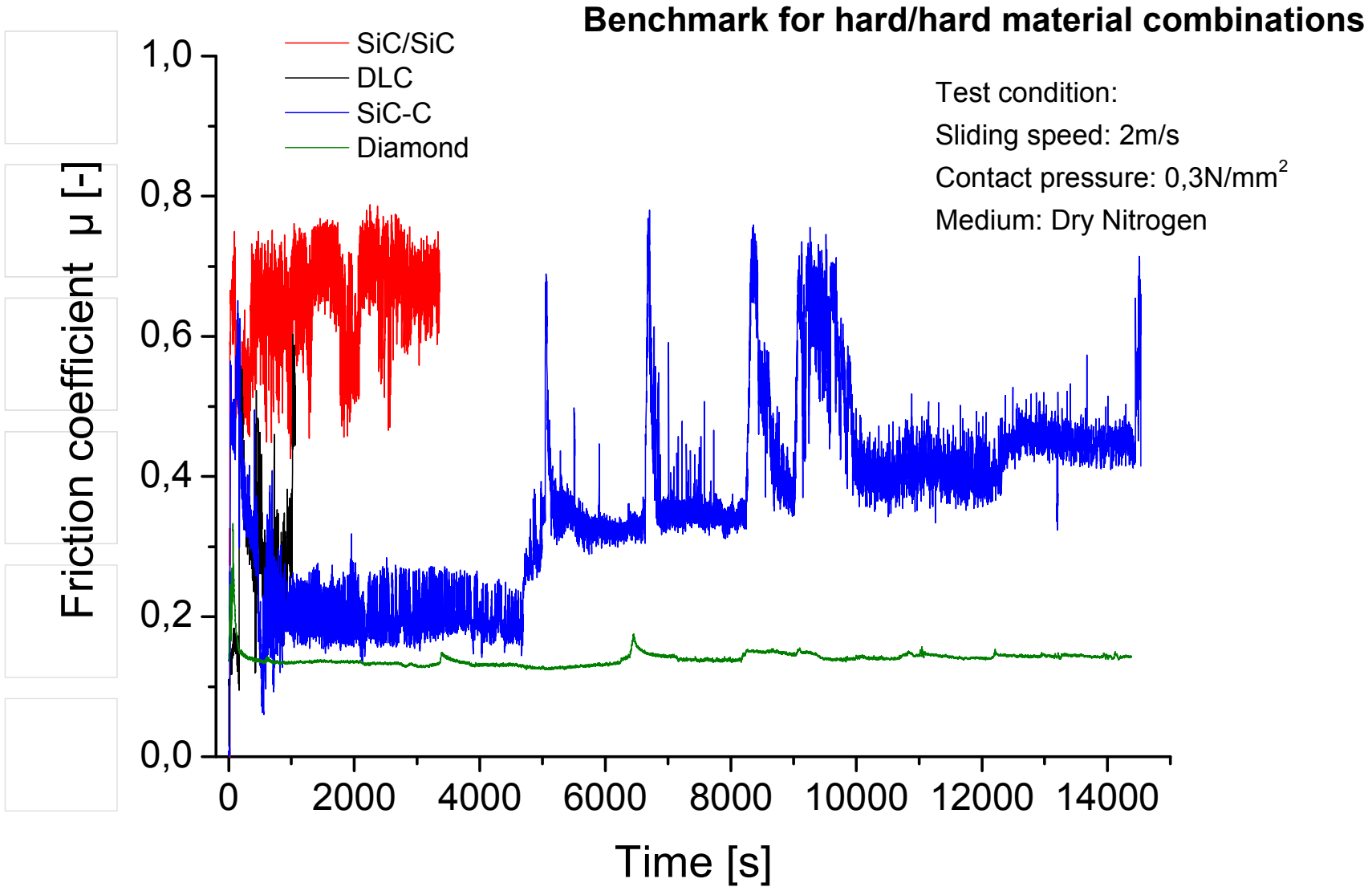
(0,2-1,0 µm/h)

In the reactor with horizontal filaments silicone carbide seal face surfaces are coated with diamond

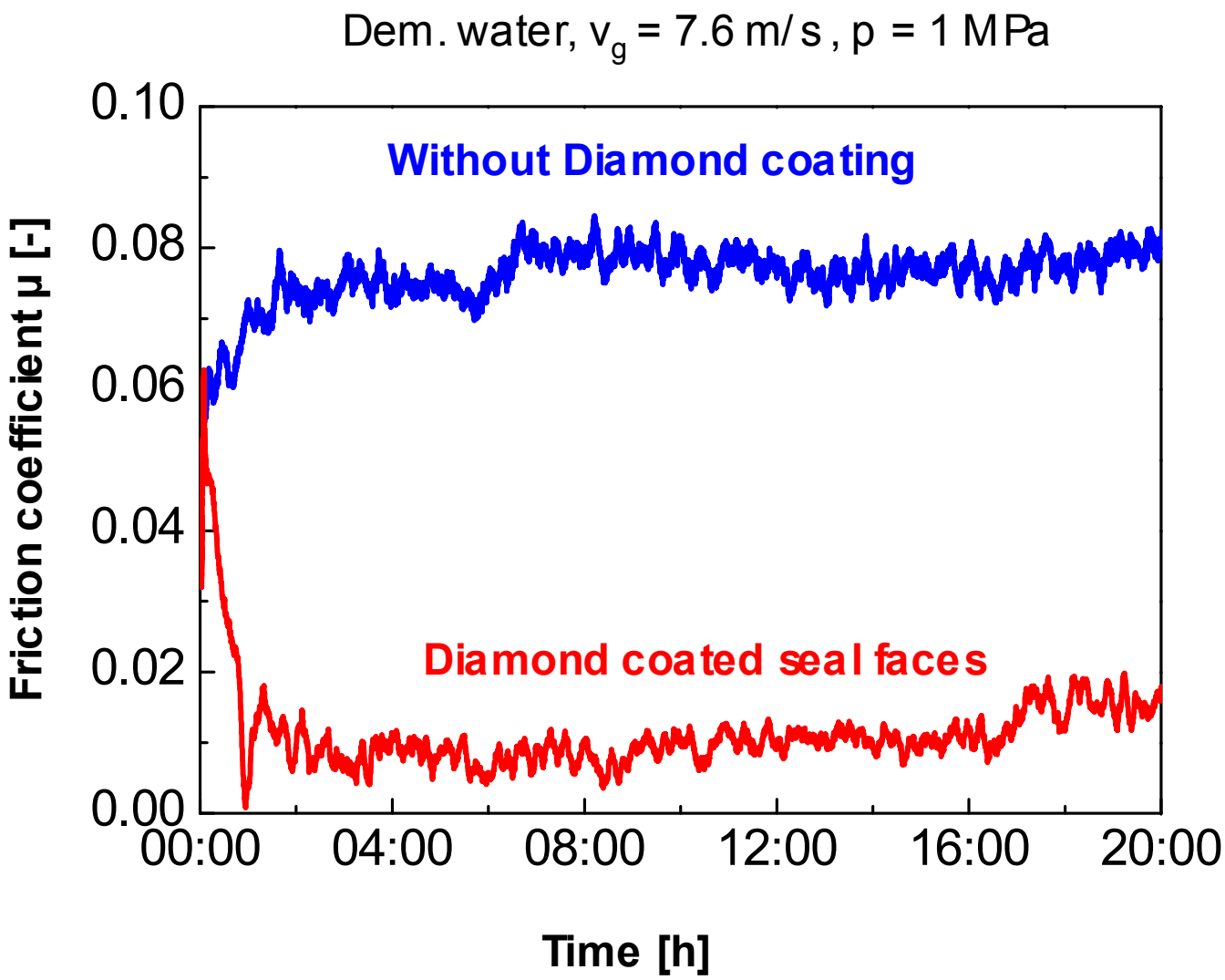




The tribological performance

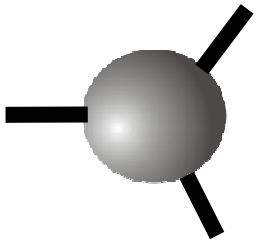


Tribological Performance – Benchmark of friction coefficient (poor lubrication)

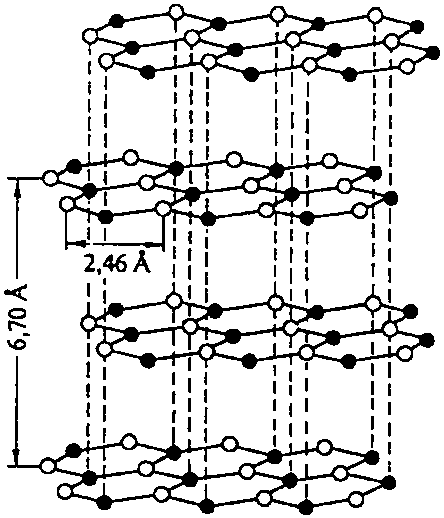


Diamond – Comparison Graphite / Crystalline Diamond

Graphite



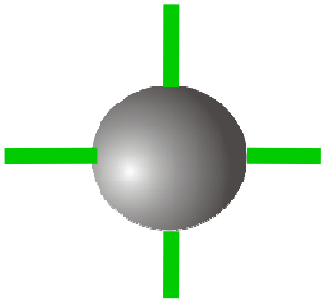
sp^2 = 3 covalent bonds



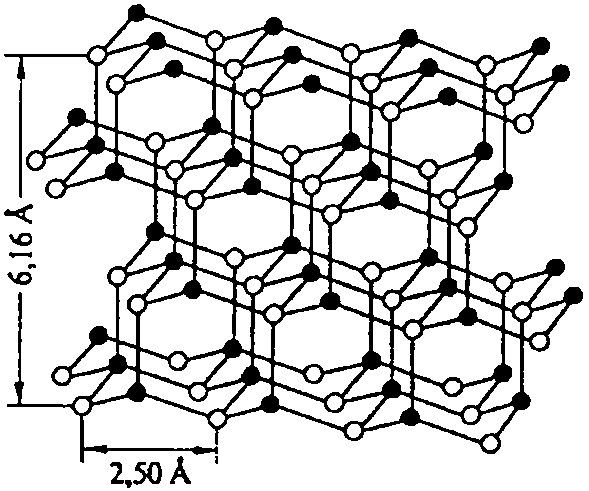
strong horizontal bonding

weak vertical bonding

Diamond

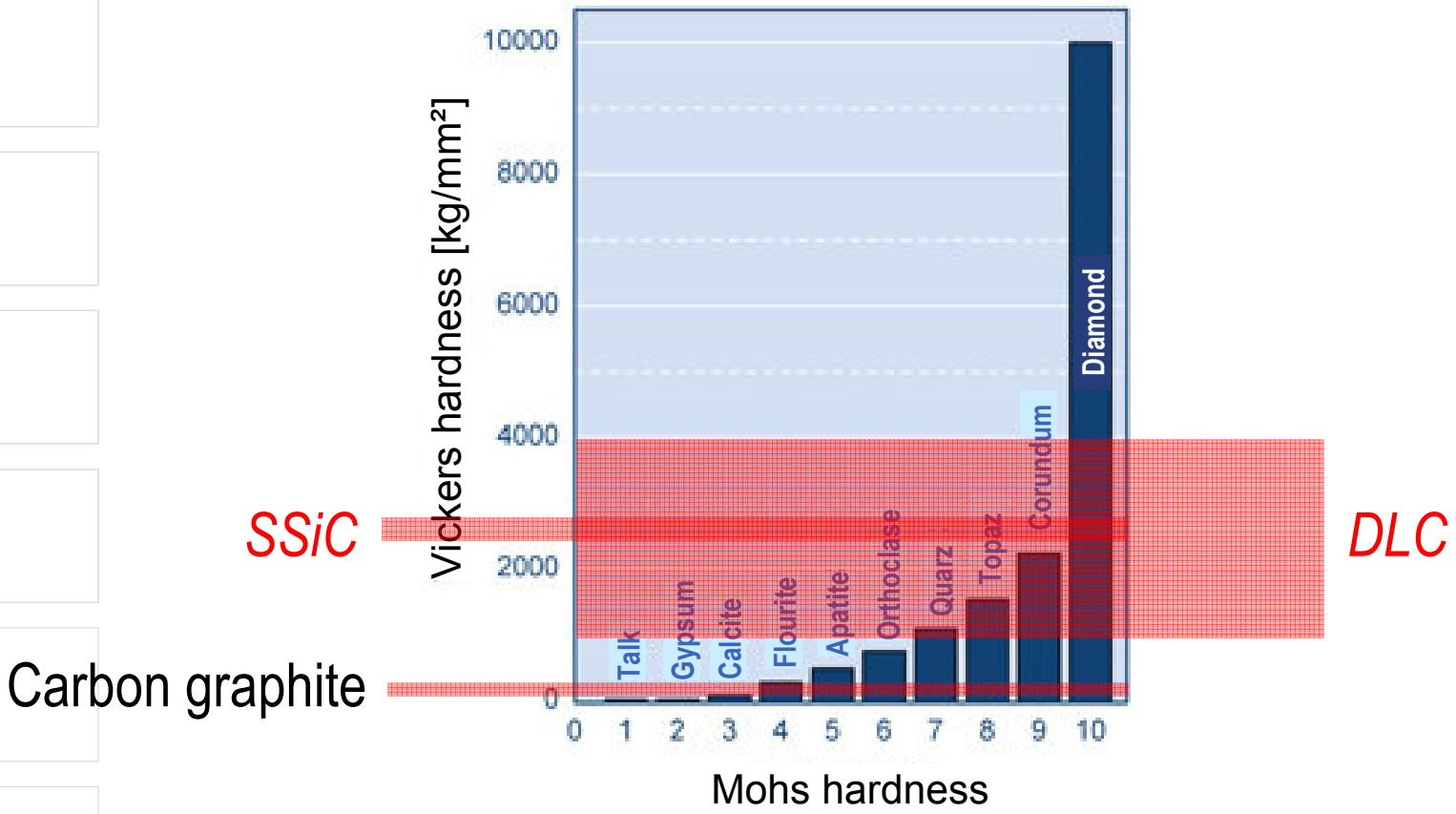


sp^3 = 4 covalent bonds



strong bonding in all directions

Diamond – Hardness



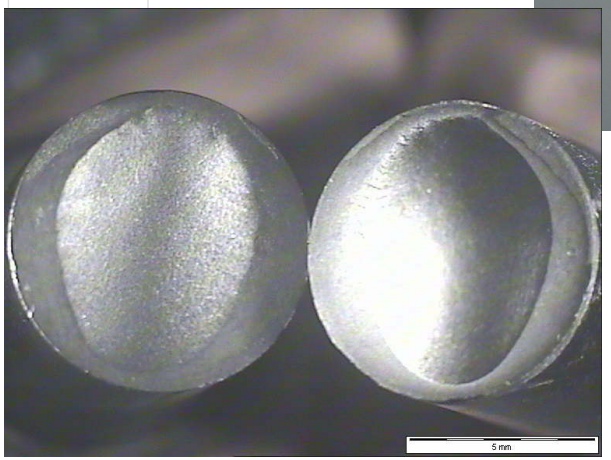
Quelle: Fraunhofer IAF

http://www.cvd-diamond.com/tfdiprth/frames_d.htm

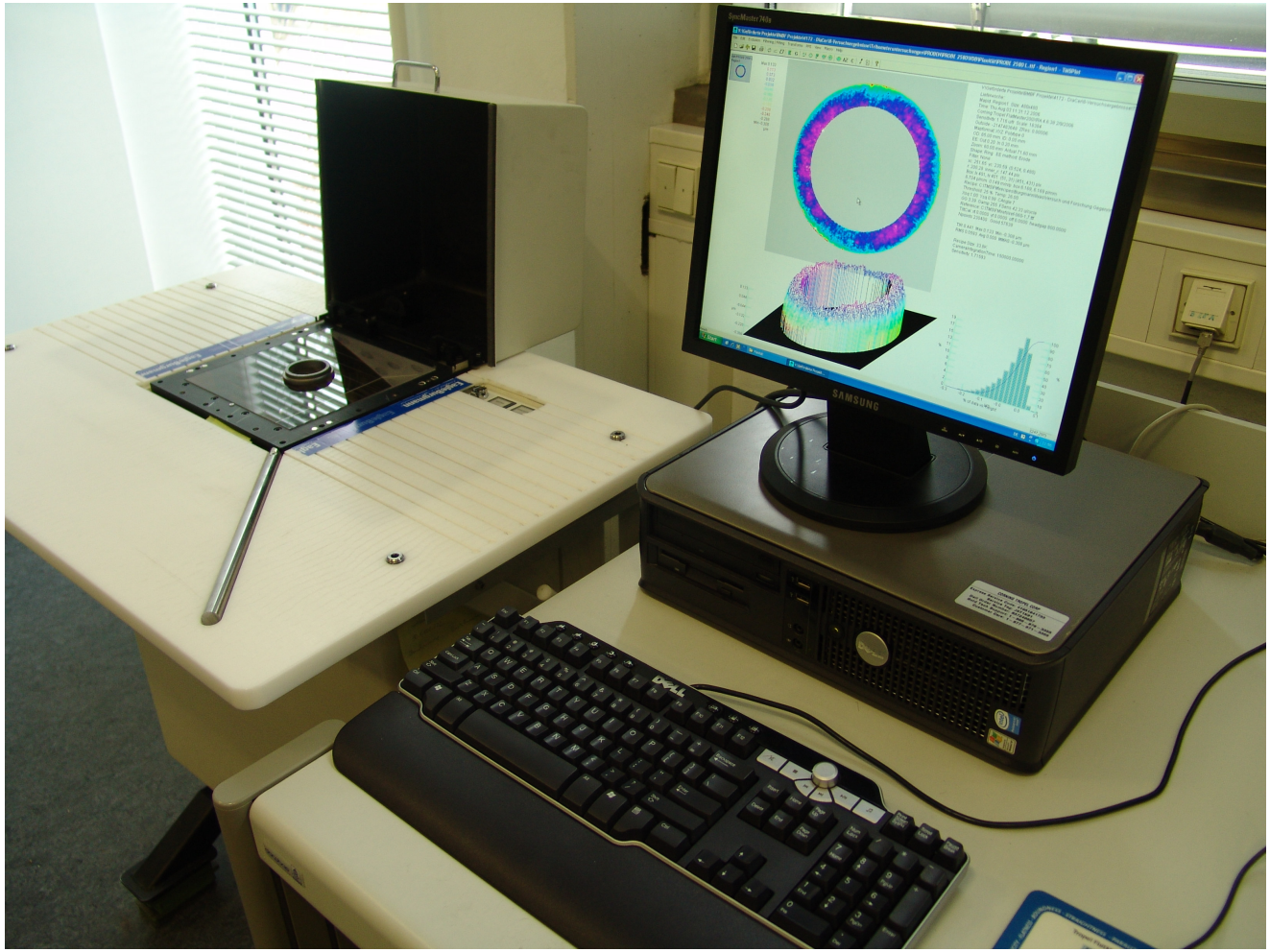
Adhesive strength – Results:

Adhesive strength diamond-SiC test:

- Adhesive strength (tensile strength) status 2007: **70-80 MPa (diamond layer can not be pulled off, values correspond to maximum tensile strength of the glue!)**

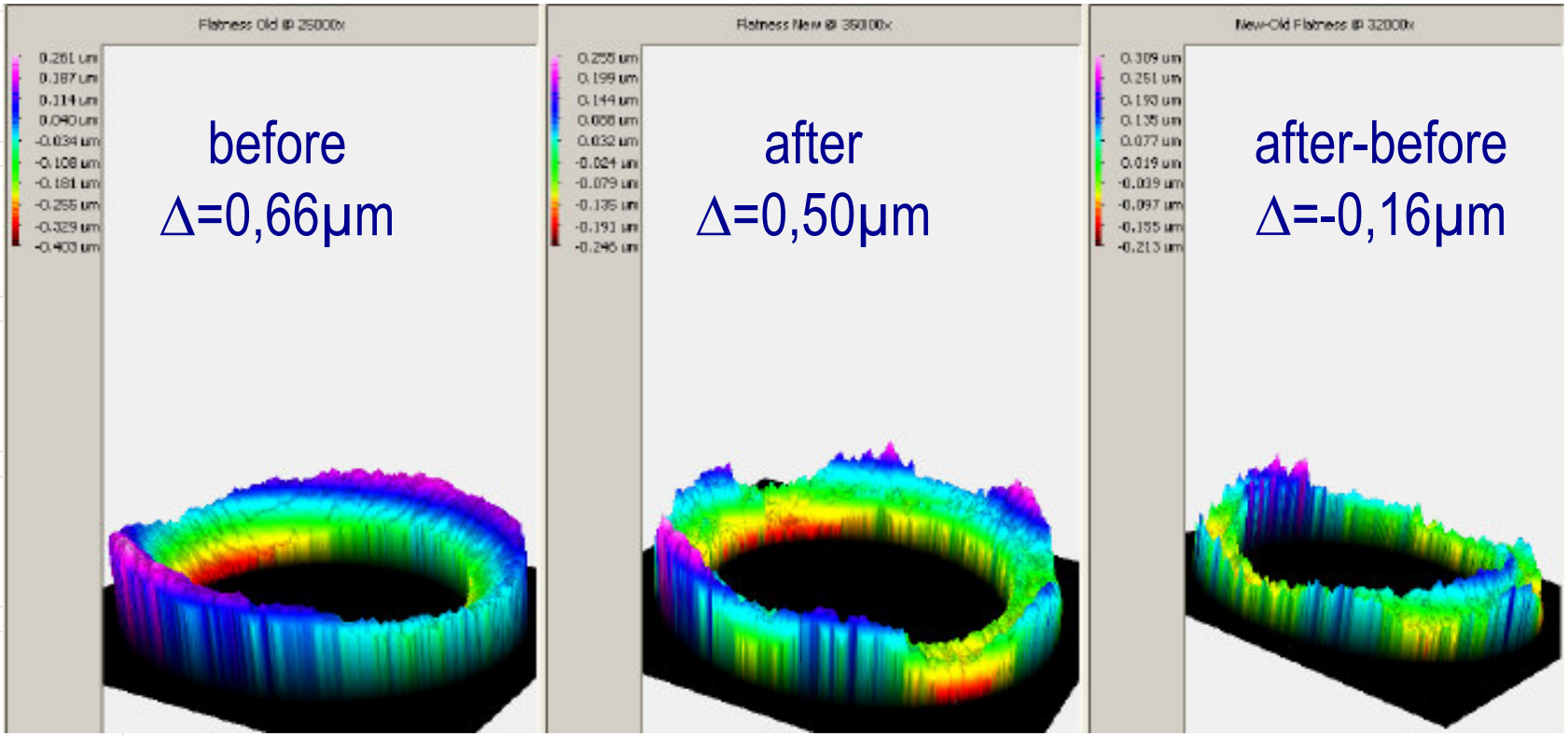


Diamond deposition – Flatness measurement by laser interferometer



Diamond deposition - Homogeneous deposition standard seal face

Flatness measurement before and after coating



Due to the high hardness of the coating a final polishing after the coating process is not feasible. Therefore the process was optimized to achieve homogenous deposition rates in order to minimize the change of the ring flatness.

The result

- Single Mechanical Seals have proven their ability to seal multiphase mixtures using current seal designs and diamond coated sliding face materials

- Correct installation and operation are the key-factors for a long MTBF-value