



**DGSV**

Deutsche Gesellschaft für  
Sterilgutversorgung e.V.

**Dr. Matthias Tschoerner**

**Characterization of surface  
alterations on surgical  
instruments caused by  
silicates and titanium oxides**

WORLD CENTER  
FOR

# Characterization of surface alterations on surgical instruments caused by silicates and titanium oxides

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## 1: Characterization of surface alterations

EDX-Analysis (*Scanning Electron Microscopy with Energy Dispersive X-ray Spectroscopy*)

XPS-Analysis (*ESCA / XPS – X-ray Photoelectron Spectroscopy*)

Cytotoxicity (*EN ISO 10993-5; EN ISO 10993-12*)

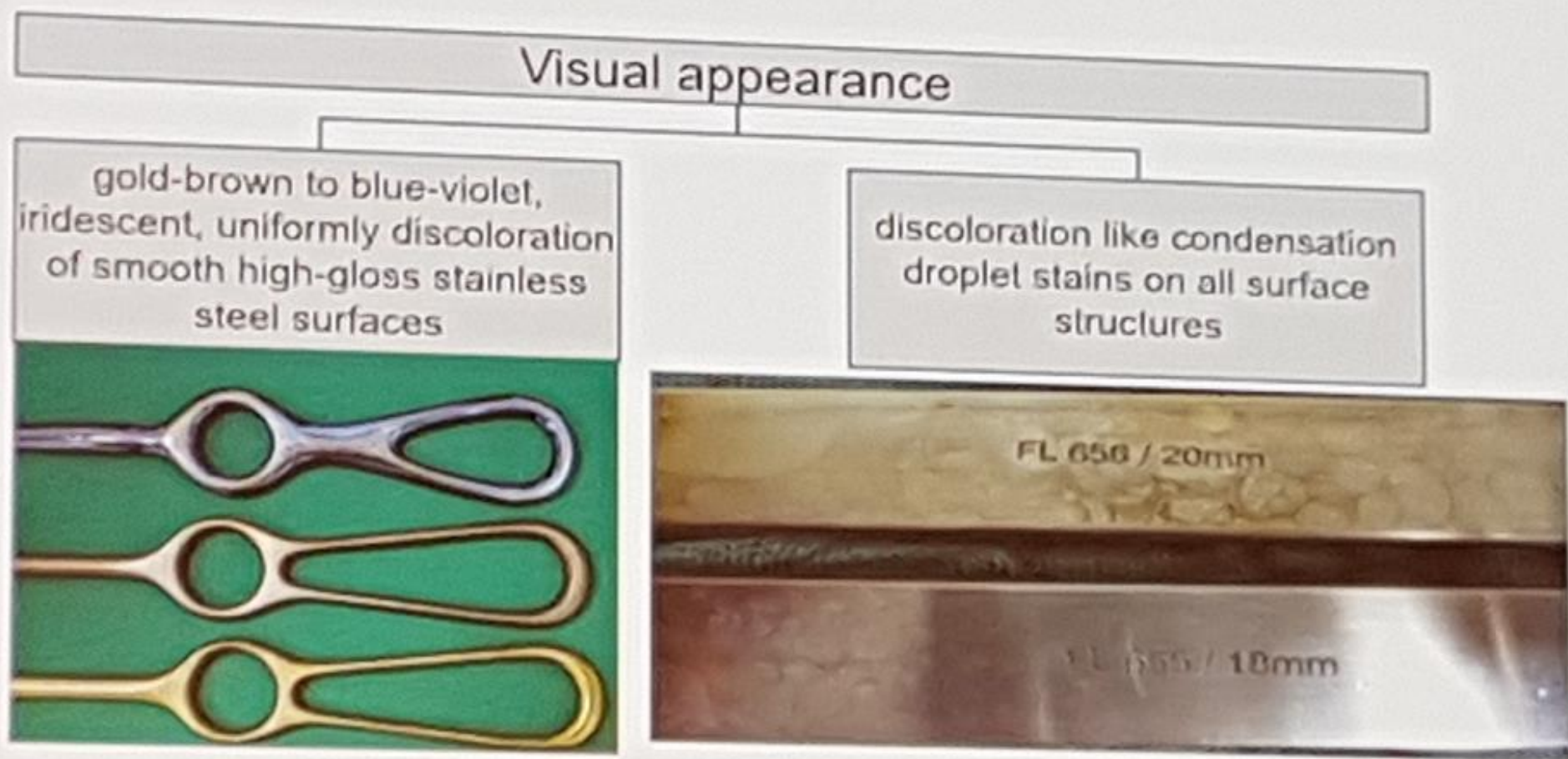
## 2: Mechanical Stressing

Mechanical Stress: elastic and plastic deformation with scanning electron microscopic imaging

## 3: Conclusion

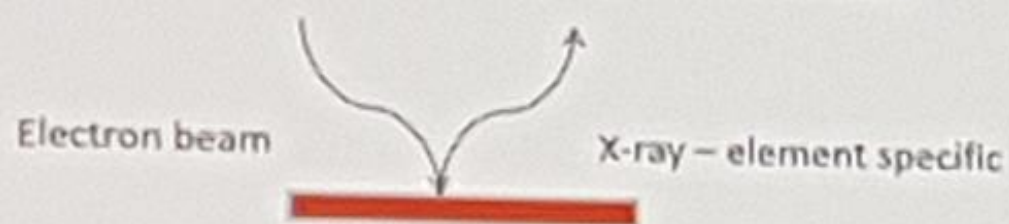


# Surface alterations on surgical instruments after reprocessing

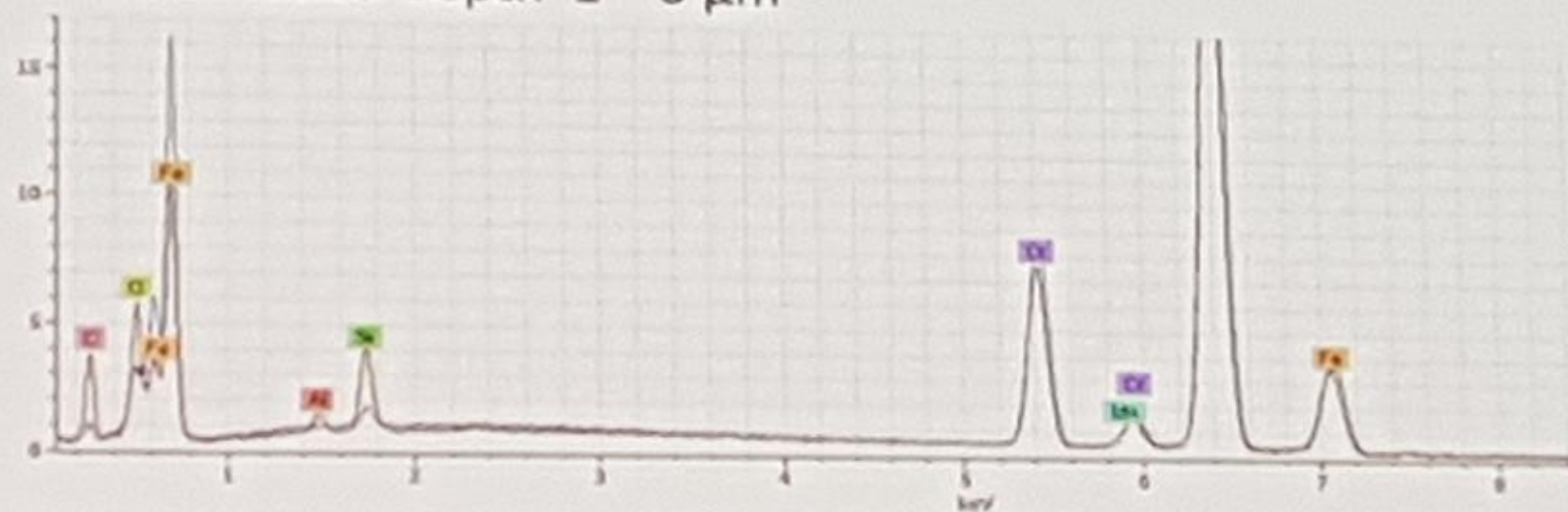


## Characterization of surface alterations

### SEM-EDX, Scanning Electron Microscopy with Energy Dispersive X-ray Spectroscopy



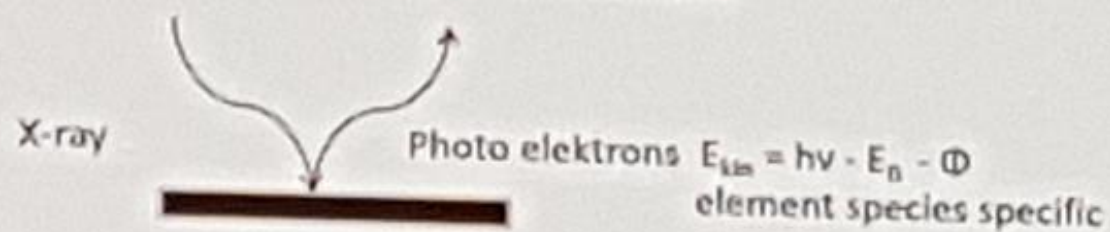
- Information depth 1 – 3  $\mu\text{m}$



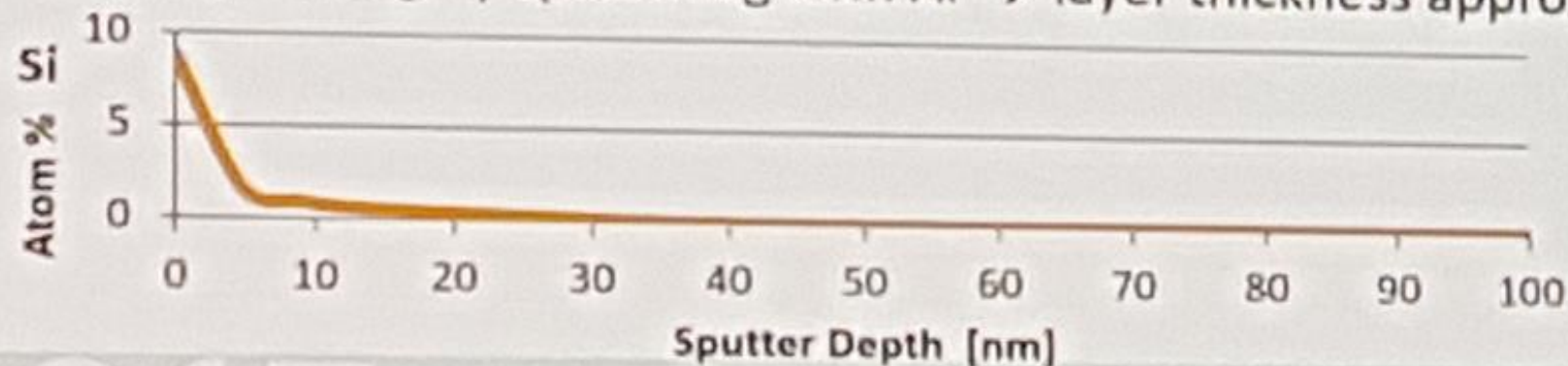
Tschöerner, M., ZAHN PRAX 16, 5, 274-277 (2013)

## Characterization of surface alterations

### ESCA / XPS – Electron scattering for Chemical Analysis / X-ray Photoelectron Spectroscopy



- Information depth 1 – 10 nm
- Si  $E_b$  102,8 eV  $\rightarrow$  chemical shift specific for bonding state: SiO<sub>2</sub>
- Depth profiling by sputtering with Ar  $\rightarrow$  layer thickness approx. 10 nm

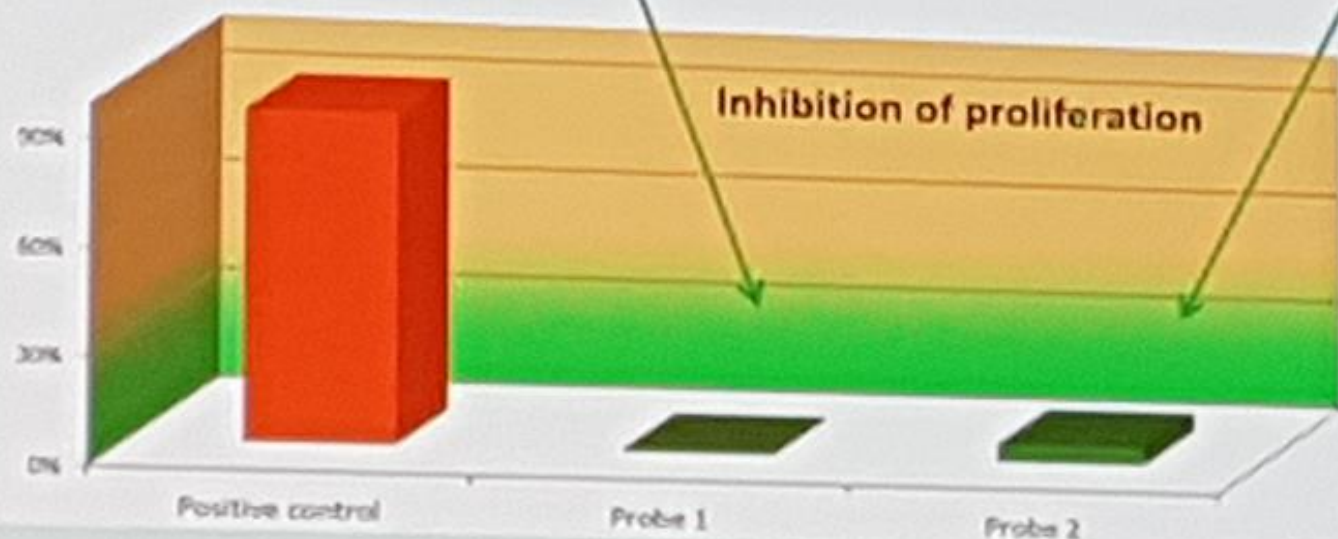


Tschoerner, M., ZAHN PRAX 16, 5, 274-277 (2013)

## Cytotoxicity

Strong spots due to silicate deposits during sterilization in the autoclave.

EN ISO 10993-5,  
EN ISO 10993-12



*EDX and XPS-Analysis:*

**Probes from clinics**

Osteotom

Wound hook golden

Wound hook green

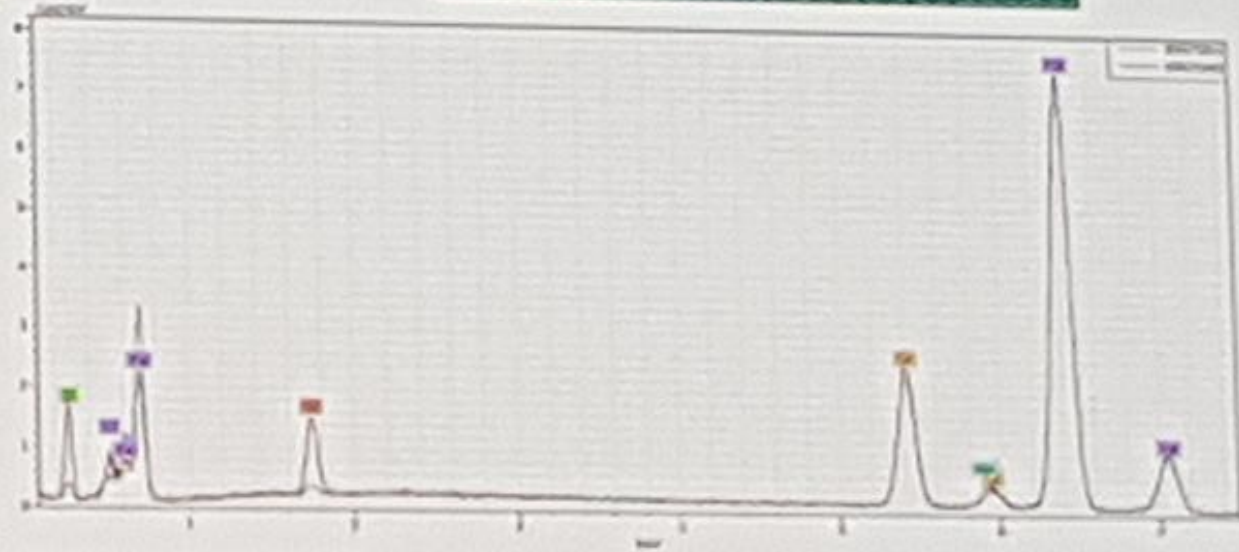
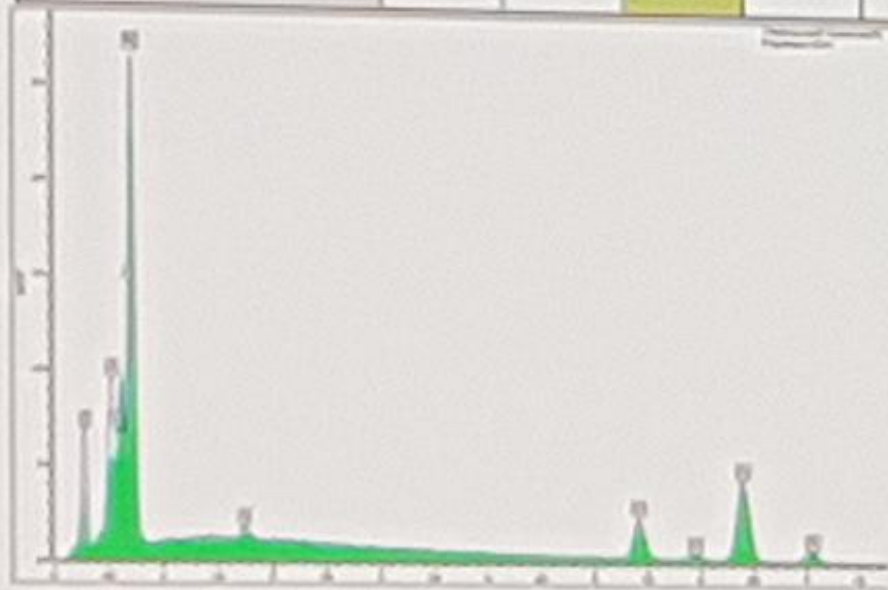
Wound hook blue

Wound hook grey



## Osteotom, EDX

Element analysis	C	O	Si	Cr	Fe
Instrument material	8,23	2,91	0,41	13,7	73,2
Discolored Surface	4,49	0,86	0,37	14,4	79,9





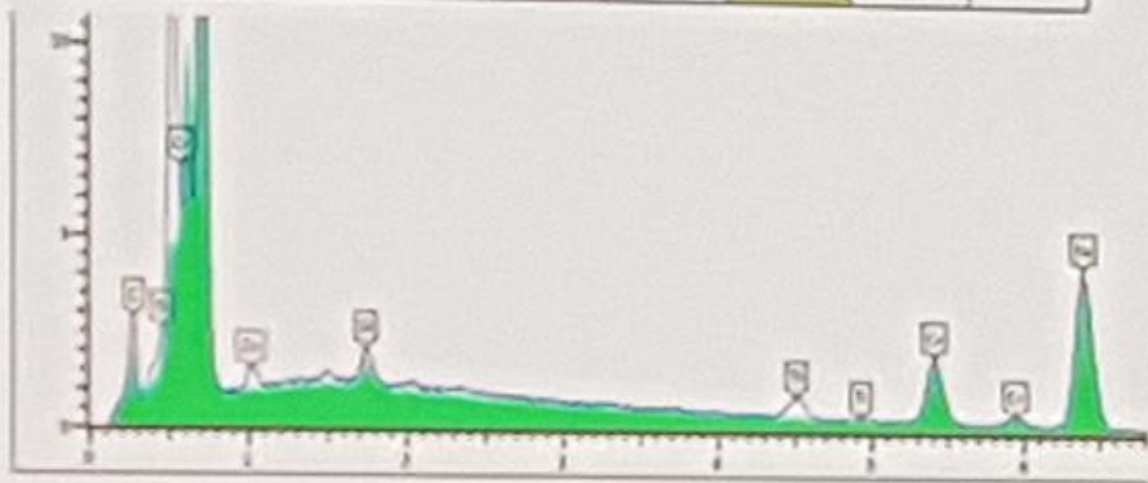
## Osteotom, XPS

Element analysis	C	O	Si	Ti	Cr	Fe
Discolored Surface	79	15,4	1,4	-	0,4	0,4
Discolored Surface, 4 min sputtered	56	23,2	1,5	-	3,9	6,6

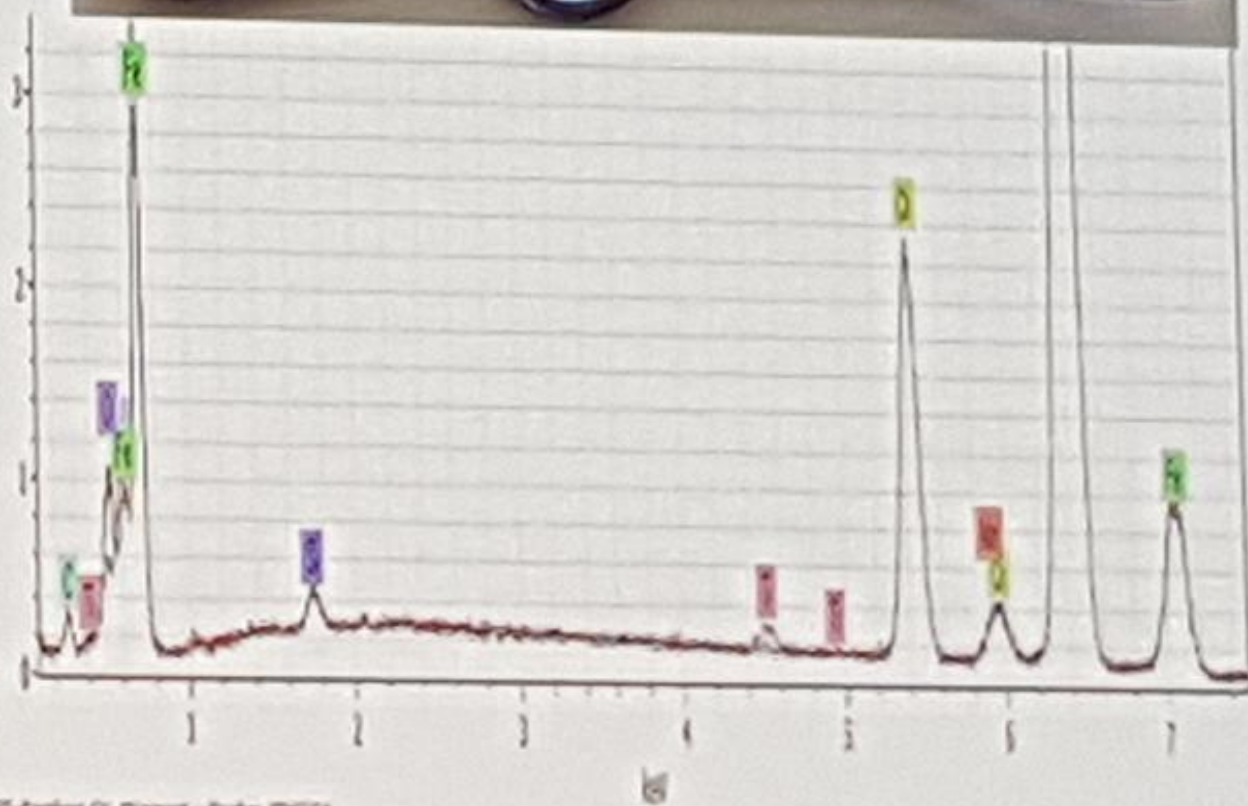


## Wound hook blue, EDX

Element analysis	C	O	Si	Ti	Cr	Fe
Instrument material	2,02		0,58	0,37	13,7	83,3
Discolored Surface	0,9	1,59	0,22	1,24	8,35	86,0



EDX-Analyse Fa. Romulph - Probe WIT Blue

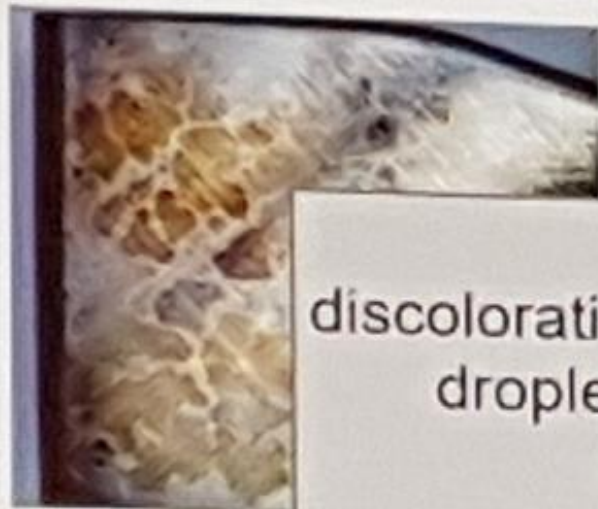


EDX-Analyse Dr. Wiegert - Probe WIT Blue

Wound hook blue, XPS



Element analysis	C	O	Si	Ti	Cr	Fe
Discolored Surface	76	17,3	0,8	1,5	0,3	0,7
Discolored Surface, 4 min sputtered	17	46,9	-	13,8	1,9	18,8



discoloration like condensation droplets on all surface structures



Silica deposits (ca. 10 nm)

silicic acid deposits caused by contaminated sterilization steam



gold-brown to blue-violet, iridescent, uniformly discoloration of smooth high-gloss stainless steel surfaces



Titanium oxide layers (ca. 10 nm)

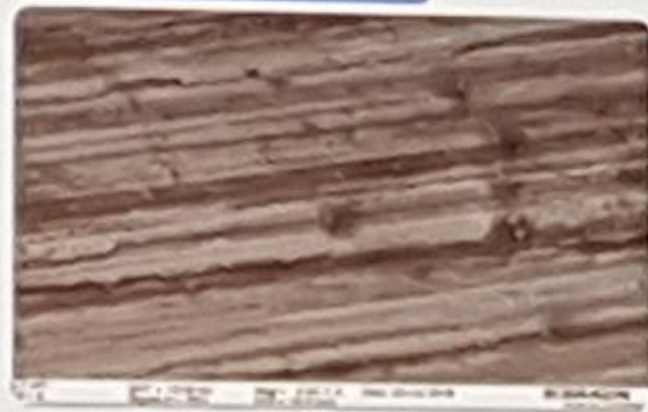
caused by traces of titanium minerals in silicate-containing cleaners

# Mechanical Stressing on Instruments with Titanium Oxide Layers and Silica Deposits

→ Bending test in the area of elastic and plastic deformation with SEM imaging before and after the test (SEM, resolution < 2  $\mu\text{m}$ )

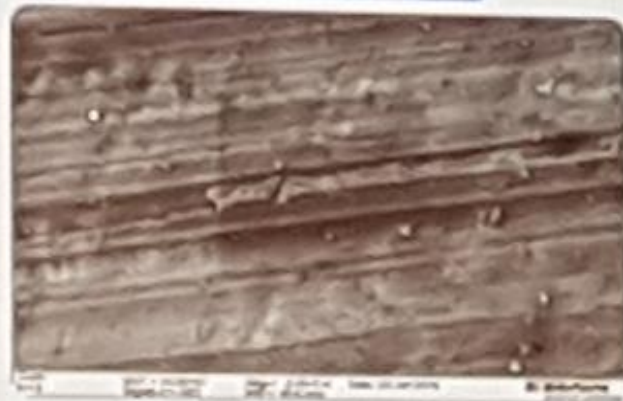
- Start

**Picture A**  
(start condition)



- Bending 2 mm  
(**elastic deformation**)

**Picture B1**  
(elastic deformation)



- Bending 4 mm  
(**plastic deformation**)

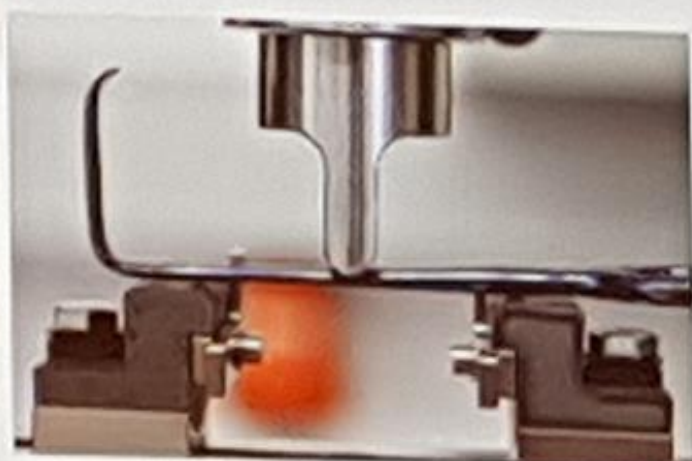
**Picture B2**  
(plastic deformation)



## Bending Test



Method of bending test



### Parameter:

Deformation:	2 mm (elastic) 4 mm (plastic)
Initial force:	5 N
Test speed :	5 mm/min

Osteotom:

100

500

1000

5000

Start condition

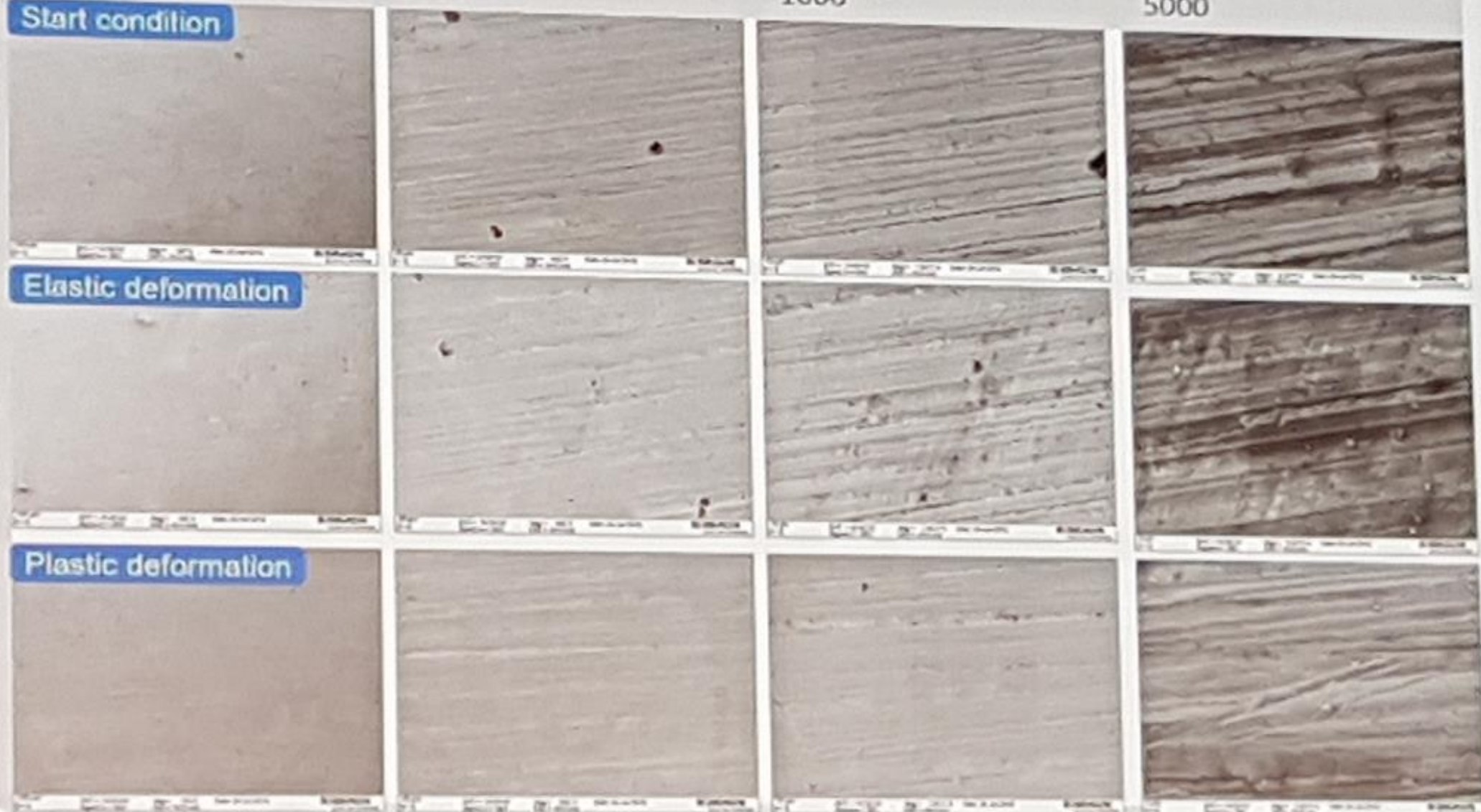
A

Elastic deformation

B1

Plastic deformation

B2



Wound hook blue

100

500

1000

5000

Start condition

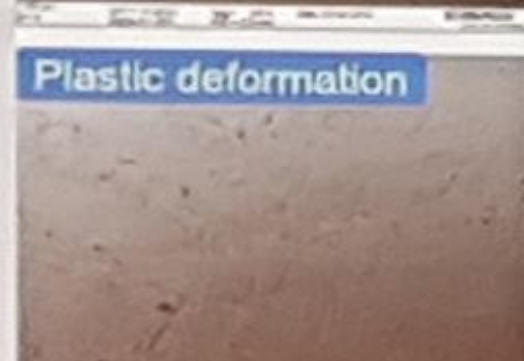
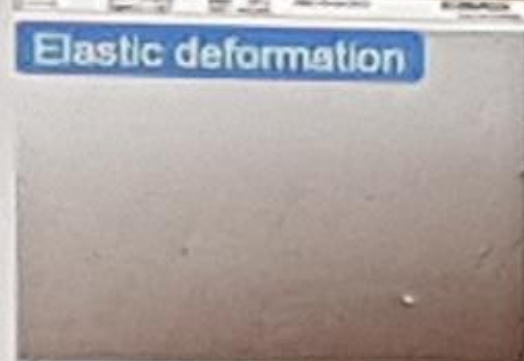
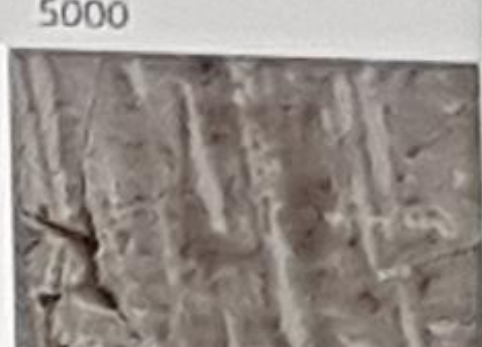
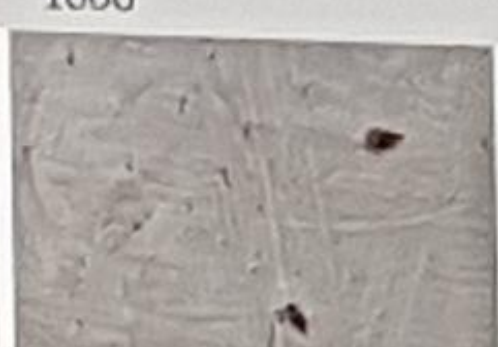
A

Elastic deformation

B1

Plastic deformation

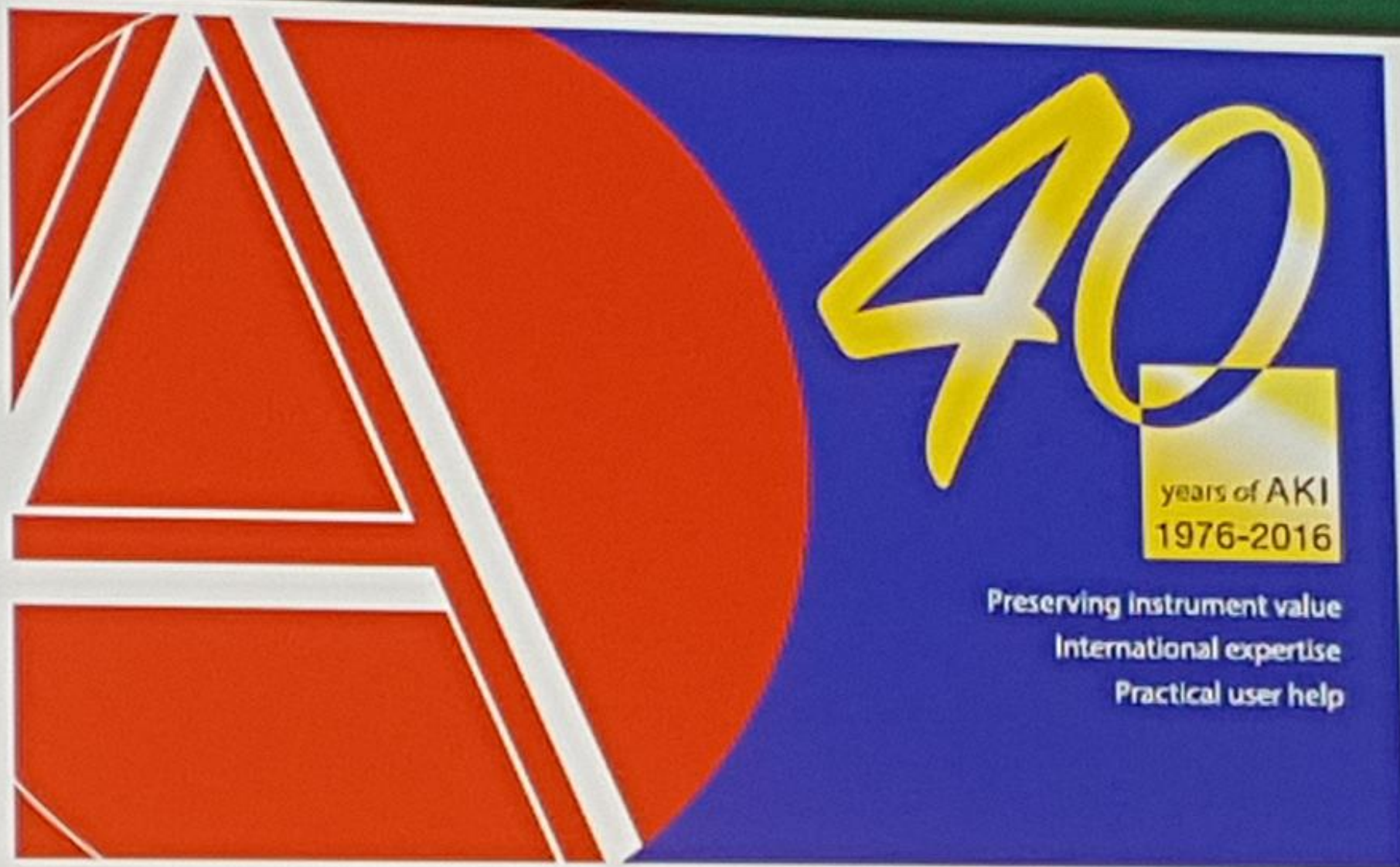
B2





## Conclusion:

- The discolorations are caused by a few nm thin titanium oxide layers and silicate layers.
- After mechanical stressing, no changes in the surface structure were observed for all characterized linings. No disruption or detachment were observed with SEM.
- Due to mechanical stress, no particles of SEM detectable size were separated from the test instruments.
- The investigated deposits show no cytotoxic properties.



Thanks for your attention! Questions?