NewSkin Surface Texturing Value Propositions.

Automotive and General Industry

15.10.2020

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 862100 (NewSkin). The output reflects the views only of the author(s), and the European Union cannot be held responsible for any use which may be made of the information contained therein.

NewSkin and Surface Texturing:

Automotive and general industry

- Despite laser is expected to contribute in different fields **the current ppt is limited to those applications related to the application tribological and enhanced lifespan for automotive and industrial applications** for components working on dynamic environments. Others such applications will be addressed on separated meetings. Micro-electronics, optics, anti-fouling, anti-ice will be disclosed on different meetings.

- Transfer of **Laser Micro/Nano Texturing and Surface Modification** of materials (metals/polymers/composites/ceramics) to industry

- **Modelling and Testing** (LUH / ITAINNOVA)

- **Fabrication** of textured surfaces – (DCU/AIMEN/A-NOV)

Automotive and general Industry

Use Cases.

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Direct Texturing of Components:

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- **Use cases CP1 to CP3** represent 3 examples of components installed in engines, energy generators and others. The textures result in vibrations damping, friction reduction and improved lifespan. Friction and vibrations damping have a positive effect on energy efficiency of engines and equipment and will increase energy generation in turbines, co-generators, heat pumps and others.

- **CP1 to CP3 are metallic components**, but the textures can also be implemented on ceramic components.

- Generally speaking, the **textures can be implemented in any surface subjected to reciprocating, rotation and oscillating movement**: gears, piston, shafts, rings, gaskets…

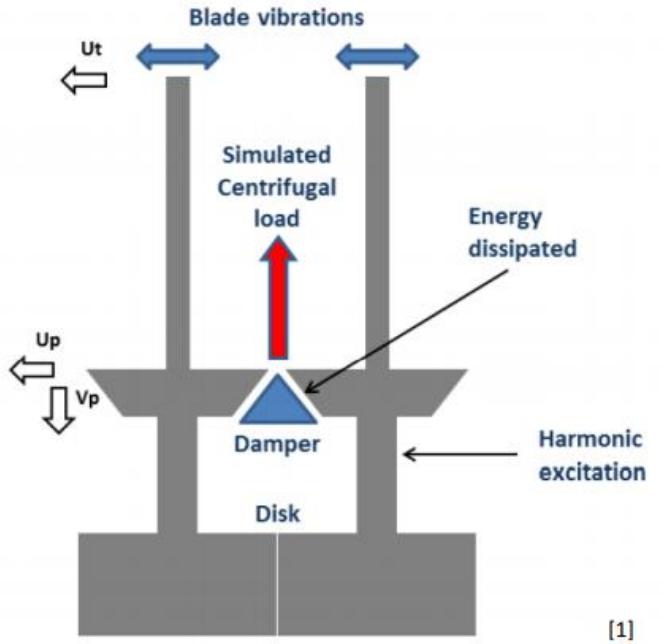
- **Designs and evaluation of the use cases** will be conducted by LUH and ITA, while AIMEN will **texture** the different component.

- A plan for the engagement of **key actors in the automotive and other industries needs to be created**.

WP 5: CP1 – Retrofit under platform damper

Component:

- Function: Dissipate vibration energy in gas and steam turbines
- Material of the Damper: Steel



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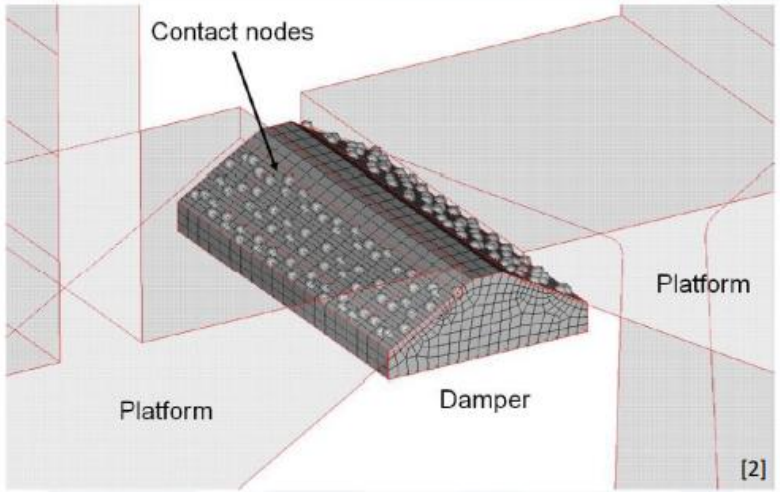


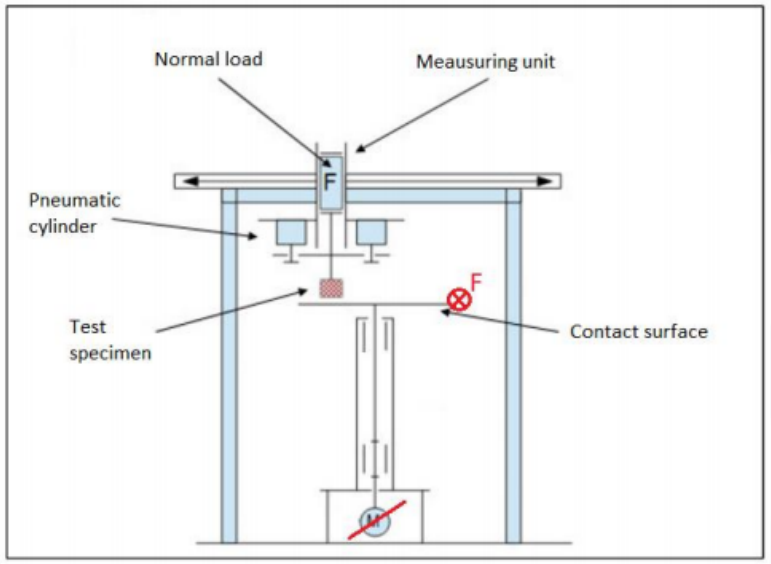
[2]

: Pesaresi, L., et al. "Numerical and Experimental Investigation of an Underplatform Damper Test Rig." Applied Mechanics and Materials, Vol. 849, 2016, 1–12.
: Pesaresi, L., et al. "An advanced underplatform damper modelling approach based on a microslip contact model."Journal of Sound and Vibration, Vol. 436, 2018, 327-340

WP 5: CP1 – Retrofit under platform damper

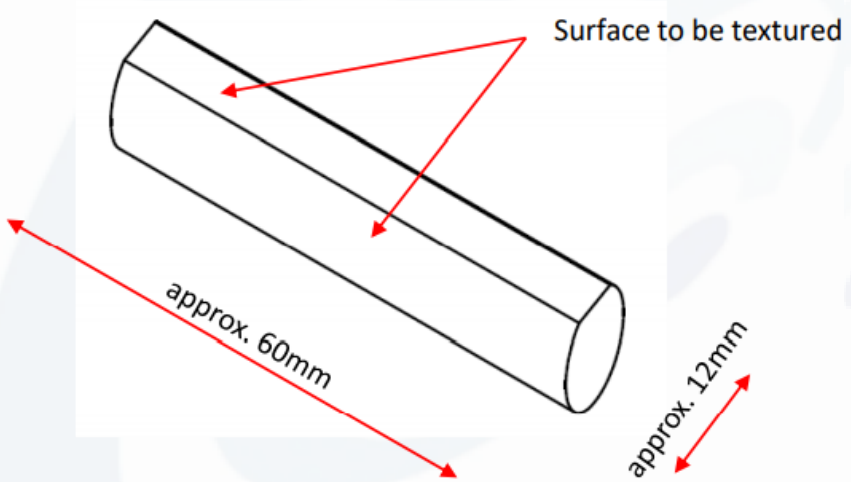
Test-rig:

- Excitation: Shaker to achieve a micro-slip between the test specimen and the counter surface
- Operating conditions:
  - Relative displacement: approx. 50µm
  - Normal pressure: approx. 10 MPa – up to 30 MPa
  - Frequency: wide range, < 100Hz up to kHz-Range



Test component:

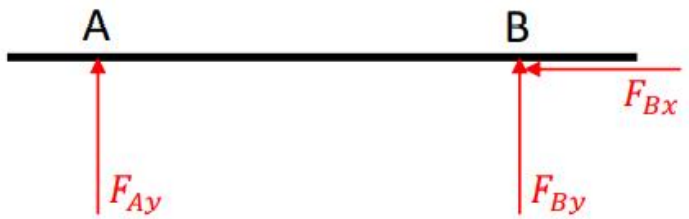
- Test specimen geometry:
- Material: Steel



WP5: CP2 – Shaft/Bearing in electric cars

Component:

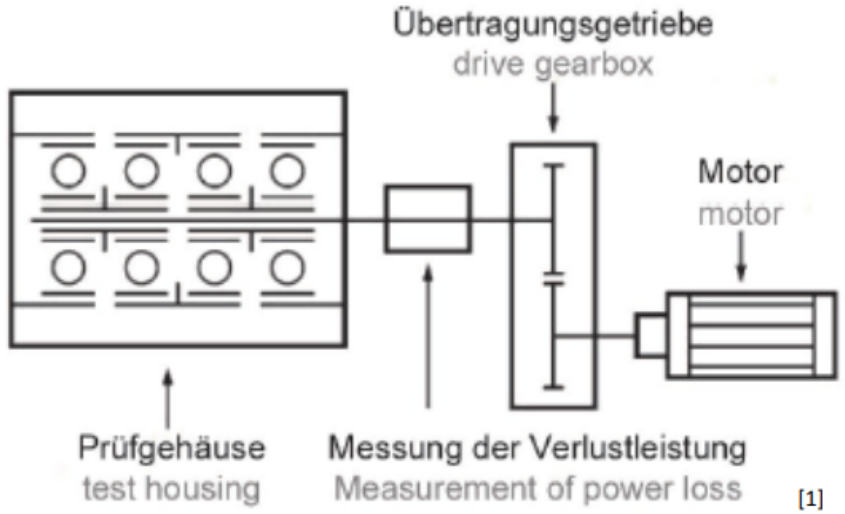
- Functions:
  - Bearing of a rotating shaft
  - Carrying of loads (F_{Ay}, F_{Bx}, F_{By})



WP5: CP2 – Shaft/Bearing in electric cars

Test-rig:

- Operating conditions:
  - Radial load: approx. 10 kN
  - Rotational speed: To be defined



[1]

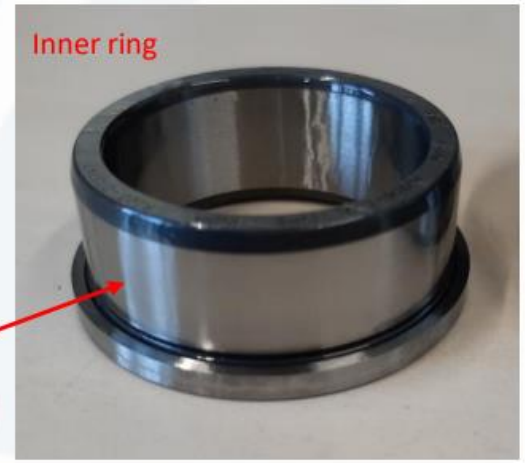
https://www.mw.tum.de/fzg/forschung/ausstattung/

WP5: CP2 – Shaft/Bearing in electric cars

Test component:

- Bearings used in electric cars
  - Inner diameter: 35mm (Tesla Model S), 30mm (Nissan Leaf)
  - Outer diameter: 72mm (Tesla Model S), 62mm (Nissan Leaf)

- Chosen type: Cylindrical roller bearing with original dimensions (Reason: Ball bearings cannot be disassembled non-destructively)
- Material: Steel



WP5: CP3 – Compressor

Component suggestion: Scroll compressor

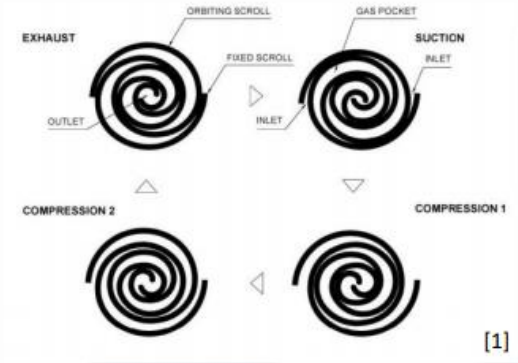
- Application:
  - Heat pumps
  - Thermal management electric vehicle
  - Air conditioning
  - Performance range: 5kW – 70kW
- Challenge: Non-destructive disassembling
- Alternative compressor:
  - Rotary screw compressor
  - Swash-plate compressor

Test-rig:

- To be defined

Test component:

- Original component with original spare parts (Compressor type is to be defined)
- Material: Steel or Aluminium



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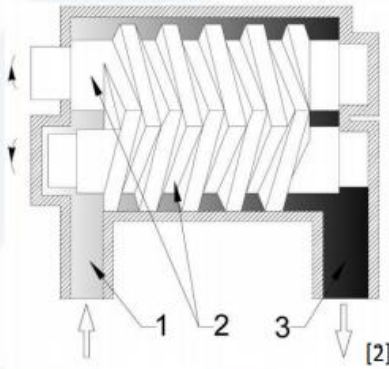

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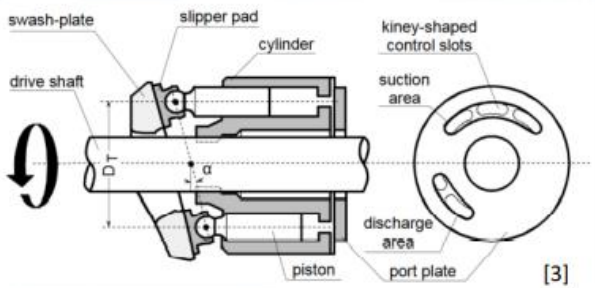

[3]

[1] + [2] Gużda, A., et al. „Compressors in Heat Pumps." Machine Dynamics Reasearch, Vol. 39, 2016, 71-83.
[3] Försterling, S., et al. „Theoretical And Experimental Investigations On Carbon Dioxide Compressors For Mobile Air Conditioning Systems And Transport Refrigeration", 2020.

Texturing During Moulding:

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- **Use cases CP12 and CP13** represent 2 examples of **texturing during moulding** components. Textures (negative patterns) are engraved in the mould and the textures is transferred to the molded components.

- The technology was developed in an FP7 (TDM-Seals) and two H2020 projects (SoftSlide and MouldTex). TDM allows the **low-cost mass production of textured components**. When seals are equipped, significant energy reduction in different devices such as hydraulic or pneumatic actuators can be obtained (up 60% friction reduction and over 2 times lifespan.

- Textures has been **validated on elastomeric components** and extended to thermoplastics.

- LUH and ITA will oversee the **design of textures**, AIMEN will **conduct moulds texturing** and ITA will validate the TDM process.

- LUH and ITA have also developed **supportive tools and software for the design of textures** and processes.

Solution – Surface texturing

Friction reduction:

- Surface texturing: Proven technique for reducing friction across lubricated rigid materials
- For elastomeric materials proven at laboratory level: >50% friction and wear reduction measured in seal prototypes
- Without affecting its functional properties

- Knowledge from EU projects:

TDM-SEALS

SoftSlide
New dynamic sealing generation

MouldTex
3D mould surface texturing

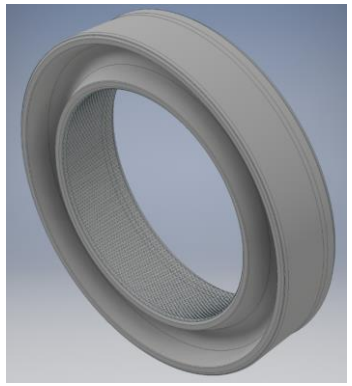
- TDM-Seals
- SoftSlide
- MouldTex

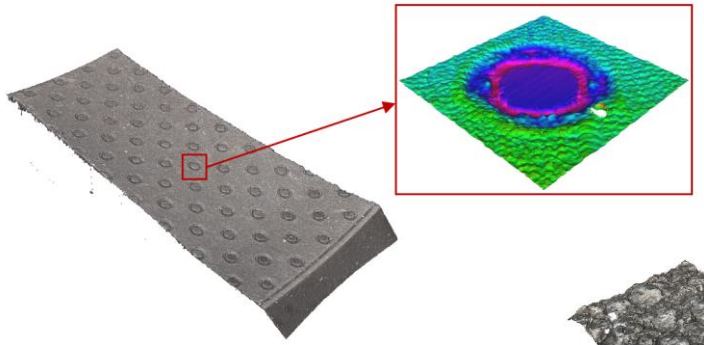
Surface textures - Specification

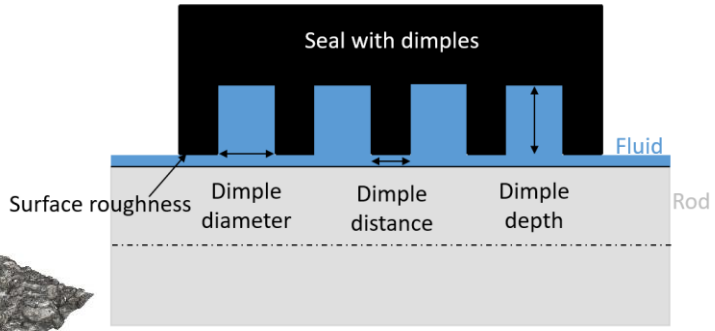
Friction reduction:

- Modification of the surfaces: Dimples and roughness
- Specification of the dimple textures: Diameter, Distance and Depth
- Dimple dimensions applied in previous projects:
  - Diameter: 100-300 µm
  - Distance: 100-300 µm
  - Depth: 10-30 µm

- Example: Reciprocating dynamical rod seal





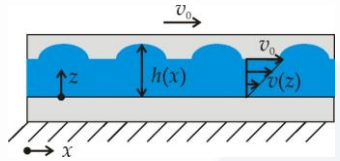


Surface textures – Effects

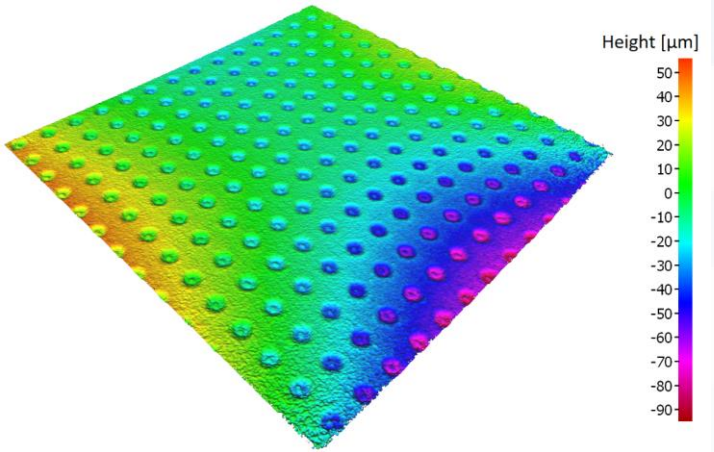
Effects of surface texturing:

- Contact are reduction
  - Reduction of real contact area → Reduction of dry friction

- Viscous friction reduction
  - Friction reduction due to higher fluid film



- Lubricant storage
  - Dimples can store lubricant
- Wear particle storage
  - Dimples can store wear particles

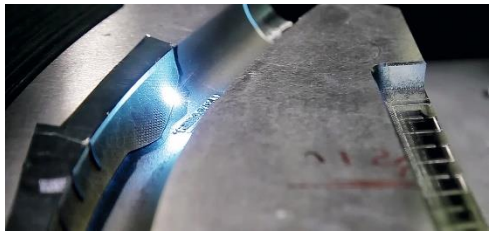


Surface textures – Production (LUH)

Production of surface textured seals:

- Surface texture applied in a post process individually on each seal
  → Cost-intensive, unfeasible for mass production

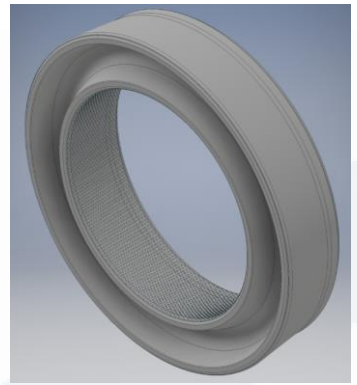
- Texturing during moulding → Production in large volumes
- The negative of the desired surface texture is applied to the metallic mould by laser
- The texture is transferred to the seal surface during moulding
- Adaptable process for a large variety of seal types

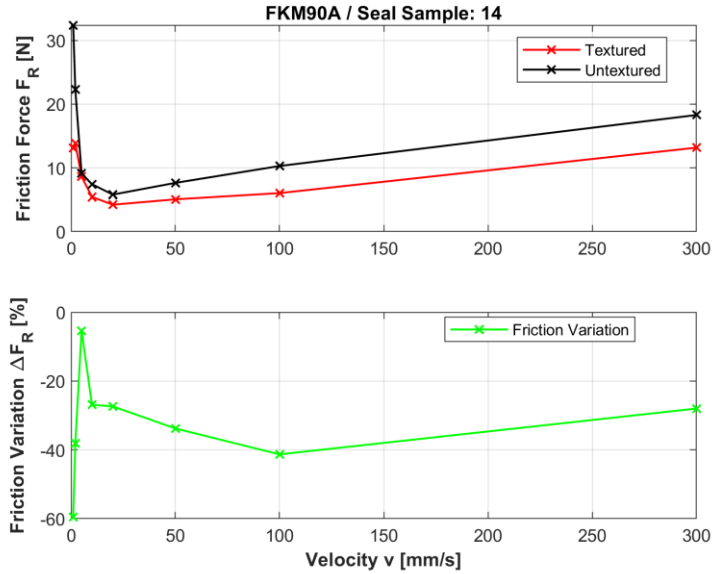


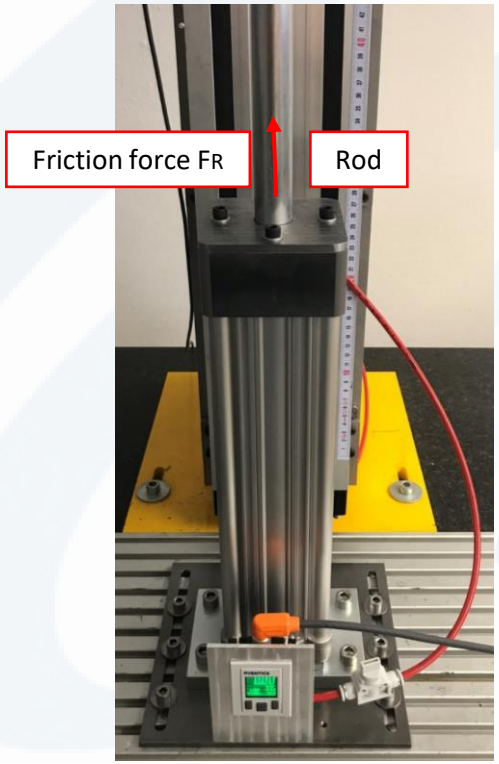
Surface textures – Exemplary Results

Friction reduction by surface texturing:

- Reciprocating rod seal
- Surface texture:
  - Dimple diameter: 200 µm
  - Dimple distance: 200 µm
  - Dimple depth: 20 µm



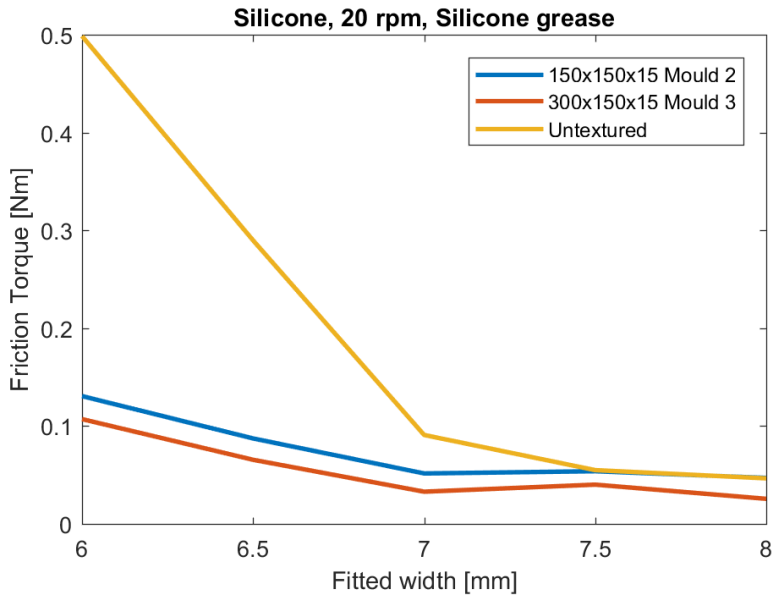




Surface textures – Exemplary Results

Friction reduction by surface texturing:

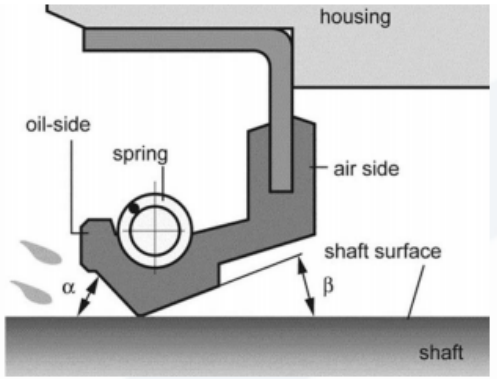
- Rotating V-Ring seal
- Surface texture applied to the red surface:
  - Dimple diameter: 150/300 µm
  - Dimple distance: 150/150 µm
  - Dimple depth: 15/15 µm



WP5: CP12 – Radial shaft seal and wipes

Component :

Function: Prevents the leakage of fluids along a rotating shaft



[1]

Test-rig:

- Shaft/Bearing test rig used in CP2

Test components:

- Original component, currently available in the market (Available without and with wipes)
- Alternative: Production by texturing during moulding
- Material: Elastomers (FKM, NBR, …)

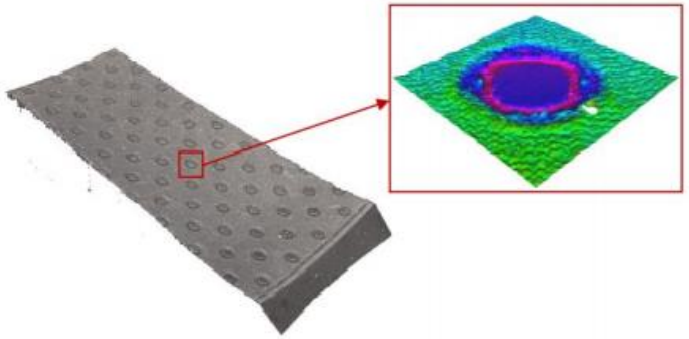

[2]

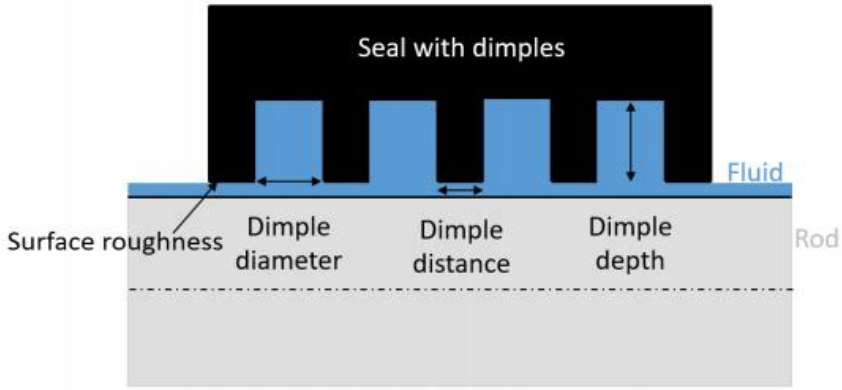
https://vacaero.com/information-resources/vacuum-pump-technology-education-and-training/9363-shaft-seals-for-rotating-shafts.html

[2] https://ecatalog.fst.com/seals/all/

WP5: CP12 – Radial shaft seal and wipes

- **Surface texture:**
- Seal with friction optimized surface texture
- Dimple texture and/or modified surface roughness
- Dimple texture is defined by diameter, distance and depth





ttps://vacaero.com/information-resources/vacuum-pump-technology-education-and-training/9363-shaft-seals-for-rotating-shafts.html [2] https://ecatalog.fst.com/seals/all/

WP5: CP13 – Handles sport equipment

Component :

Function: Strong grip and scratch resistance for sports handles and grips

Test-rig:

- To be defined

[1]

Test components:

- Original component, currently available in the market
- Alternative: 3D printed parts
- Material: Polypropylene

ttps://www.technogym.com/de/

The Laser RTD´s:

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Facility	AIMEN	DCU			ANOV
Laser Type	Ultrafast laser sources in IR, vis and UV.	1. High pulse power nano-structuring Femto; 2. High power heat treatment fibre and 3. Microstructuring CO_2 lasers			femtosecond lasers
Design Services	Nanostructured foils, shims and tools for micro and nano replication.	Nano-, micro-surface texturing and surface hardening for various applications including marine, transport, and mining.			Anti-bacterial surfaces for metal coils, cans and others
Samples Dimensions	Tools up to 0.5 m^2.	0.5m x 0.9m flat 0.2m radius x 0.3m 4-axis (			Up to 0,8 x 0,6 m^2
Resolution	< 100 nm	<100nm spot size			< 100 nm
Energy	40 µJ @1MHz	7 mJ @ 1 kHz	10 µJ @ 1 MHz	10mJ @ 50 kHz	>300µJ @ 1 MHz >70µJ @ 5 MHz
Power	40 W max.	7 W	10 W, <500 fs	500 W, 20 µs	350W femtosecond pulses for LIPSS
Productivity	> 16 cm^2/min	> 16 cm^2/min			**>100mm^2/s**
Substrates	Metallic, carbon-based, ceramic	Metallic, ceramic, polymeric, glass			Metallic
Geometries	Flat or Tooling	Complex			Flat
OWS	Yes	Upgrade required for dedicated 4-axis			No
LIPSS	No	Upgrade required for dedicated 4-axis			Yes
Process	Batch	Batch / Continuous			Continuous
Functionality	Optical, tribological, bio-compatibility, contact angle, wettability, heat exchange improvement. Membranes.	Anti-fouling in hulls and propellers and membranes, Nano-pores creation on membranes, reduced friction and wear in propellers, rock drills, hulls and pumps for improved efficiency and increased life time			Anti-bacterial (Chemical and nano-topography modification), superhydrophobic surfaces, etc.
Use	Roll to roll cylinders, moulds (embossing, ICM), filtration, medical devices and electronics (display).	Texturing of complex geometries: Propellers, pistons, gears, shafts, pinions, rock drills, hulls, membranes. Laser drilling/perforation of pores			Can and coil coatings, food packaging
Others	Moulding, hot plate embossing and UV curing facilities for micro and nano-replication.	Hybrid laser process: Enhancing surface microstructure properties and adding texture.			Polygon Scanner + Nanotexturing machine operational for upscaling

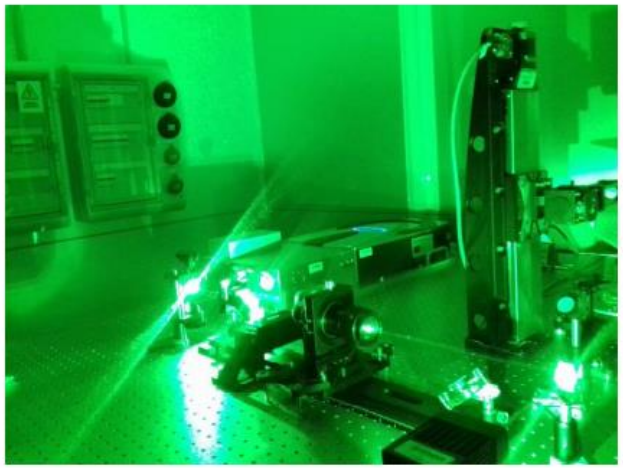
Table 1NewSkin laser Up-scaling facilities Overview

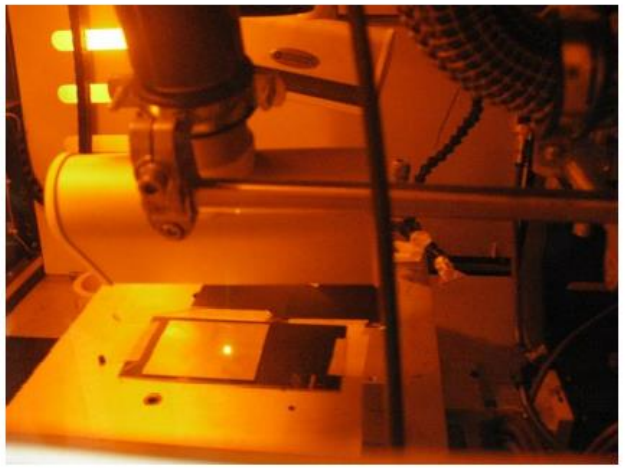
- 5 axis (complex shapes).
- Moderate size components.
- Accurate Patterning on graphene

EQUIPMENT

LASER SOURCES

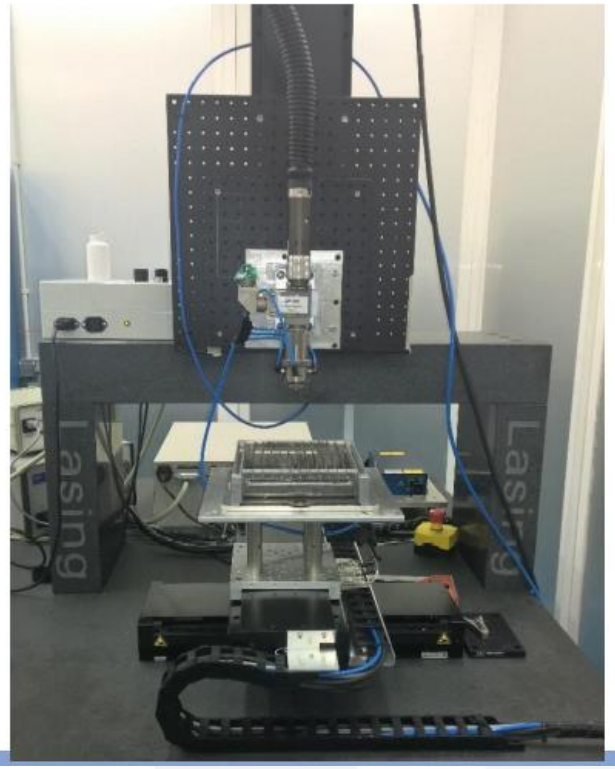
- ✓ ROFIN SCx30 CO_2 of maximum power 300W
- ✓ LASERLINE LDM 400/600 of maximum power 150W
- ✓ TRUMPF single mode fiber laser of maximum average power 400W
- ✓ ROFIN single mode fiber laser of maximum average power 1.500W
- ✓ ROFIN POWERLINE 20, IR (1064nm), 16W at 20kHz and ns pulses
- ✓ ROFIN POWERLINE 20 SHG, Green (532nm), 12W at 50kHz and ns pulses
- ✓ TRUMPF TruMark 6350, UV (355nm) Q-Switched Nd:YVO4 source, 5W, >250 µJ, 10ns, up to 120MHz
- ✓ TEEMPHOTONICS POWERCHIP, Green (532nm), up to 1kHz and sub-ns (<400ps)
- ✓ CRYLAS MOPA 266-50, UV (266nm), and sub-ns (<950ps)
- ✓ 3D micro-Fabrication module: microchip laser, Green (532nm), down to 650ps
- ✓ EOLITE HEGOA IR40/G20/UV10; 40W at IR (1030nm) and 30 ps pulses; with SHG and THG. Up to 2 MHz.
- ✓ AMPLITUDE SATSUMA HP2; 20W at IR (1030nm) and 400 fs pulses; with SHG and THG. Up to 2 MHz.

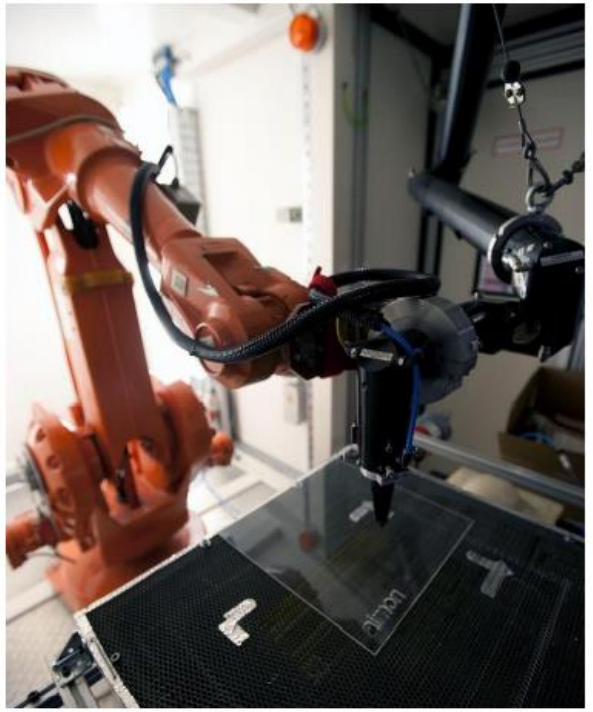




OTHER EQUIPMENTS

- ✓ Systems for beam characterization SPIRICON LBS-300 and Mode Check
- ✓ Power measurement systems
- ✓ Sensors for measuring diffuse radiation
- ✓ Autocorrelator for ultrashort laser pulses characterization
- ✓ High precision motion systems
- ✓ Micro cladding laser head and micro cladding powder feeder
- ✓ Cutting and welding heads, galvanometric scanners for high precision micromachining
- ✓ Optomechanical components for beam forming and guidance
- ✓ Robot ABB IRB 140
- ✓ Confocal microscope / Optical profilometer





This project has received funding from the European Union's Horizon 2020 research

- Larger Components
- 4 Axis
- Ceramics processing.
- Texturing and hardening of metals

Planned Work within NewSkin

DCU Open Innovation Test Bed

- Integrated micro/nano machining and surface hardening

Existing Equipment:

- 1.6 J Quanta Ray Pro 290 1064nm Nd:YAG laser
  - 30 Hz Rep Rate
  - 8 – 12 ns pulse width
- 4-axis Aerotech Motion and part handling system
  - Max substrate size: 0.5 m × 0.9 m flat or ⌀ 0.4m × 0.3 m

New Equipment (for NewSkin Project):

- Heat-treatment laser (IPG YLR 1kW CW) w/ Welding Head
- Femtosecond micro/nano machining laser (NKT OneFive Origami 10XP)
  - Controllable pulse width
  - Optical Setup for LIPSS and Optical Phase Modulation/Wavefront Shaping
  - In-situ metrology (Interferometry/IR Imaging)

Applications:

- Nano surface structuring/drilling
- Heat treatment/surface hardening
- Laser shock peening, laser polishing high aspect ratio piercing

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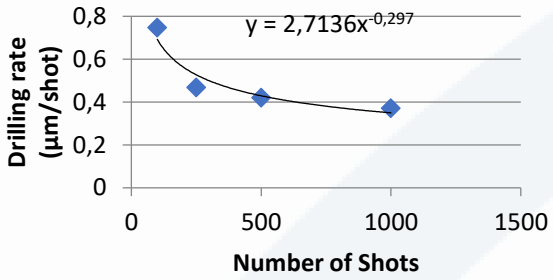
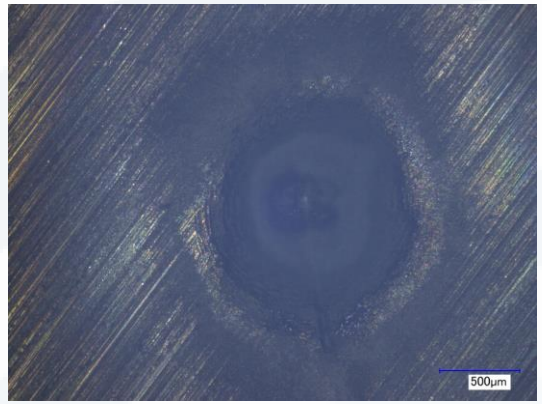
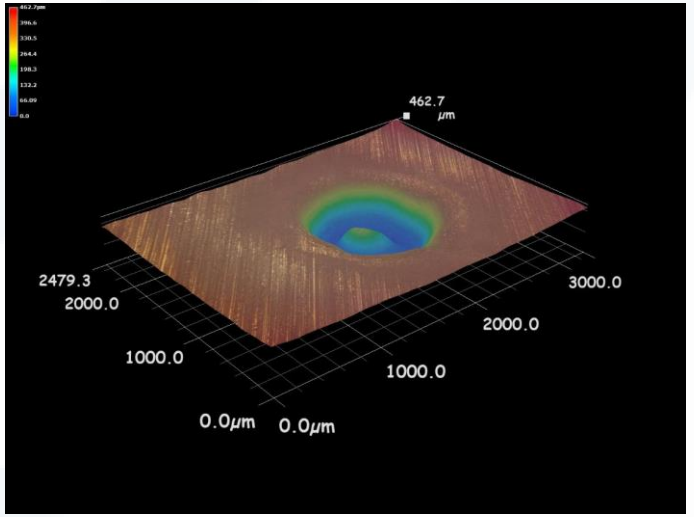
2 - Laser hardening and texturing for performance improvement (DCU)

- Combination of laser texturing and laser hardening
  - Reduced cavitation/bubble generation of propellers in liquid environments.
  - High wear environments in energy/mining sector





- Unique Selling Point:
  - Increased part lifetime
    - Reduced cavitation damage of propeller blades, bearings and motor components.
  - Low fiction applications
  - High wear resistance

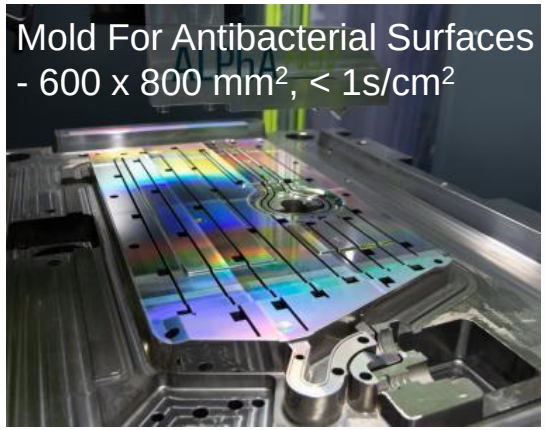


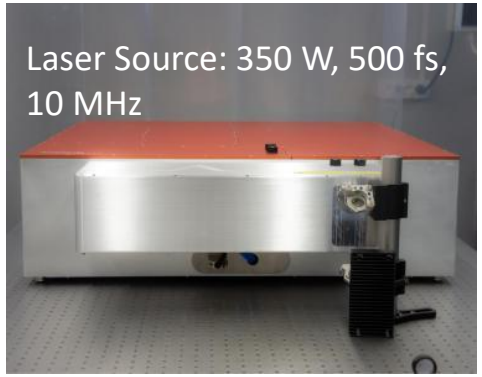
- Benefit for customers:
  - Lower part maintenance, enhanced reliability, lower energy requirements

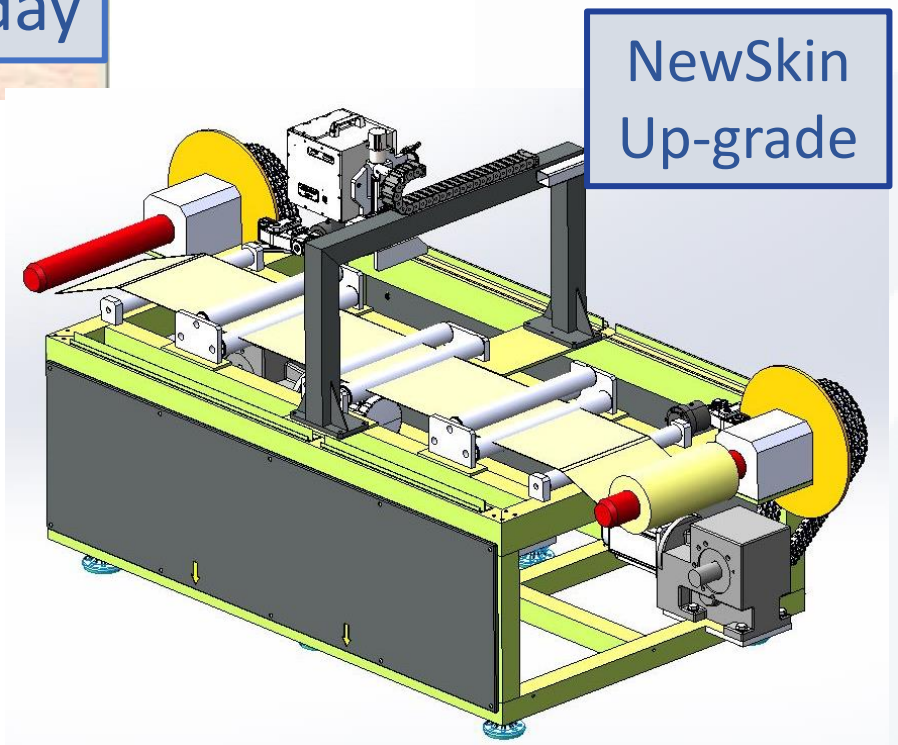
ALPhA NOV

Centre Technologique Optique et Lasers

- Continuous and Automated Roll to Roll laser processing
- Processing of Metal foils and other flexile materials
- Surface Texturing and functionalization (anti-icing, anti-fouling, anti-bacterial, self cleaning, etc.)







- Direct High Throughput Processing.
- Very large Surfaces with coils and rolls
- Compatible with Moulding, cold forming and other mechanical processes.
- Structures can be created before forming

NEW SKIN

Thank you!

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