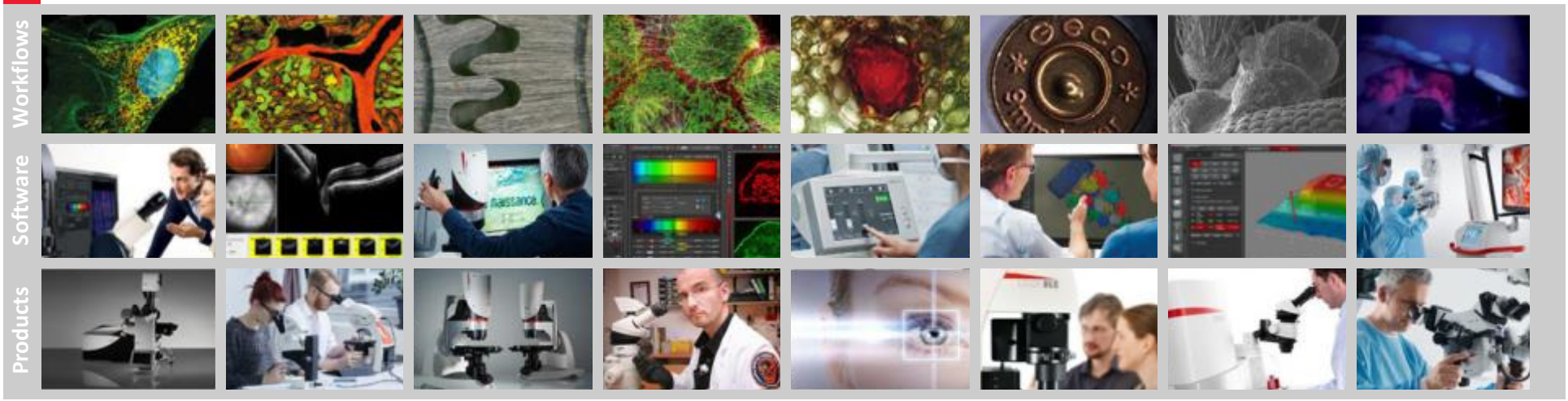
From Eye to Insight



Webinar

New cleanliness workflow from Leica and Pall

Dr. Nicol Ecke Leica Microsystems
Christophe Goasdoué Pall Corporation

Science Lab

New cleanliness workflow from Leica and Pall

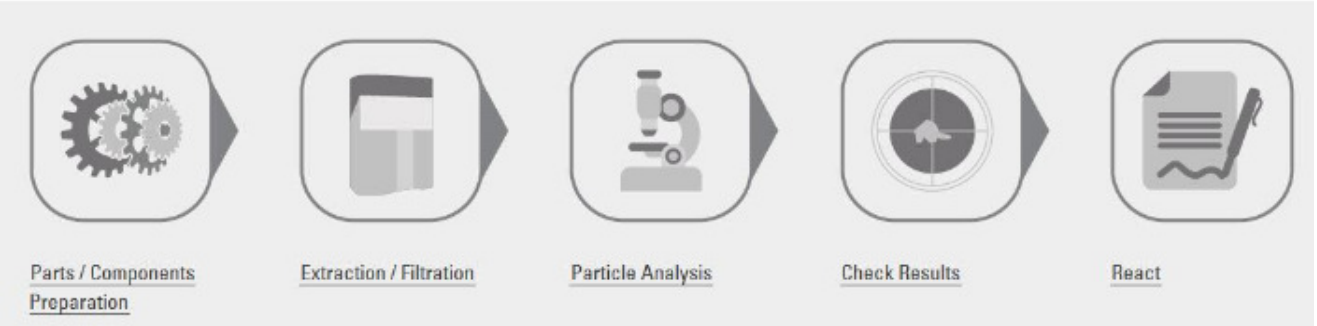
Pall Corporation

The global leader in high-tech filtration, separation and purification

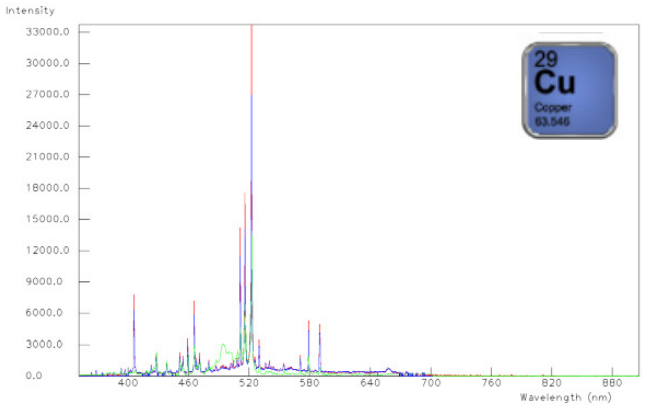
DANAHER

MICROSYSTEMS

The world leader in microscopes and scientific instruments



New LIBS (Laser Induced Breakdown Spectroscopy) System available soon!



Exciting product news: optical & chemical identification of particles

Topics

Part 1 EXTRACTION

- Why component cleanliness is important
- Measure to control
- Standards for Component Cleanliness
- Pall Component Cleanliness Cabinets

Part 2 FAST & RELIABLE OPTICAL and CHEMICAL CLEANLINESS ANALYSIS

- Process chain: damage potential and source of particles
- Combine optical and chemical analysis with LIBS (Laser Induced Breakdown Spectroscopy)
- Dedicated workflow solutions fitting to each need

Why do components need to be clean?

- Fluid systems become more sophisticated and less tolerant to dirt and so controlling and measuring cleanliness of wash-fluids has become a vital part of the manufacturing process.
- Reducing contaminant levels has a positive influence on both Catastrophic and Wear related failures.

Main drivers

Engineering

. Tighter clearances / tolerances*
. Higher degree of surface finish
. Higher operating pressure
. Reduced dimensional footprint

Consequences

Manufacturing

. Cleaner manufactured parts & components
. More efficient washing process
. Cleaner wash-fluids

* 4µ tolerances on a piston rings for instance
Source: Mahle





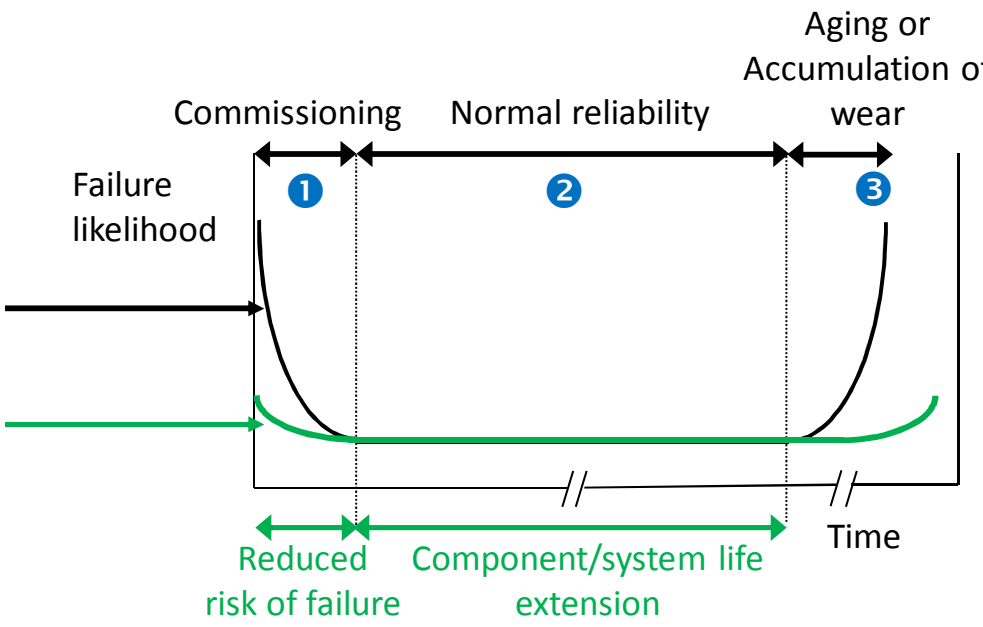
Cleanliness, the best insurance to avoid failures

Clean components help

- Reduce the probability of catastrophic failures during the commissioning phase (❶)
- Extend the service life of components once the system is in operation phase (❷)

Higher risk of catastrophic failures occur when the system is not initially clean

Quicker & safer commissioning achieved with a clean system. Direct contribution to the life extension of the component

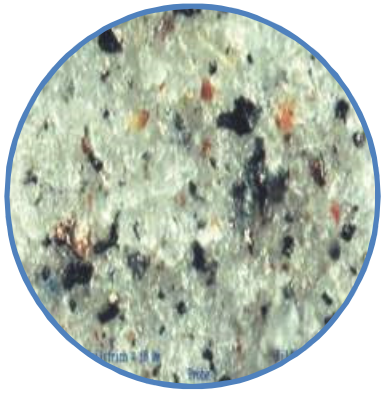


The measurement of Component Cleanliness is a critical part of the manufacturing/assembly process control and continuous improvement practice

Measure to control

Size thresholds to consider

From a few microns to a few millimeters…depending upon components and cleanliness specifications



Built-in contaminants (manufacturing and assembly)

- Casting and machining debris (silica, metallic)
- Hose debris (rubber, metallic)
- Polishing compounds (alumina)
- Fibrous and other materials
- Fluid contamination

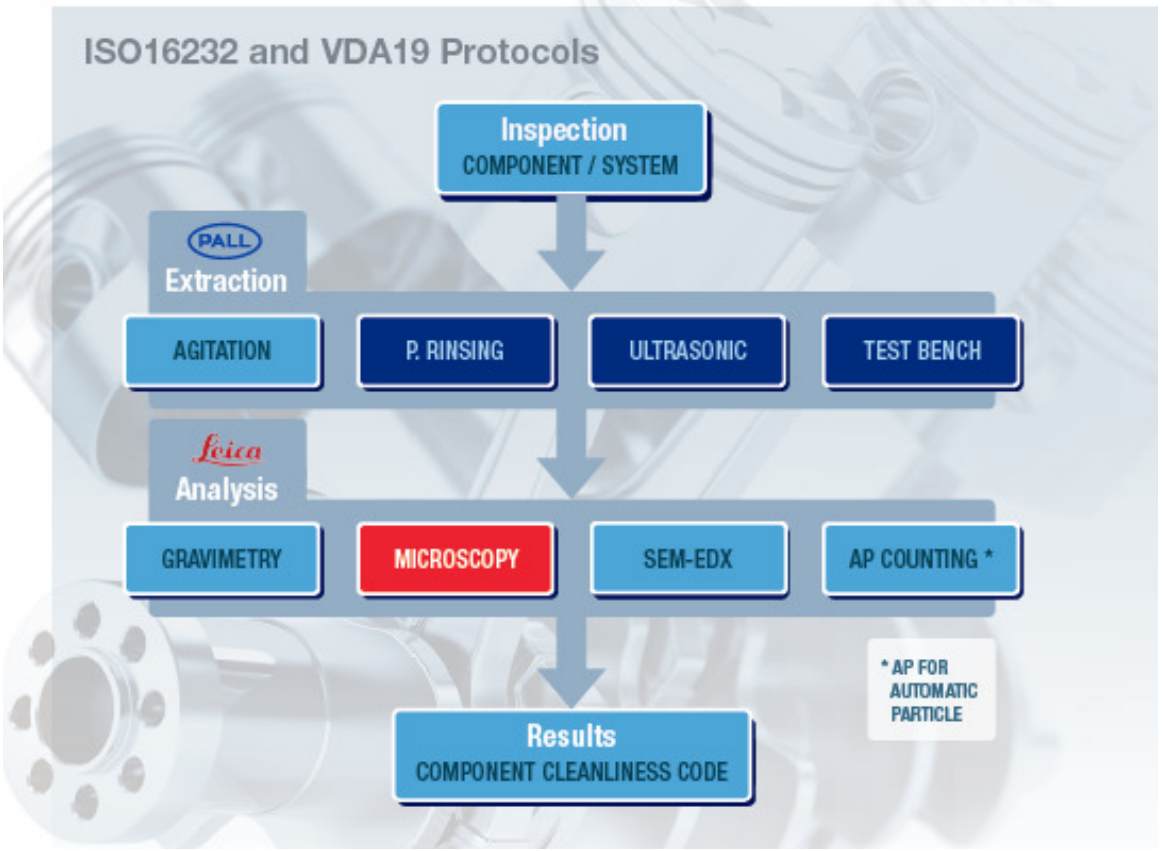
Measurement allows us to ensure that processes are capable and in control

Component cleanliness is measured to a given **standard**, against a given **specification**

- The **standard** describes how to test a component, and how to report the findings. This is to ensure the test is repeatable and meaningful
- The **specification** is the value of the desired result, the maximum level of dirt allowed, and is specific to the component

Standards for Component Cleanliness

ISO 16232 – General overview



Other standards exist

VDA 19 – *Equivalent to ISO 16232,* prevalent in Germany

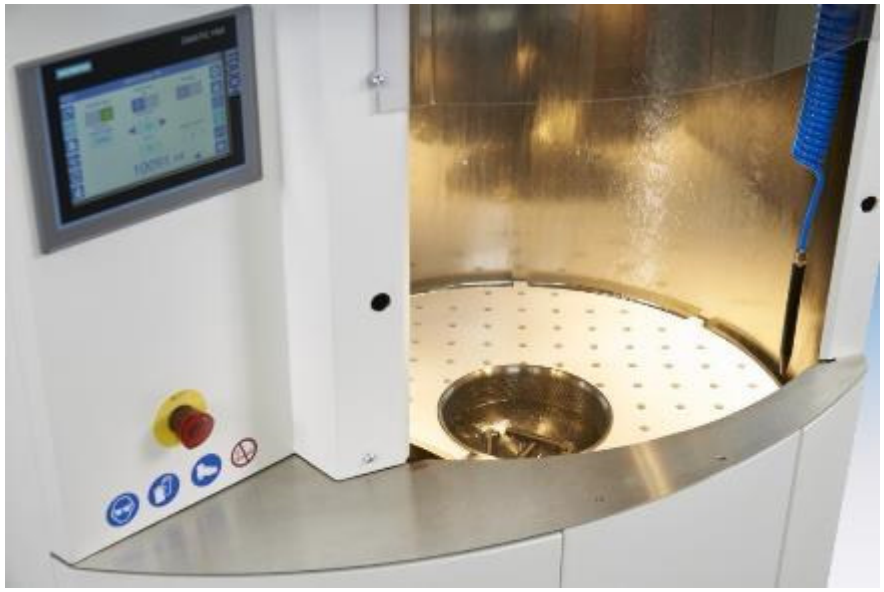
ISO 18413 – Hydraulic fluid power – Component cleanliness – Sample collection, analysis and data reporting,

Standards for Component Cleanliness

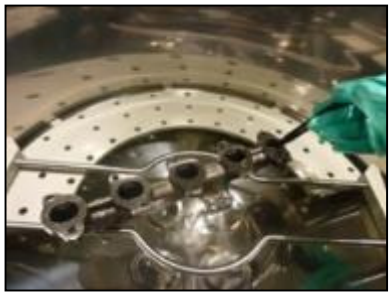
ISO 16232 – Validation of the extraction method

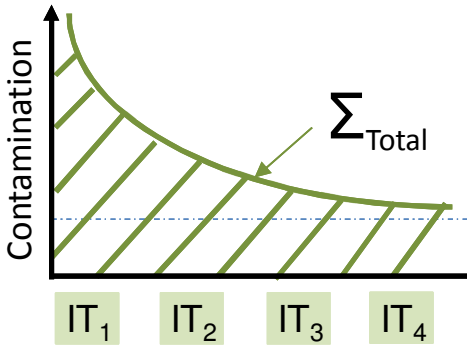
Procedure set-up to test each type of components

Pressure rinsing method applied to a reservoir and a collector



Ultrasonic method applied to bolts





The extraction method is based on successive iterations. It is stopped when the total contamination collected is > 90% of the actual contamination

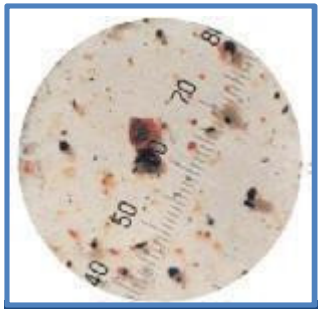
$< 10\% \Sigma_{Total}$

Standards for Component Cleanliness

ISO 16232 – Analysis of the extraction fluid

Apart from the automatic particle counting method, the 3 techniques used to quantify and qualify solid contaminant levels require a filter membrane.

This is best achieved by the use of a Pall Cleanliness Cabinet.



Filter membrane

Photomicrograph showing built-in contaminants captured on a membrane after extraction from the component

Technique	Standard equipment	Result
Gravimetry	Laboratory balance	Mass of contaminants
Microscopy	Image analyzer	Particle counting
Microscopy	MEB-EDX* and LIBS**	Nature of contaminants

*Scanning Electron Microscope associated with a X-ray detection system

**Laser Induced Breakdown Spectroscopy included in VDA 19

Pall Component Cleanliness Cabinets (PCC)

Assessment of incoming or in-process components to cleanliness specifications

Focus on components/systems

- Product/system quality and reliability
- Warranty/service life
- Critical review of the component/system design versus cleanliness specifications
- Improvement recommendations and Guidelines

Focus on manufacturing/assembly processes

- Process performance baseline
- Evaluation of the Cleanliness control at every stage of the manufacturing/assembly processes *(from incoming components to finished products)*
- Improvement recommendations and Guidelines

- Laminar flow with HEPA
  No cross-contamination from the environment
- Self-cleaning automated sequence
  No 'dead zone' within the enclosure

- Working area
  Mirror polished stainless steel with rounded corner. Possibility to add ultrasonic transducers
- Pressurized dispensing & recycling circuit
  Minimal fluid consumption (high performance filters installed)
- Membrane holder
  Up to 3 membranes installed in cascade

Examples of PCC units

Pall Component Cleanliness Cabinets (PCC)

Wide and comprehensive range of Component Cleanliness Cabinets

PCC Features

- Easy to install and use
- Controlled cleanliness environment
- Super mirror stainless steel extraction enclosure
- Pressurised solvent dispensing and recycling circuits
- Full work area access for service operation
- Requires only a power source and exhaust vent

PCC series cabinets can be supplied unpainted as an option

	Pressure Rinsing	Ultrasonic (option)	End-use Simulation	Dims (W x D x H mm)	Typical Parts
PCCXS	Yes	Yes	No	1000 x 500 x 1200	Small bearings, small gears
PCCS	Yes	Yes	No	1072 x 785 x 2101	Injectors, turbo-chargers
PCCM	Yes	Yes	No	1552 x 785 x 2101	Pistons, rods, camshafts
PCCL	Yes	No	No	2095 x 911 x 2304	Large cylinder blocks or heads
PCCXL	Yes	No	No	2495 x 1215 x 2662	Very large cylinder blocks or heads, hydraulic cylinders
PCCFR	No	No	Yes	Depends on the model	Pipes, hoses, small cylinders

Pall Component Cleanliness Cabinets (PCC)

1000 PCC units in operation today, global basis
in Automotive, Mobile/Industrial OEM and General Industry

- Without standard, repeatable cleanliness validation, you cannot meet Automotive ISO standards
  - —Pall PCC provides a more automated, repeatable process for checking parts cleanliness
  - —Start test sampling in much less time (up to 50% quicker)
  - —Less human errors involved
  - —PCC eliminates cross contamination
  - —Test sample is true representation of part contamination
  - —Avoids costly re-work caught later in the production process due to missed contamination
  - —Avoids shipping contaminated parts / components reducing warranty issues
- Protect your employees and the environment by using a totally self contained washing system
  - – Employees not exposed to harsh chemical or pressurized systems
  - – No VOC's / hazardous exhaust released to working environment, HEPA filtration ensures
  - – Prevents lost time accidents / injury claims

Design it Build it Keep it CLEAN

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- Process chain: damage potential and source of particles
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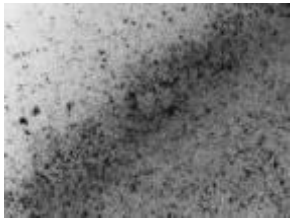
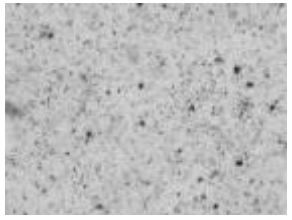
Cleaning & extraction – An essential part of the process

- Components are cleaned **during** or **after** production

- Particles have to be extracted from the components, e.g. in cleanliness cabinets
- The cleaning fluid is poured through a filter
- The filter is dried in an oven.

Filter preparation is key for reliable analysis





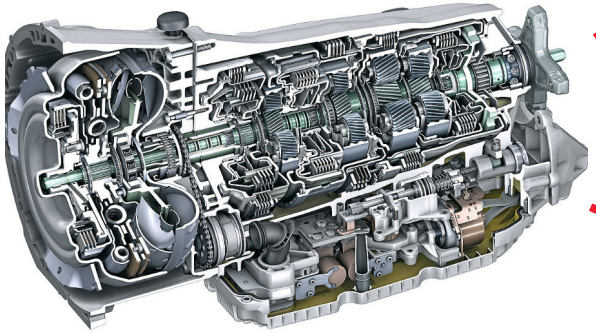
Process chain

- Value stream from raw material to product ready to use
- Contamination may come from: External, carry over from particles, particles coming from the process

Areas:
- Production
- Assembly
- Staff
- Cleaning
- Packaging
- Logistics
- Stocking

Damage potential

- Damage potential depends on the product and the functionality of the product.



Cleanliness of oil and hydraulic fluids: Particles above 5 µm

Component cleanliness of mechanical parts: Particles above15 µm or 50 µm
- Largest particle ‚killer particle‘
- Material type (chemical)

- Stiff particles: Metals, Grinding material
- Conductive particles: Metals (electronics)
- Fibers

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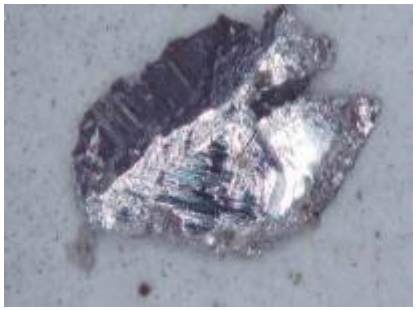
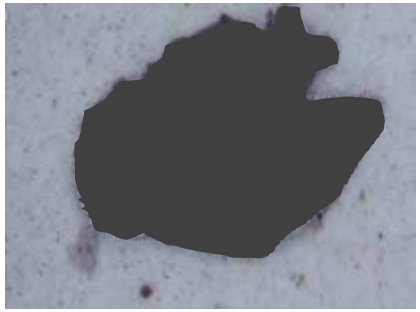
Optical Contrast

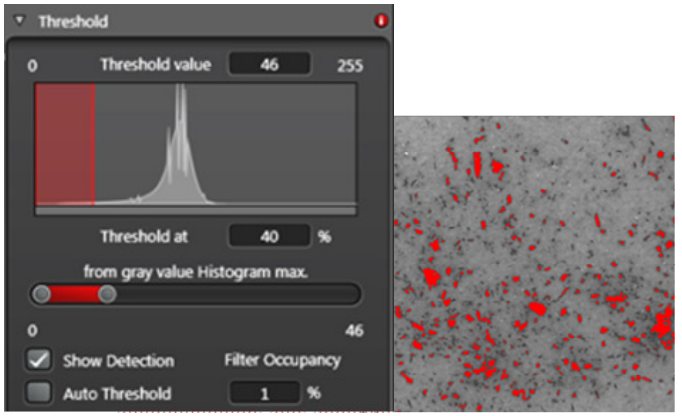
- Metallic particle showing reflexes in Brightfield ⇒ inhomogeneous
- Reflexes make automatic detection of particles difficult

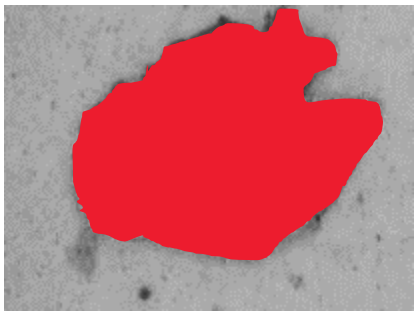


- Crossed Polarizers eliminate reflexes ⇒ homogeneous
- Metallic particles are dark and are contrasting to the bright filter background (bright/dark)



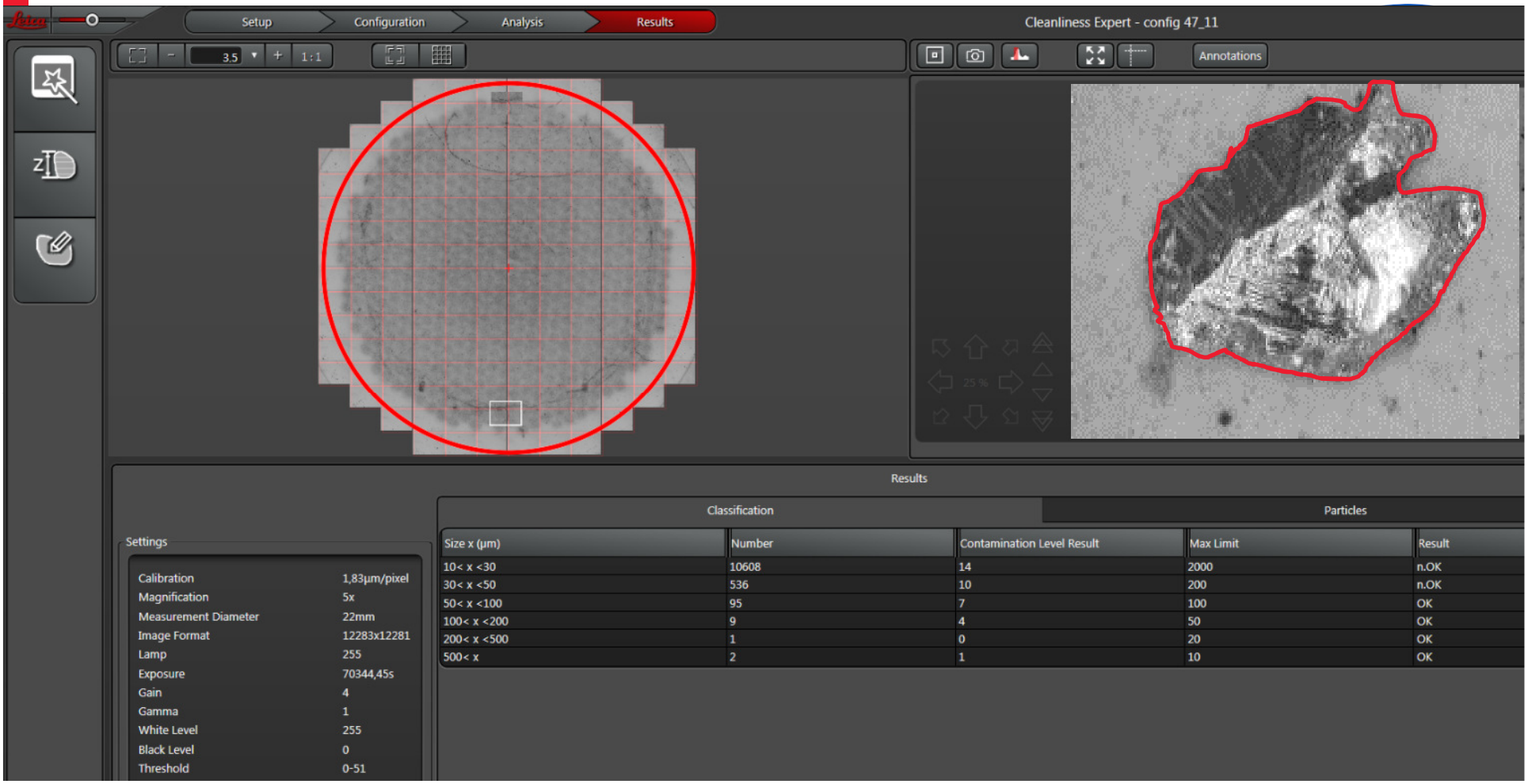
- Contrast of bright/dark ⇒ Greyscale image (BW image)
- Detection of particles, counting and classification





Particle analysis is done using crossed polarizers and greyscale mode

Optical analysis



- Counting, measuring 3D (length, breadth, height), classifying
- Indication: metallic glance and non metallic glance

What is the nature of the particle? What is the source of contamination?

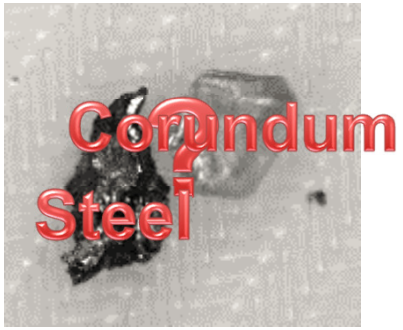
Nature of particles

Damage potential: hard and conductive particles

- Hard particles have higher damage potential ⇒ damage of mechanical systems
- Metal particles are conductive ⇒ damage of electronics, electronic boards
- Reflexes on particles are used as indicator for metals:
  - No chemical analysis (alloy, chemical compounds)
  - No information about particle source, e.g. tool, grinding material, grit

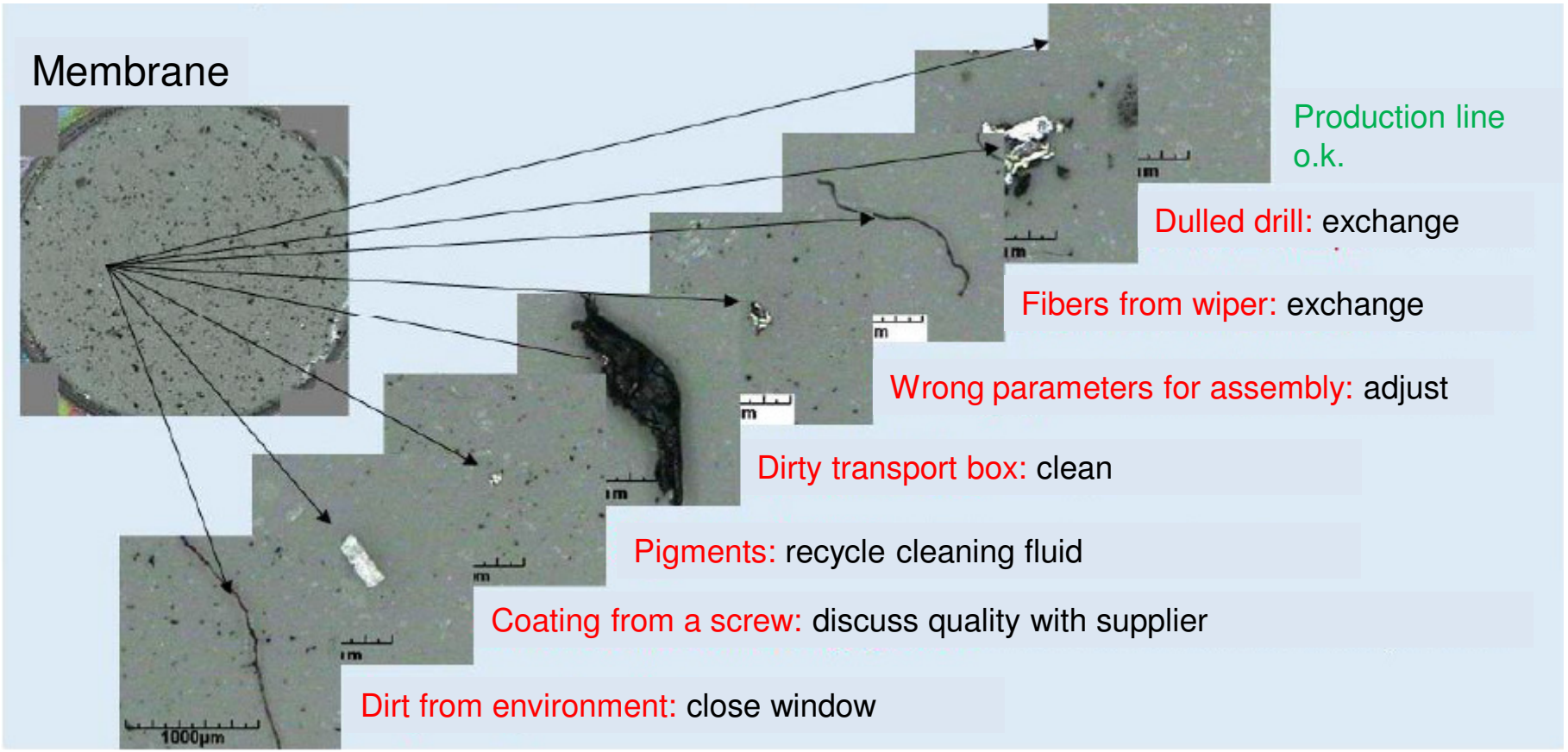
‚Information about physical features such as ‚hardness' or ‚abrasiveness' or other material characteristics can only be gained using **extended analysis methods.**

VDA 19, 8.3 Extended Analysis



Component Cleanliness

- All suppliers have to prove the cleanliness of their components
- Component Cleanliness is not part of curriculum at universities or colleges
- In practice component cleanliness is complex: different sources of particle contamination, no ‘perfect’ component vs. mechanical drawing, no ‚perfect‘ production environment



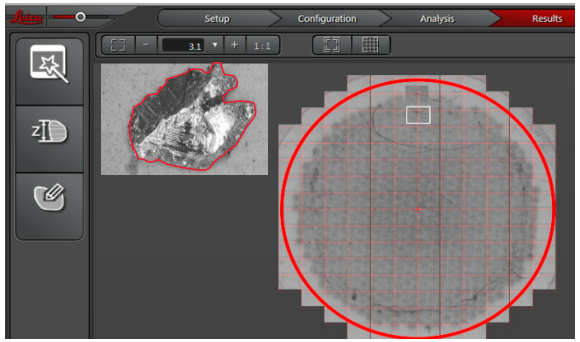
Source: IPA, Revision VDA19

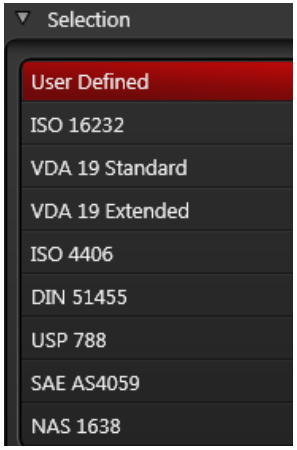
Optical particle analysis has a lot of advantages…

Weight	Size Limits (µm)	Number	Particles per 100cm³	Xcount	100%	Max Limit	Result
1	15-25	3239	6478	6478		0	n.OK
1	25-50	1455	2910	2910		300	n.OK
1	50-100	239	478	478		200	n.OK
2	100-200	24	48	48		100	OK
5	200-400	4	8	8		20	OK
10	>400	2	4	4		5	OK

…provides a lot a results

…is fast and easy to use

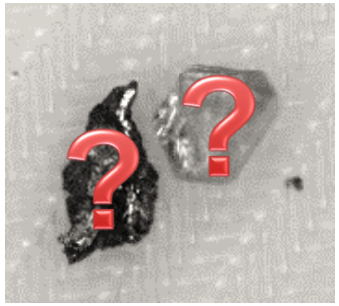




… is used by many standards

…is a common method to document cleanliness of components – worldwide users

BUT wouldn't it
an advantage to get the
chemical fingerprint as well?

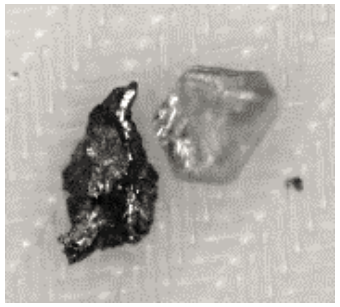


BUT wouldn‘t it an advantage to get the chemical fingerprint as well?

AND if we could do so…

WE want to do it…

…. EASY



… FAST

… SECURE

… without changing the device and searching the particle again

… without preparing particles for SEM/EDX analysis

…simply use one system for your optical and chemical inspection…

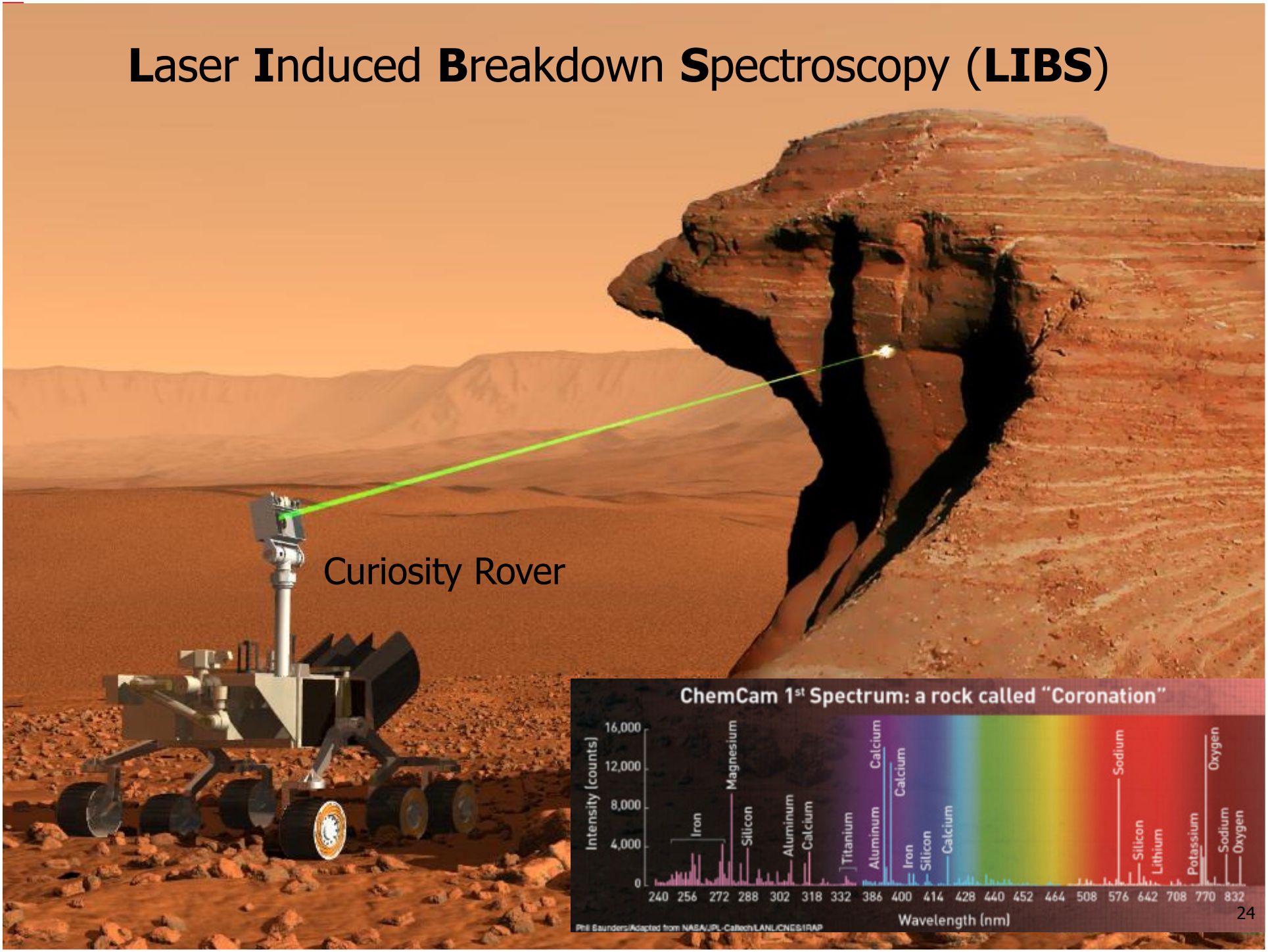
It‘s possible!

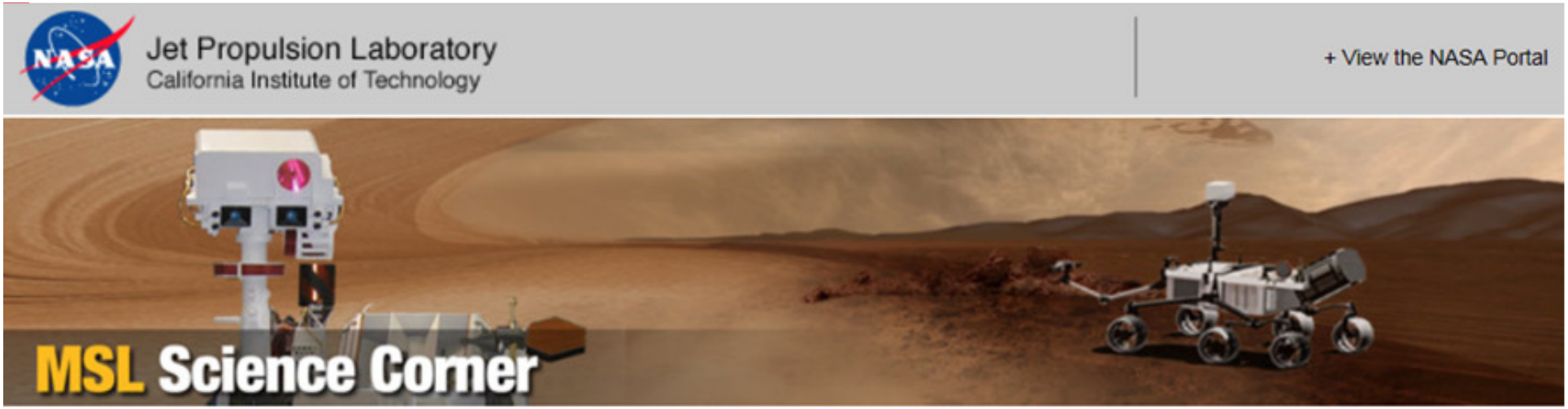
Leica

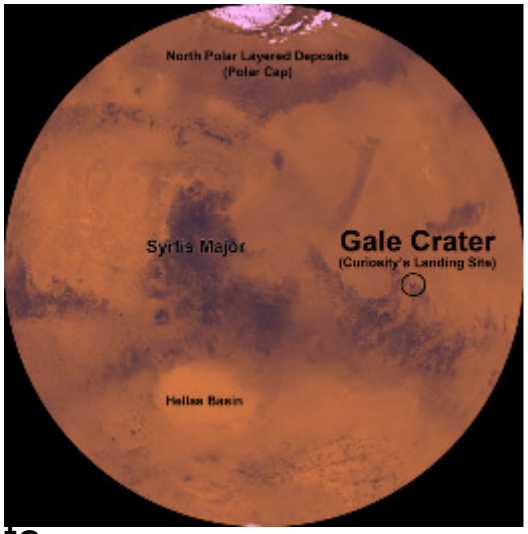
PALL

Get the full picture with the Leica DM6 LIBS system!

Laser **I**nduced **B**reakdown **S**pectroscopy (**LIBS**)







The advantages of the LIBS instrument are:

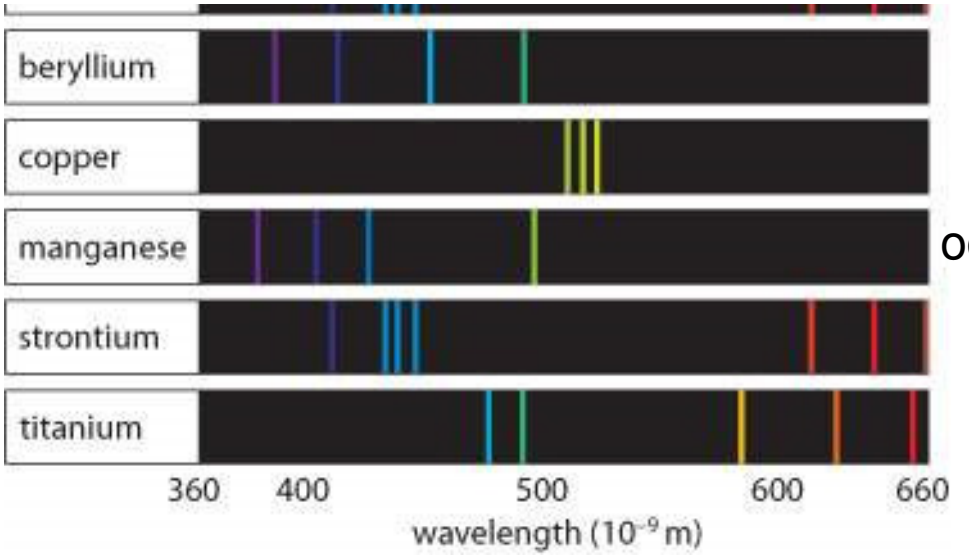
- Remote elemental analysis with **no sample preparation**
- Ability to **remove dust and weathering layers** with repeated laser pulses trained on the same spot
- **Simultaneous analysis of many elements**
- **Low detection limits** for a number of minor and trace elements
- **Rapid analysis**; one laser shot can constitute an analysis, though many spectra are often averaged for better statistics, still only taking a few seconds
- **Small analysis spot size** of < 0.6 mm diameter
- Ability to identify water and/or hydrated minerals
- **Low power consumption** resulting from **very short analysis times**

How LIBS works

L aser
I nduced
B reakdown
S pectroscopy

Remember flame spectroscopy!

By exposing atoms to high temperatures electrons are able to “jump” to high energy levels. While cooling the electrons return to their original state and emit light.



oder

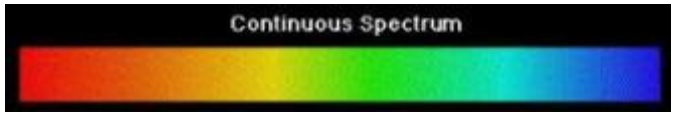
Principle of LIBS

(a) Laser pulse hits sample

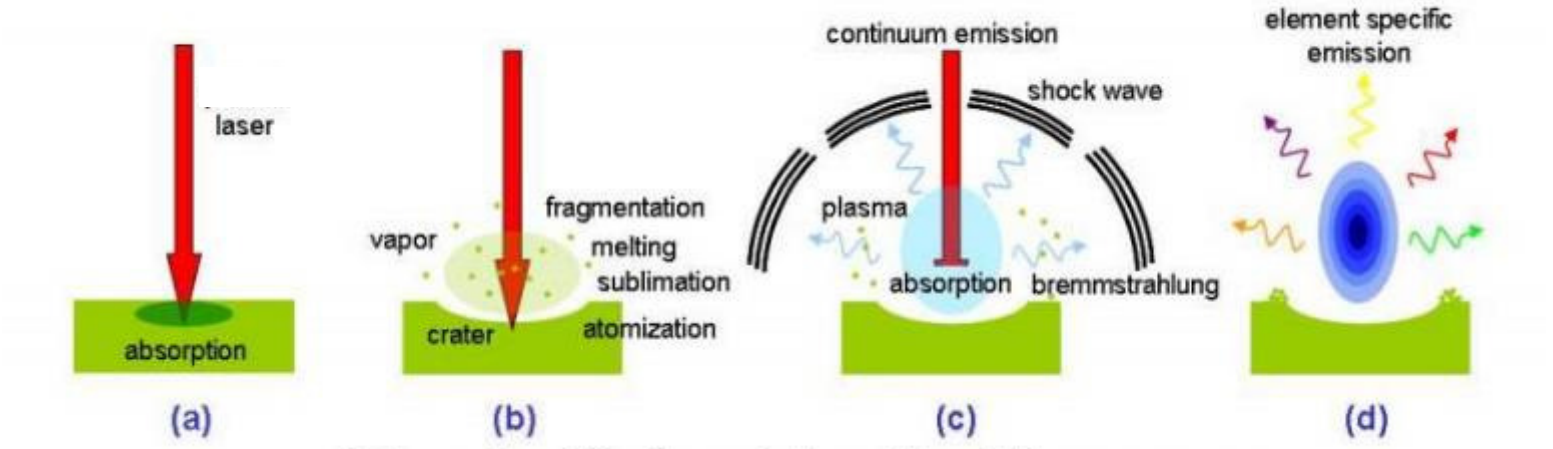
(b) Laser pulse ablates material (vapor)

(c) High energy induces a plasma

→ continuum emission (no element information)



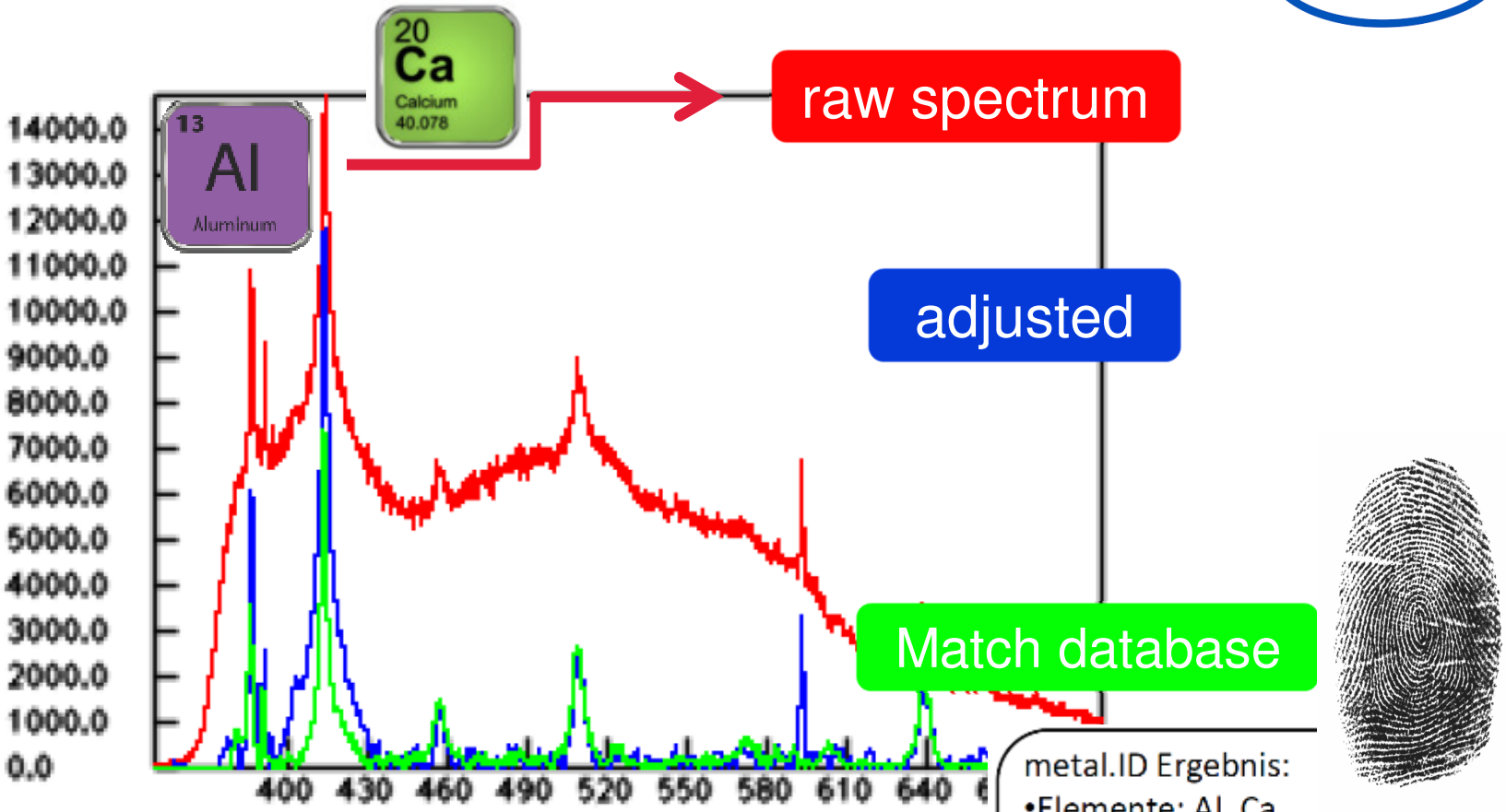
(d) Breakdown of plasmas → energy leaves in in form of emission = element specific information (line spectra)



Schematic of the laser-induced breakdown process.

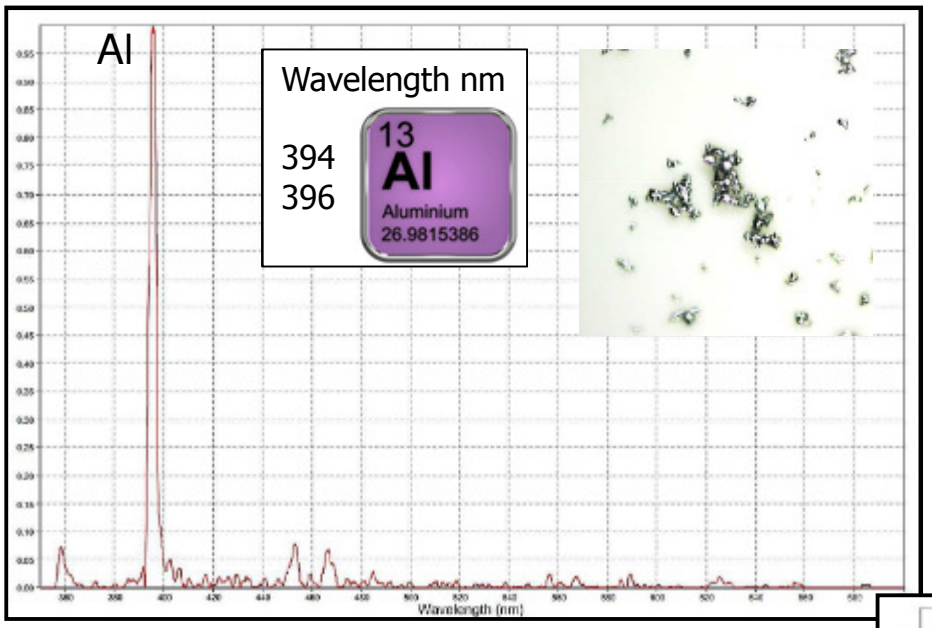
Quelle: University of Windsor

Fingerprint spectra/database match

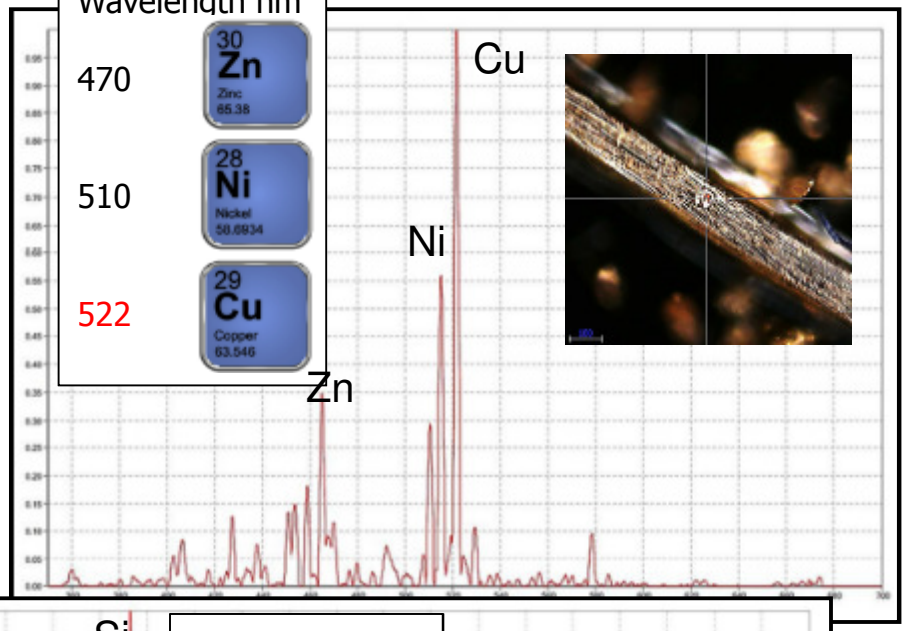


Element Specific Fingerprint Spectra:

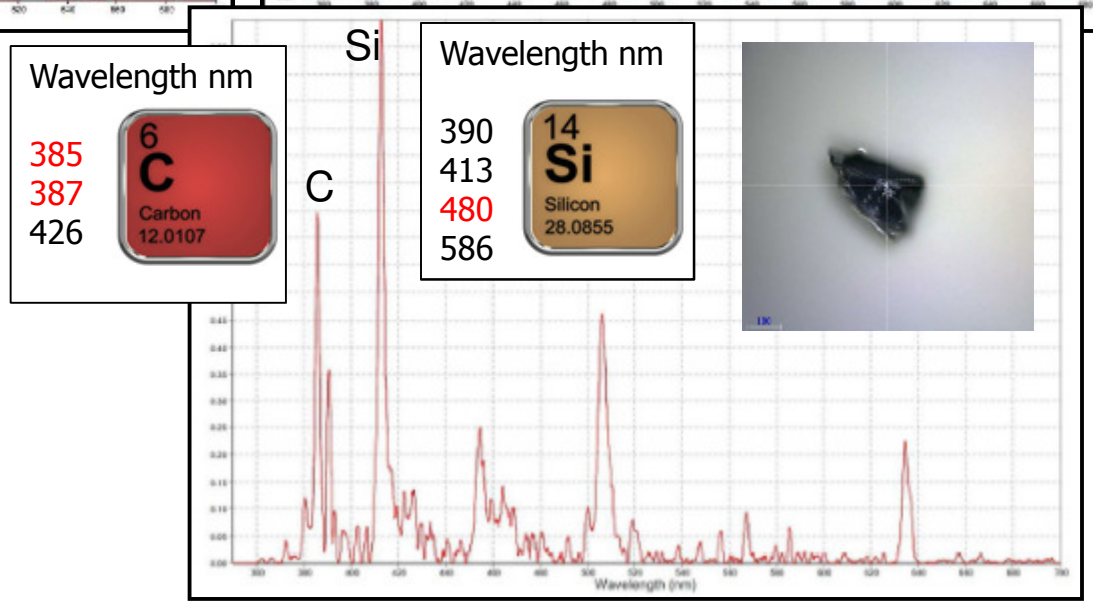
Elements:



Alloys:



Chemical Compounds:



Laser Induced Breakdown Spectroscopy (LIBS)

Why LIBS?

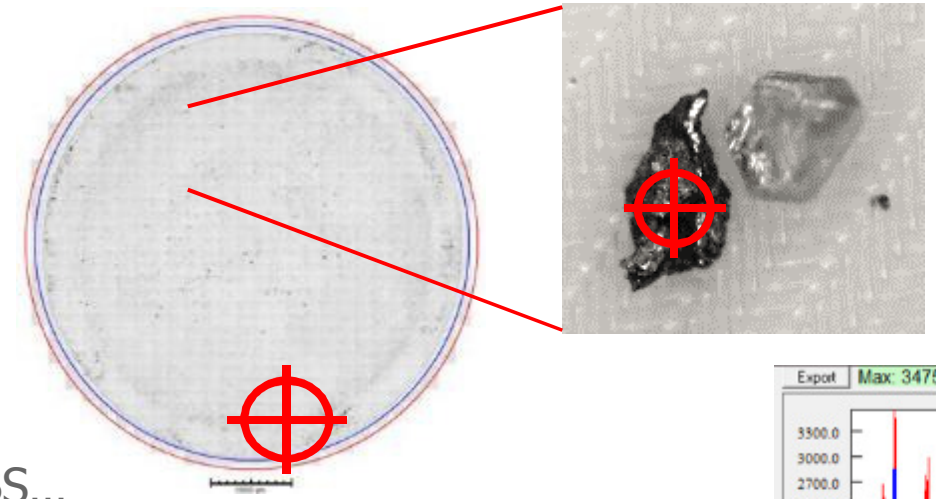
Combine optical and chemical Cleanliness Analysis at one system

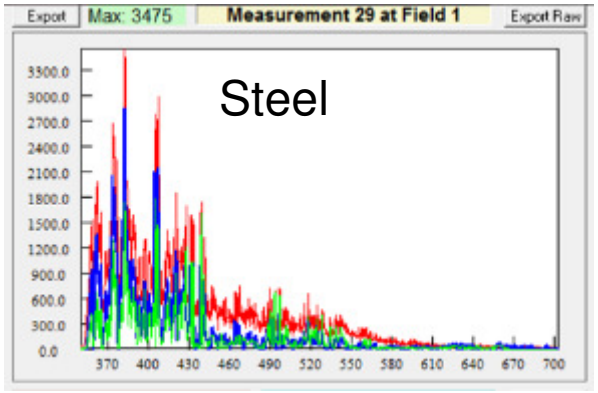
Scan…

Relocate…

Analyze by LIBS…

Document…





…within seconds! Fast and reliable at one single system!

Laser **I**nduced **B**reakdown **S**pectroscopy (**LIBS**)

Why LIBS?

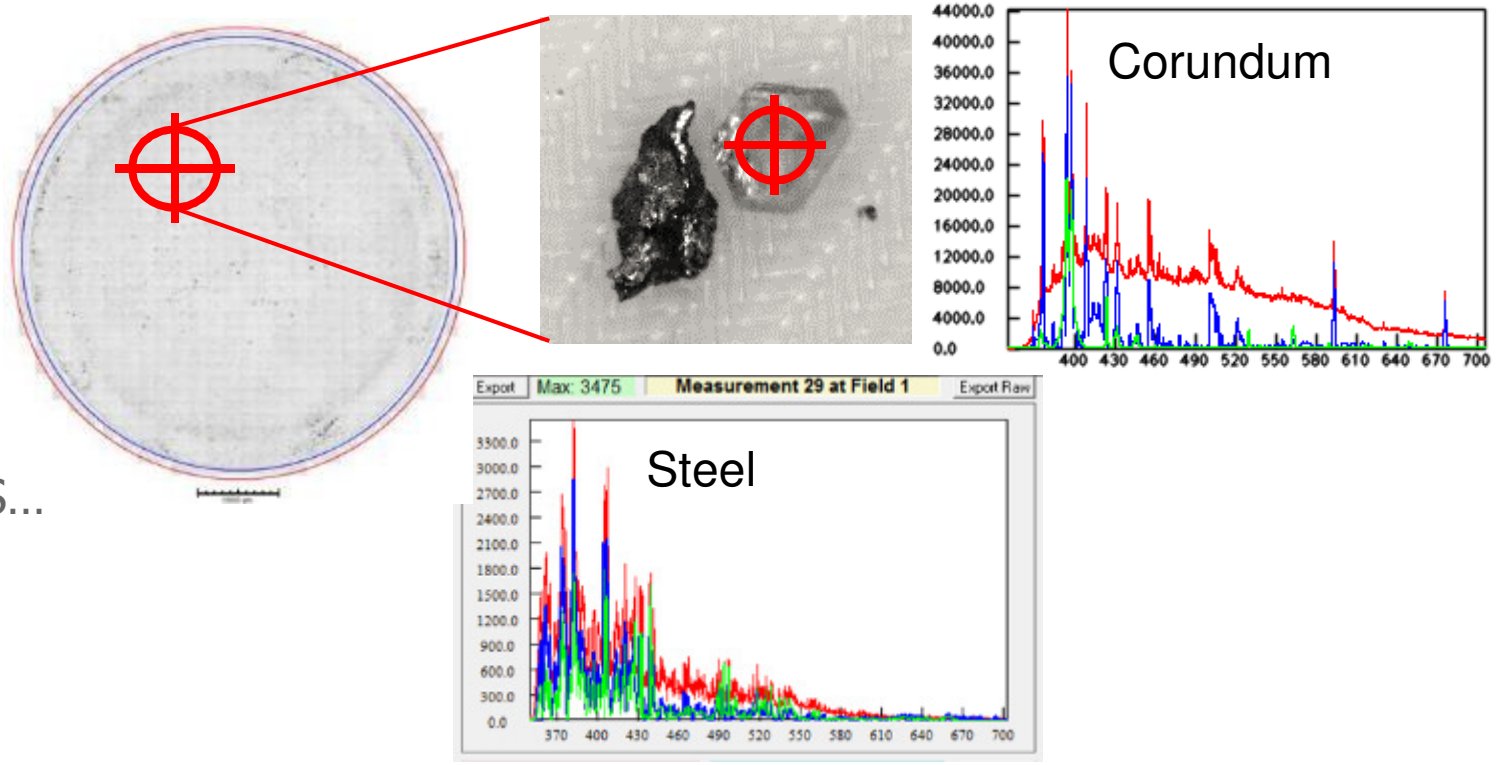
Combine optical and chemical Cleanliness Analysis at one system.

Scan…

Relocate…

Analyze by LIBS…

Document…



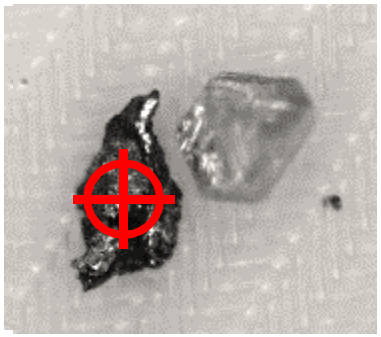
…within seconds! It's incredible fast and easy to use!

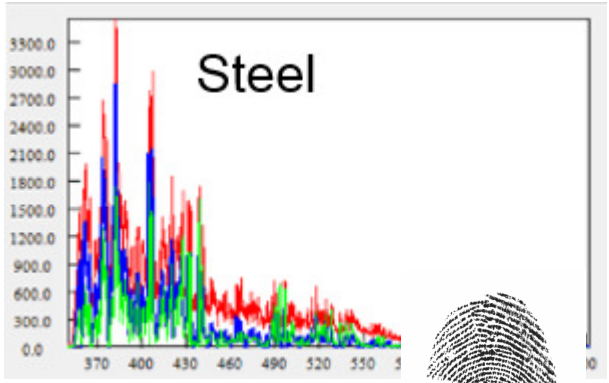
Laser **I**nduced **B**reakdown **S**pectroscopy (**LIBS**)

Why LIBS?

Extend your database and identify the source of the contamination

Is the particle is
coming from my tools?





…simply proof it by analyzing the tool and the particle!

Extended particle information

Laser **I**nduced **B**reakdown **S**pectroscopy (**LIBS**)

Optical inspection (measure & classify) – chemical analysis – documentation

- Combine optical and chemical information coming from one system
- Super fast! Multi-element analysis in real time!
- No special sample preparation!
- High spatial resolution
- Easy to use!
- Low maintenance costs!

Further applications:

Metallography, steel inclusion rating (non-metallic inclusions), Forensic,….

Topics

Part 1 EXTRACTION

- Why component cleanliness is important
- Measure to control
- Standards for Component Cleanliness
- Pall Component Cleanliness Cabinets

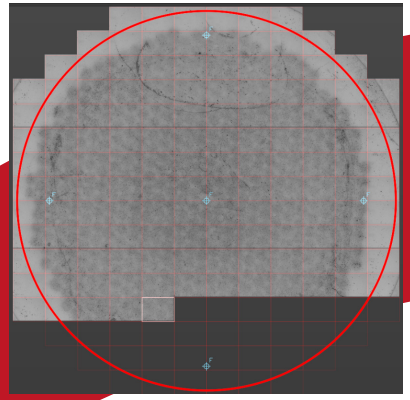
Part 2 FAST & RELIABLE OPTICAL and CHEMICAL CLEANLINESS ANALYSIS

- Process chain: damage potential and source of particles
- Combine optical and chemical analysis with LIBS (Laser Induced Breakdown Spectroscopy)
- Dedicated workflow solutions fitting to each need

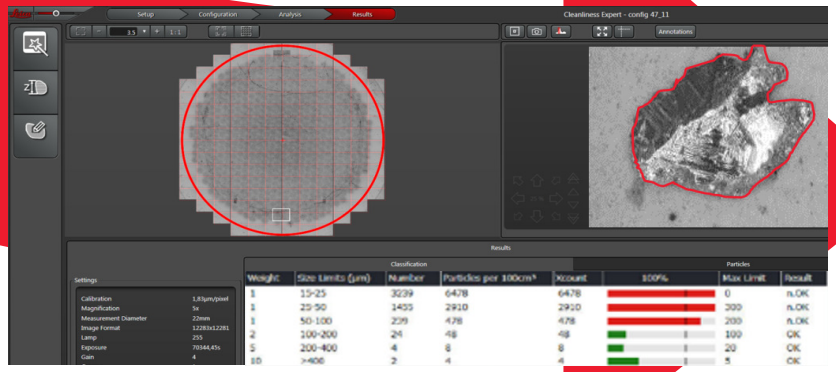
Workflow for component cleanliness

1. Cleaning, flushing, filtration…

2. Analysis of the mebrane…



3. Measure & Classify:



4. Relocalisation…

Workflow for component cleanliness

7. Evaluate:

Particle Silica carbide: hard

Length: 210 µm o.k.

Breadth: 95 µm n. o.k.

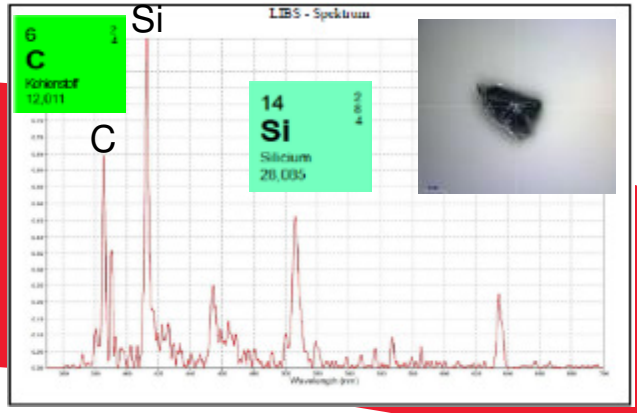
Height: 60 µm n. o.k.

Damage potential: high

Source of contamination: Residuals grinding material

React/optimize process

6. Identify /(chemical composition):

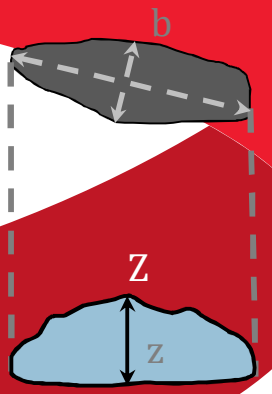


5. Properties:

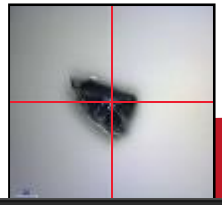
Length: 210 µm

Breadth: 95 µm

Height: 60 µm



4. Relocalisation:



Classification

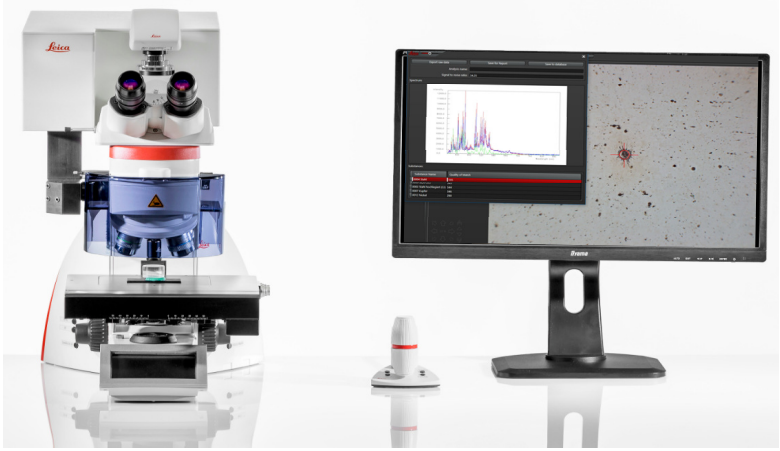
ID	Z	Rejected	Reflective	Fibre	Report	Height(mm)	Length (µm)	Area (µm²)	Breadth (Minimum Feret) (µm)
116950	N	N	N	N	N		2867,64	454259,90	980,58
36224	N	N	N	N	N		1373,40	133235,50	264,64
101505	N	N	N	N	N		1262,66	52067,22	301,19
1505	N	N	N	N	N		1086,26	114108,80	304,30
19692	N	N	N	N	N		1053,54	236805,30	598,49

System solutions fitting to your needs

DMS1000 system solution

- **VDA19 Standard Analysis: 50 µm**
- Daily analysis of particles above **30 µm**
- Coded **zoom** optics = no wrong measurements
- Macroscopic beam path
- Flex Aperture = constant brightness
- ISO16232, USP788,... user defined
- Measurement & Documentation
- **2D** analysis

DM6 system solution



- **VDA19 Standard & Extended Analysis**
- Daily analysis of particles above **15 µm**
- Fully automated & coded microscope (**fixed optics**) = no wrong measurements
- **3D** analysis (length, breadth, height)
- **Oil analysis** (ISO4406, DIN51455)
- ISO16232, USP788,… user defined
- Measurement & Documentation
- **Chemical material analysis LIBS**

Zoom — Optics — *fixed*

Macro — Size of structures — *Micro*

2 D — Properties of particles/Damage potential — ***3D*** ***Material***

Extraction - Optical & chemical particle analysis - documentation

Curious?

Thinking we are promising too much?

Visit us at the **Parts2Clean** the leading trade show for component cleanliness

&

Get your free ticket

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Or get in contact with your local Leica or Pall partner

Thank You for Your Attention!

Any Questions?