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Development of a Semiautomatic Cleaning System for Optics of Biomedical Assemblies

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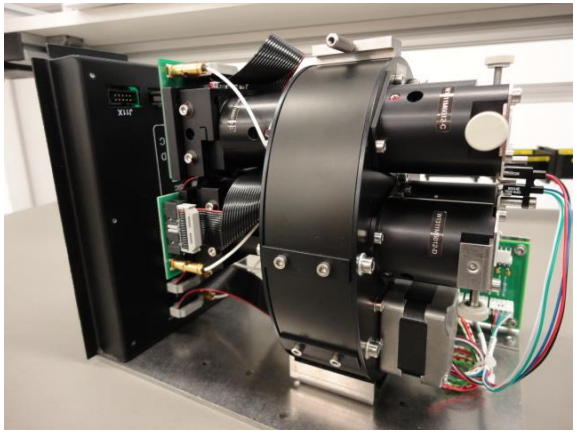
Content

1. Background and Motivation
2. Project Aims
3. Methods and Materials
4. Results
5. Summary and Conclusion
6. Device Demonstration

Introduction

- Cooperation with WILD GmbH
- Optical components are essential parts of medical devices
  - Ophthalmology: OCT-Scanner, laser system
  - In-Vitro Diagnostics: Filtermodules of PCR devices

Image source: www.ophthalmicdata.com



Why clean optics are so important?

A dirty optic can cause …

- … unwanted absorption bands
- … obscuration
- … losses in transmission
- … scattering

and this can lead to …

- … reduced sharpness or contrast of images
- … influenced measurement results
- … decreased LDT

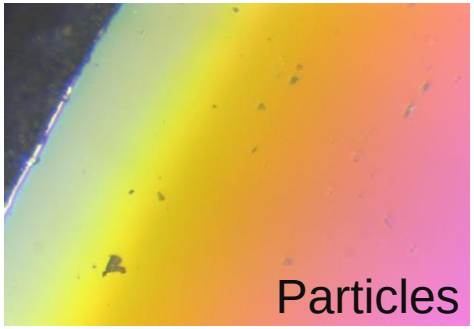
Types of Contamination

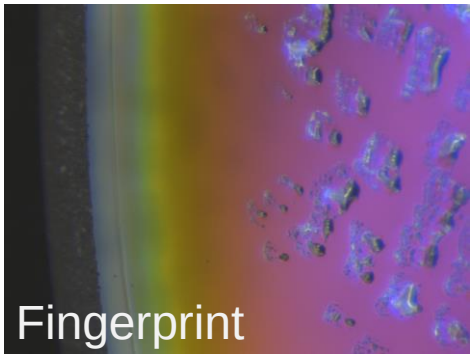
Contamination by Particles (dust)

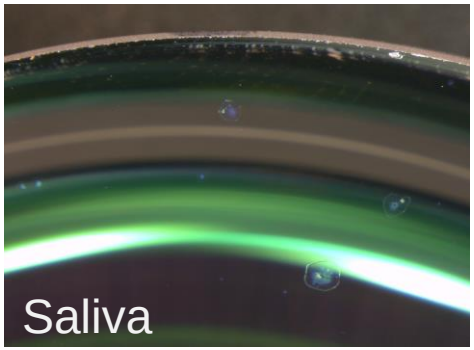
- Organic
- Inoragnic (abrasions)

Filmy Residues

- Dried out liquids
- Fingerprints







Cleaning Techniques

- Manual and machine-based methods
- Not every method suits to every type of dirt
- Method often used: ***Brush Technique***

1. Wet a cotton tip with solvent
2. Wiping in a spiral motion from the center outward
3. Carried out continuously in order to avoid drying traces

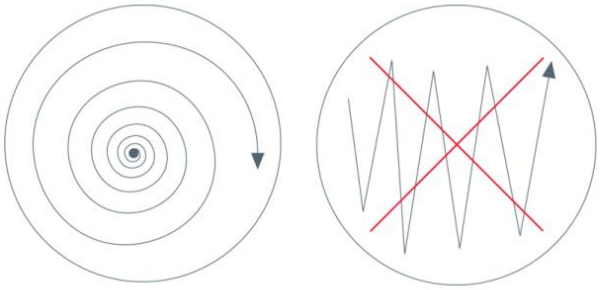


Image source: www.opti-tech.ca

Project Aim

- Development of a semiautomated cleaning system using „*Bush Technique*“
- Exclusively round optics, different curvatures and diameters
- Adjustable cleaning parameters
  - Solvent amount, rotational speed, max. force…

Benefits

- Prevention of scratches & digs of the sensitive surface/coating
- Economical use of solvents

Concept, Manufacturing and Materials

Concept

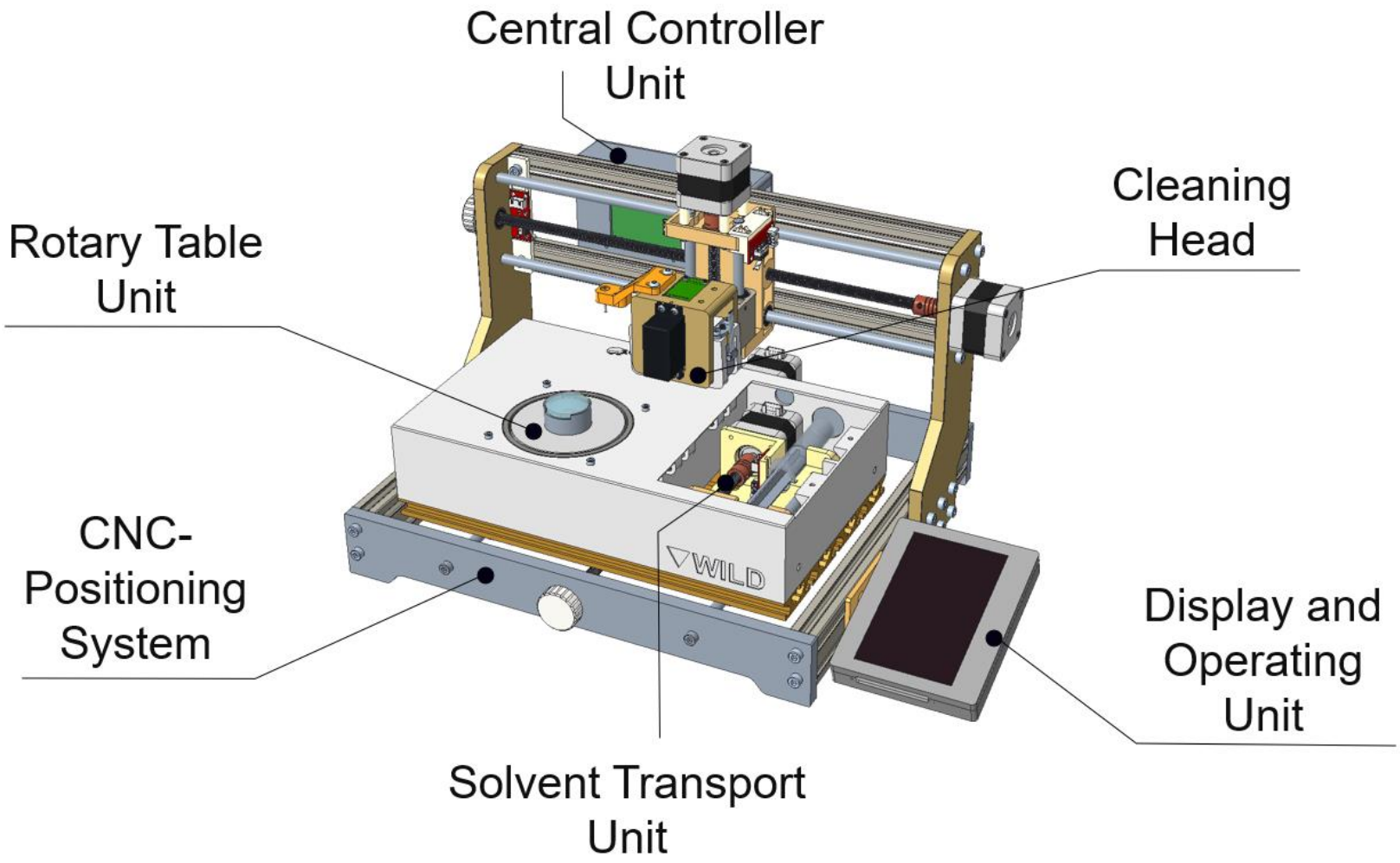
- Construction of a virtual 3D-Modell with CREO

Used Materials

- „*Rapid Prototyping*“
- Open-source hardware
- Standard parts

Image source: www.amazon.de

Hardware Overview



Central Controlling Unit

Main Tasks

- Control of the actuators
  - Steppers, servomotor, CNC-system
- Processing the sensor values
  - Load cell, leveling sensor, endstops
- Running the GUI

Image source: www.amazon.de

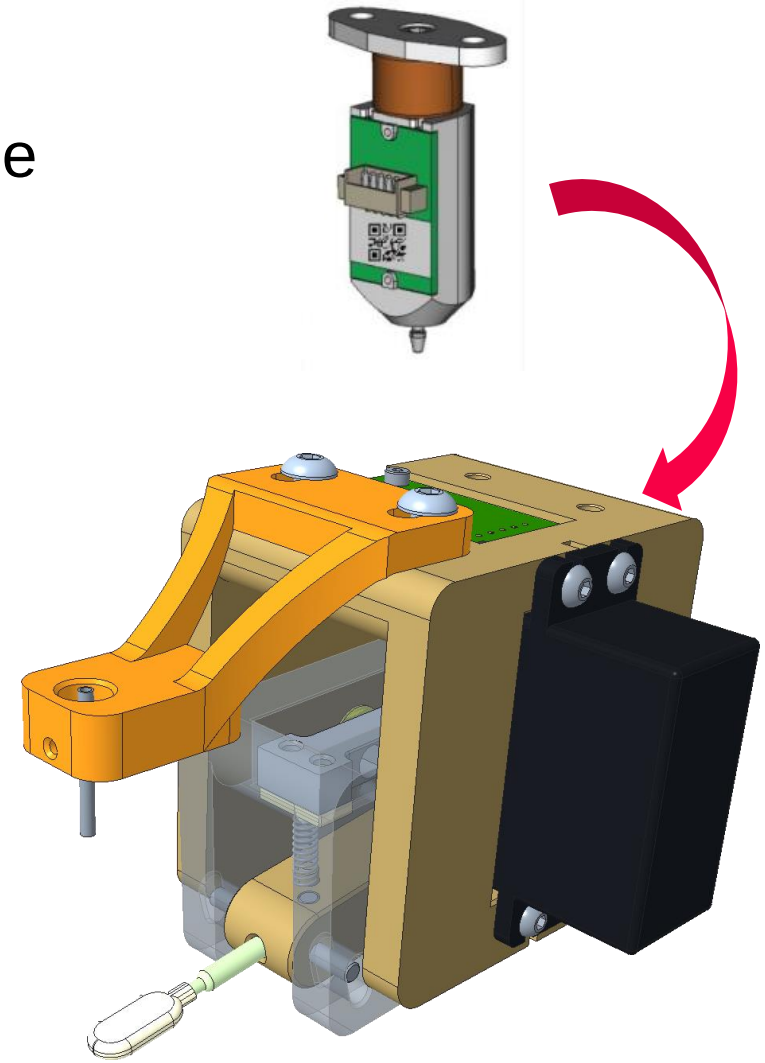
Cleaning Head

Functions

- Reading the force applied on the surface
- Scanning of the surface with leveling sensor

Features

- Angle adjustment through a servo motor (PWM controlled)
  - To wet Polyester-Pad
  - To change cleaning angle

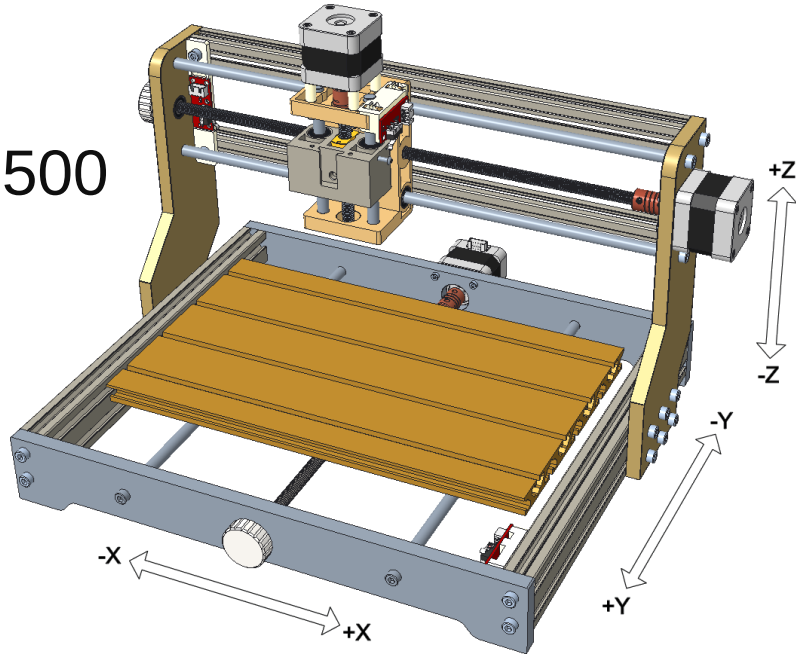


CNC-Positioning System

Functions

- Basis of the cleaning robot
- Drives X-, Y-, Z- carriers
- GCODE over serial interface
- Typical instruction:

G01 X10 Y25.10 Z-8.65 F1500



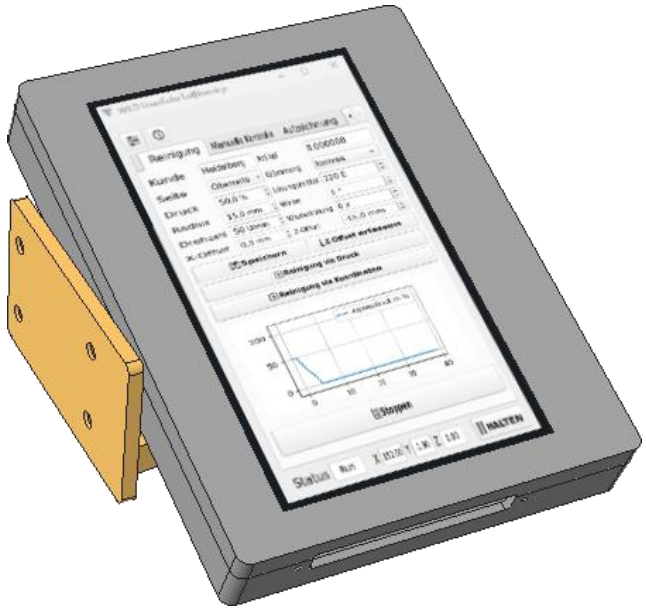
Display and Operating Unit

Function

- Interaction with the operator via 5“ Touchscreen

Operation Modes

- Standalone Mode
- Remote Control Mode



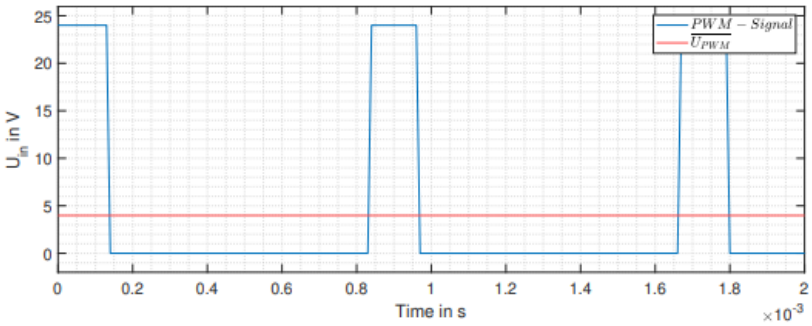
Rotary Table Unit

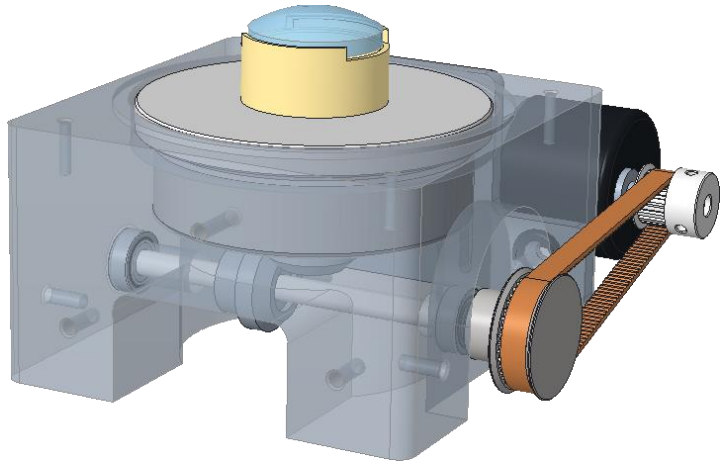
Functions

- Rotation of the inserted optic
- Holding the optic via press fit

Feature

- Adjustable speed (PWM)





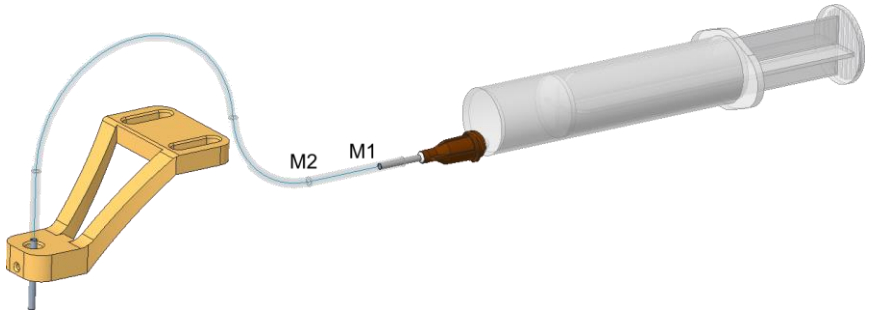
Solvent Transport Unit

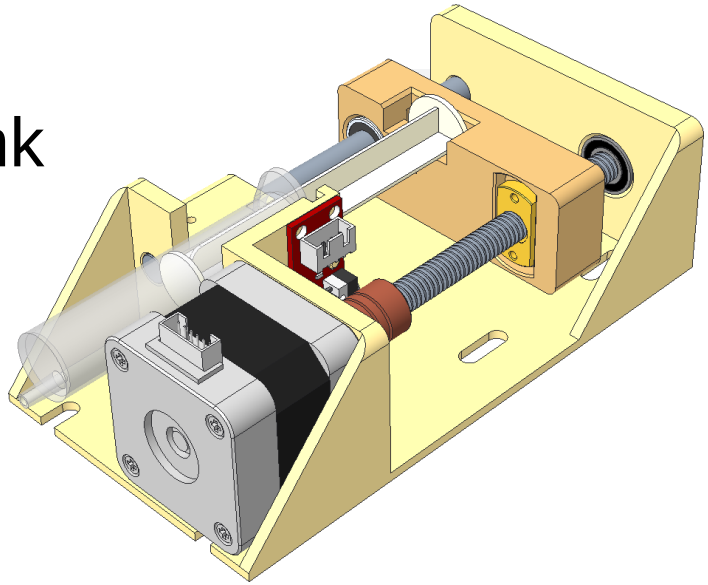
Functions

- Non continuous transport of solvents to the cleaning head

Feature

- Dosable in µL steps
- Detection of empty solvent tank





Software

Programing

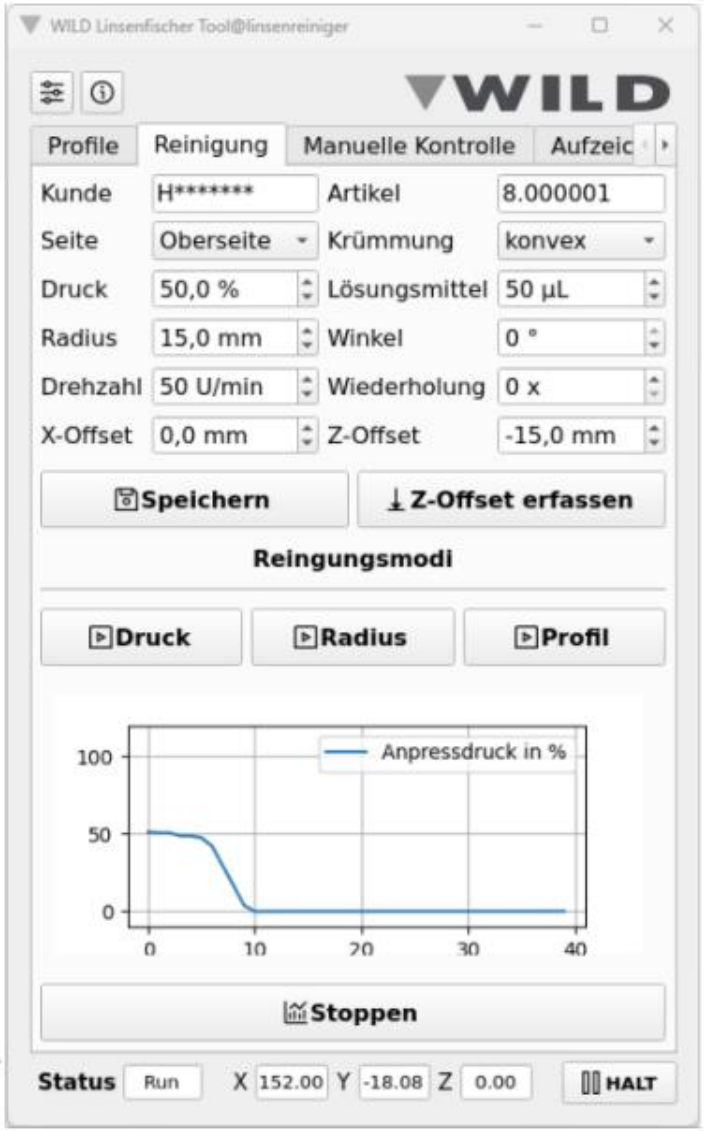
- Python
- 9 modules
- Open source libraries

Concepts

- Multithreading
- Lock-Objects
- Signals

Development Tools

- VS-Code
- QT-Designer



Cleaning Modes

Cleaning by Pressure

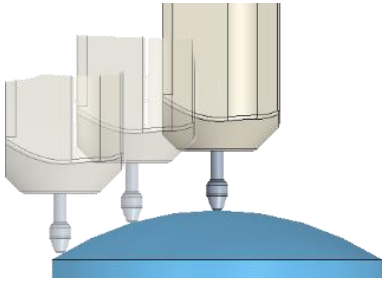
- The force applied to the surface is permanently regulated
- No need to scan the surface

Cleaning by Profile

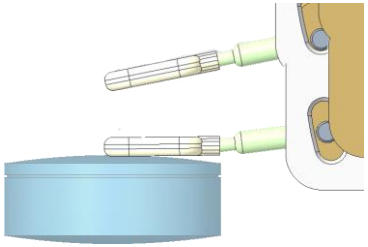
- Requires probing of the surface
- Profile (XZ-coordinate pairs) will be traced afterwards

Investigations

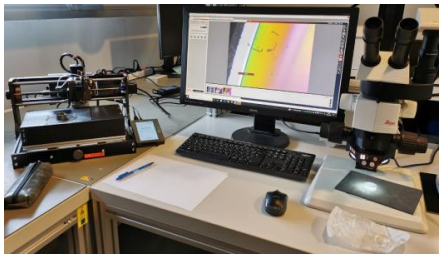
- Accuracy of the two probing sensors
  - Capazitive proximity switch
  - Leveling sensor



- Comparison between the cleaning modes



- Cleaning efficiency
  - Digital microscope
  - Special image processing software

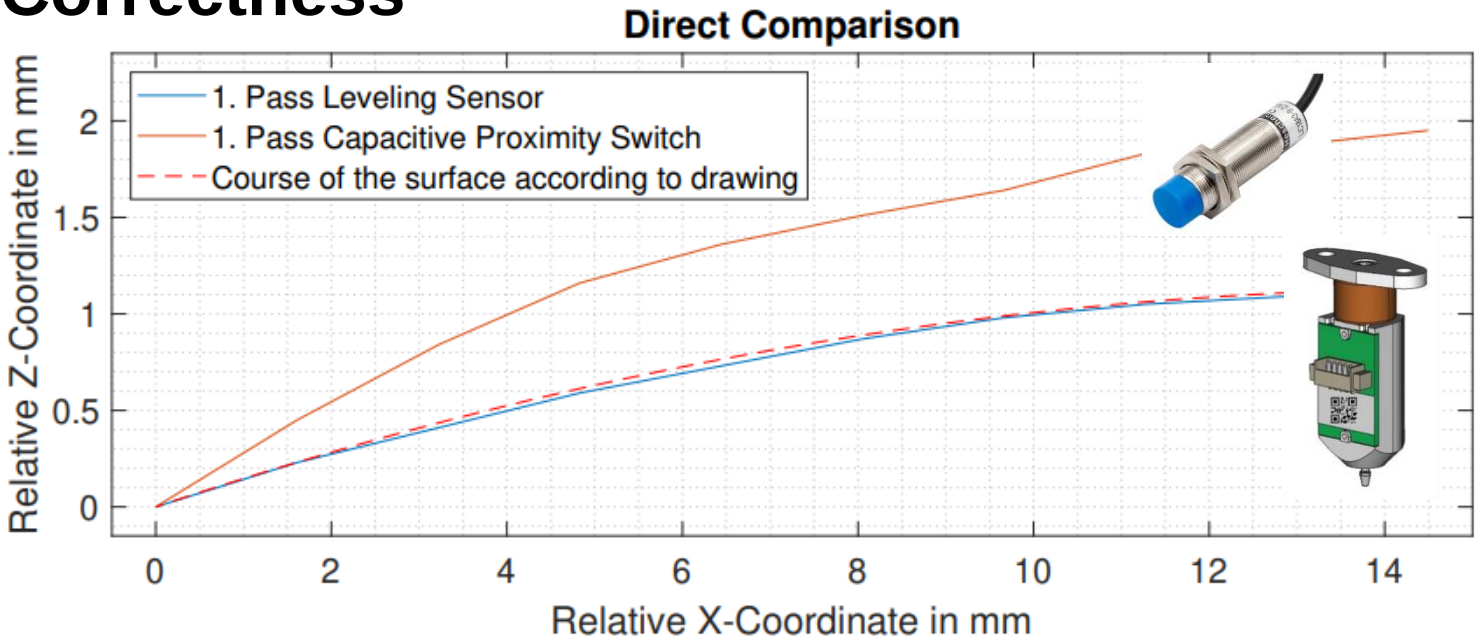


Probing Sensors

Measurement uncertainty (precision)

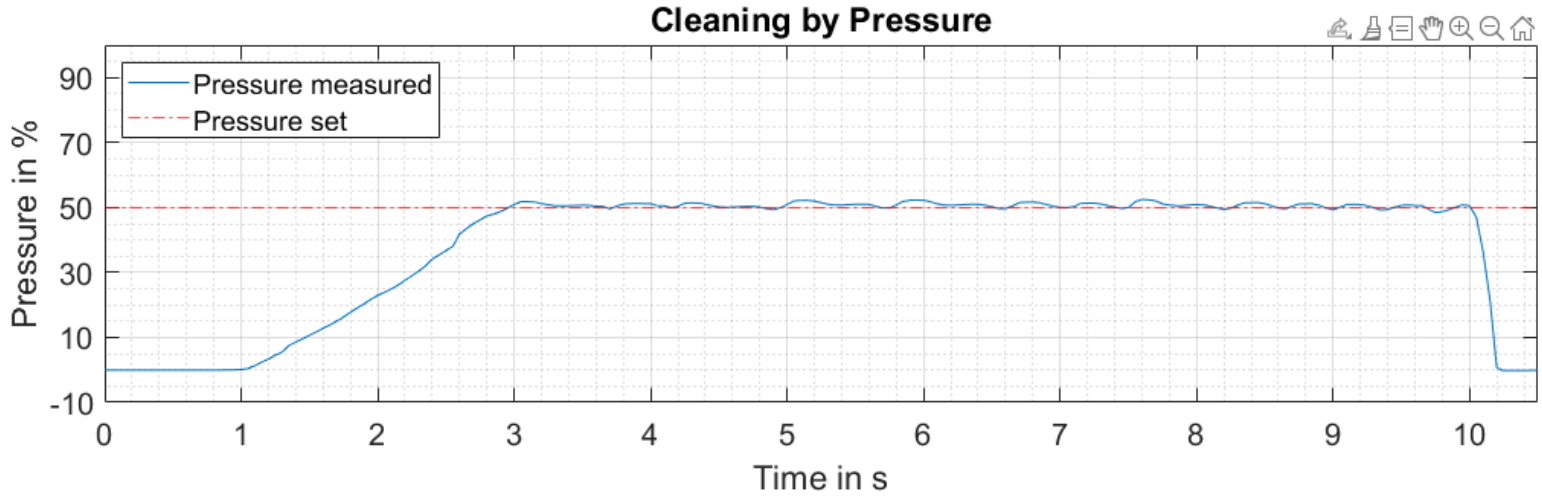
- Leveling sensor: 10.5µm
- Proximity switch: 50.2µm

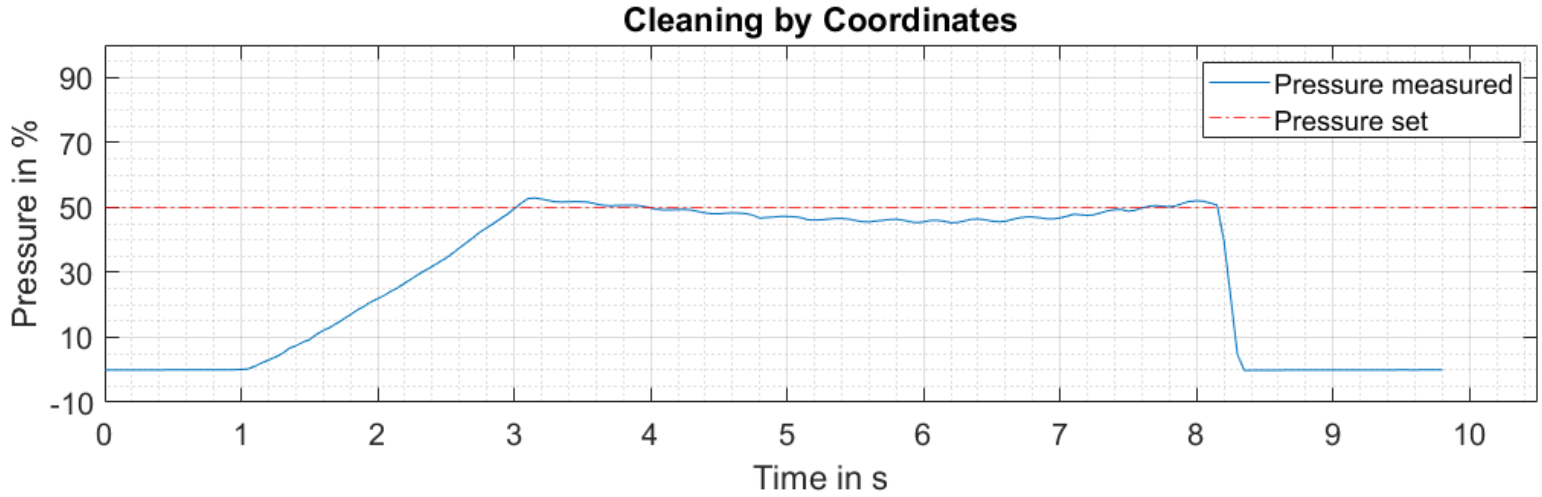
Correctness



Comparison of Cleaning Modes

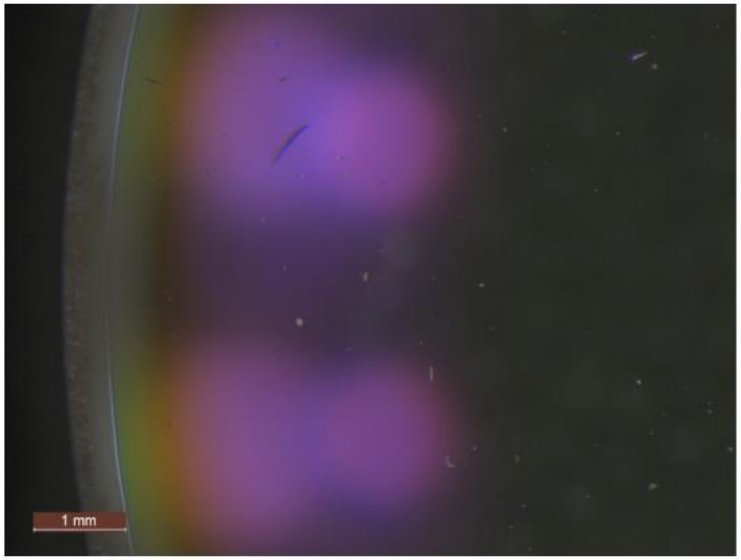
www.amazon.de



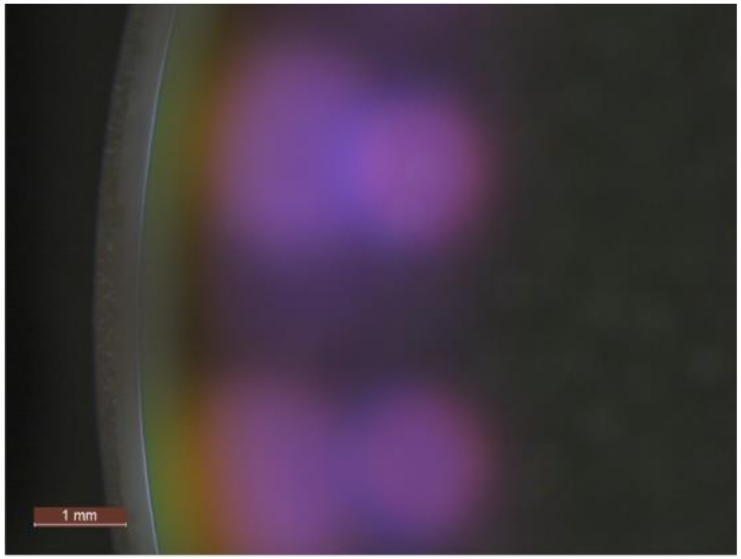


Particular Contaminations

Before cleaning



After cleaning

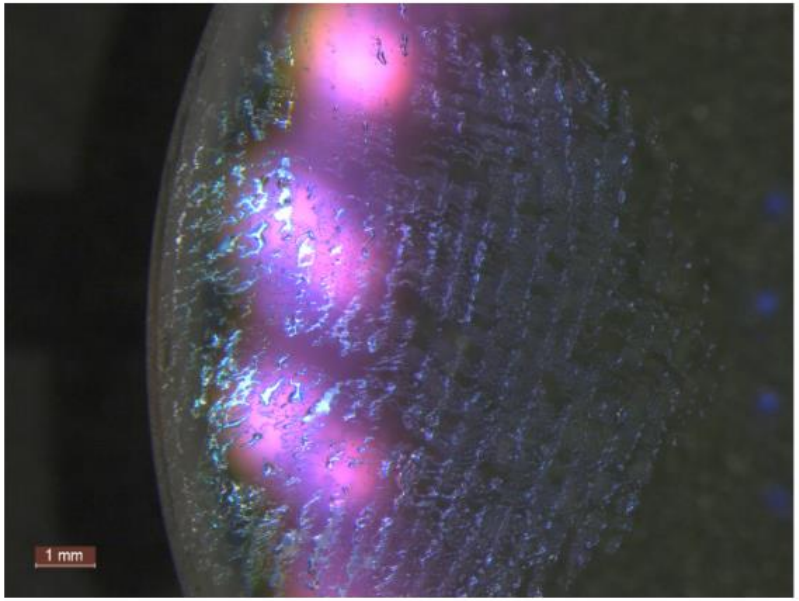


- No contaminants observable anymore (with naked eye)
- Quantified by: Classification of Cleanability:

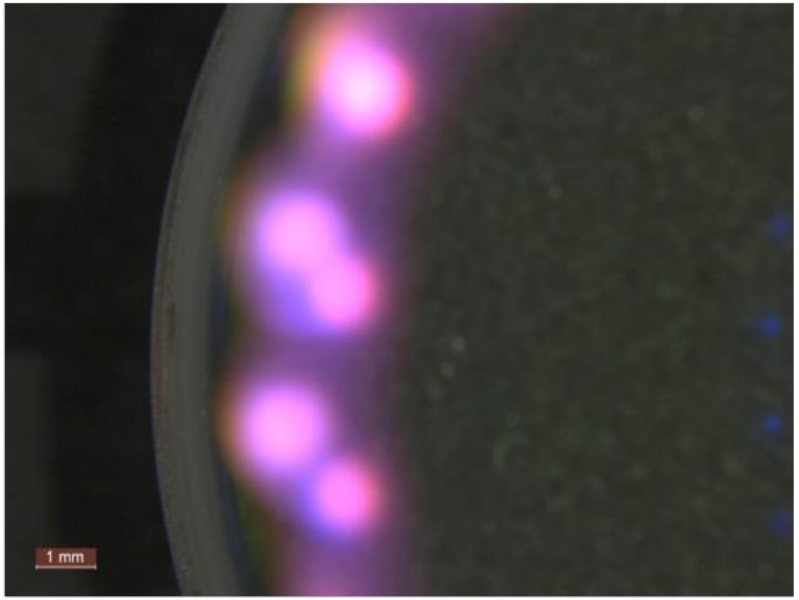
  Efficiency > **97%** (for particles >10µm)

Greasy Fingerprints

Before cleaning



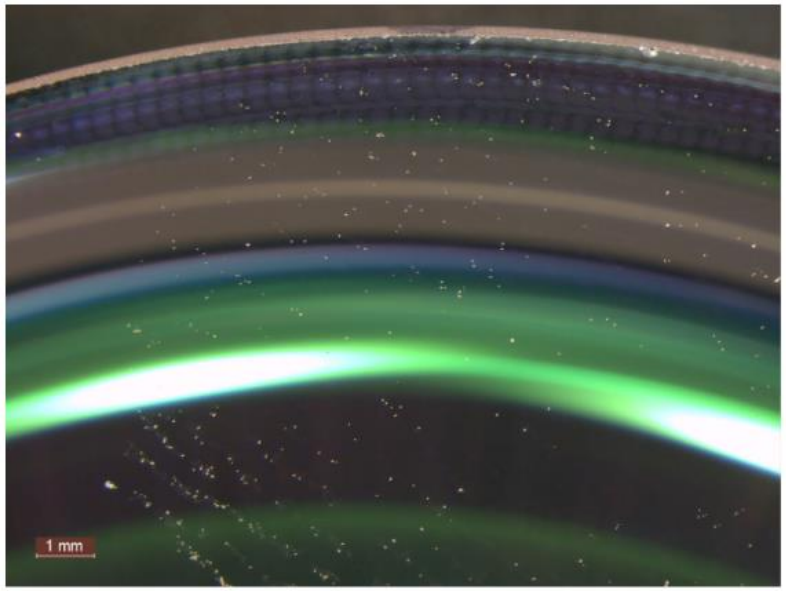
After cleaning



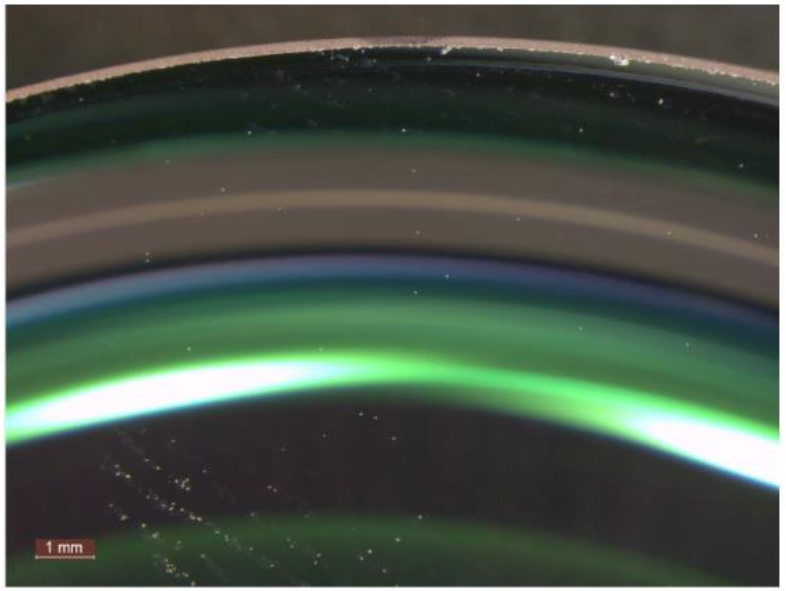
All residues could be removed!

Sweaty Fingerprints and Particles

Before cleaning



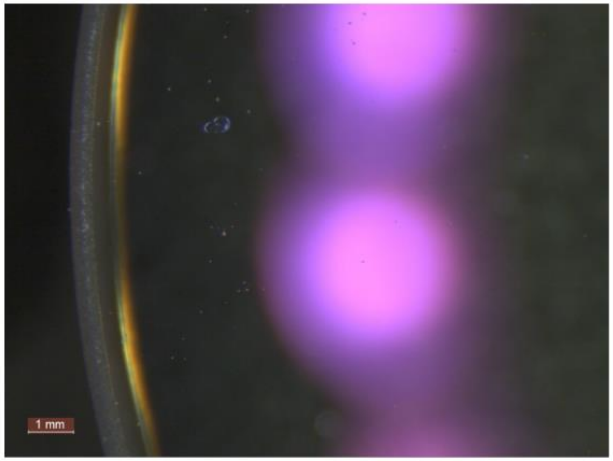
After cleaning

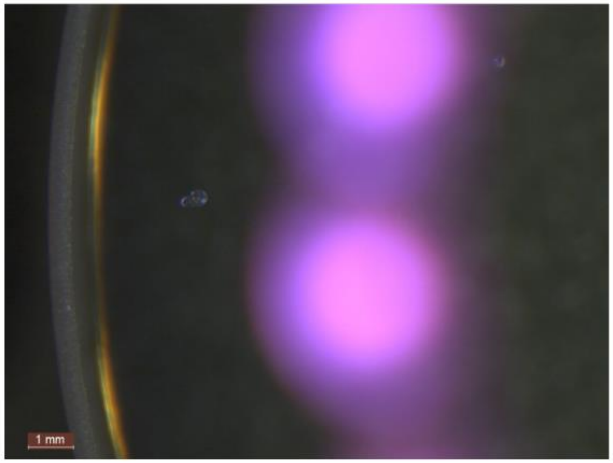


Not all contaminations could be removed!

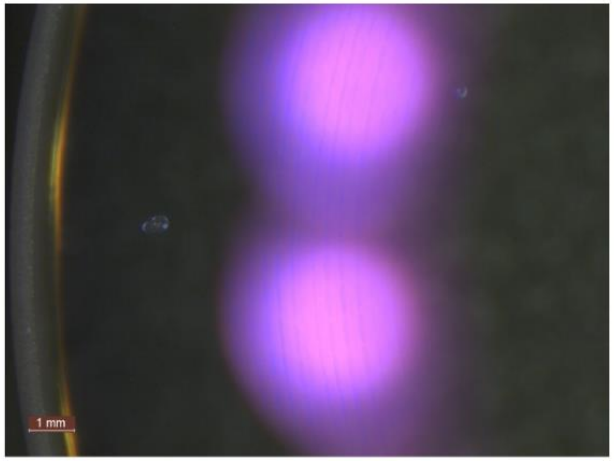
Dried Out Saliva Droplet

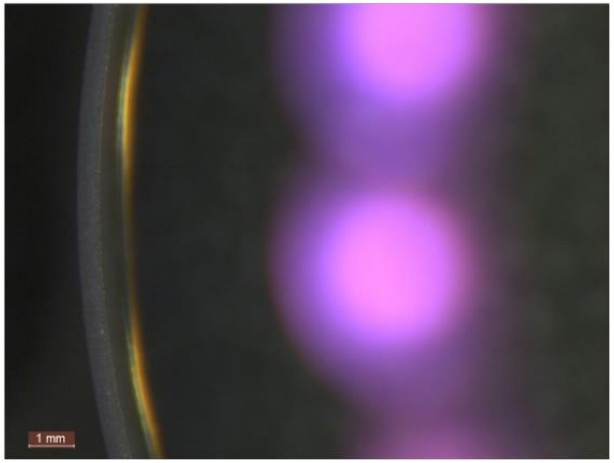
Before cleaning





After cleaning





Summary and Conclusion

- Robot works as expected 
- No damages due cleaning or sampling process 
- No waste of solvents anymore (100% usage) 

Cleaning efficiency

- Particular contaminations, greasy Fingerprints 
- Sweaty Fingerprints, saliva-droplets 

→Device has its limits!

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