Connector Application Deep Dive



31 August 2023

Value chain of connector

Telecom, Automotive, CE share more than 60% connector market

Value Chain

Upstream (Raw Materials)

- Plastic material (塑料材料)
- Metal material (金属材料)
- Electroplating material (电镀材料)
- Wire & other material
- Mold manufacturer (模具制造)

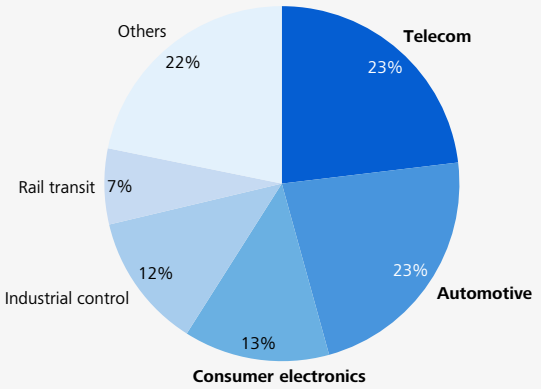
Midstream (Connectors Manufacturer)

- Electrical connector (电连接器)
- Microwave RF connector (微波射频连接器)
- Optical connector (光连接器)



Automotive | Telecom | Consumer electronics | Industrial

Downstream (Application Field)



Source: Bishop & Associates - 2020 global connector application field distribution

Typical Players

Plastic:
- 国风塑业
- 沧州明珠
- 三力士
- 凌云股份
- ……

Metal:
- 精诚铜业
- 楚江新材
- 宁夏东方钽业
- ……

Electroplating:
- 西部材料
- 兴业矿业
- ……

Mold:
- Polygon
- Maya
- Cosmos
- YIZE Mould
- ……

International:
- TE connectivity
- MOLEX
- Amphenol
- FCI
- Foxconn
- Yazaki
- ……

Local:
- Luxshare
- Deren
- 长盈精密
- 电联技术
- 中航光电
- 河南天海
- ……

Telecom:
- HUAWEI
- ZTE
- 爱立信
- Nokia
- Samsung

Automotive:
- 理想
- 小鹏
- 蔚来
- 哪吒
- BYD
- Honda
- Toyota
- BMW
- Mercedes-Benz
- ……

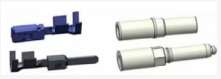
CE:
- Apple
- HUAWEI
- VIVO
- OPPO
- META
- Microsoft
- Google
- ……

Connector overview

Basic components and corresponding functions

Connector is an electromechanical device used to join electrical conductors and create an electrical circuit, it can transmit the current or signal between different devices. Most connectors have a gender – i.e. the male component, called a plug,connects to the female component, or socket. The connection may be removable.

Basic structure of the connector



Contact pin



Housing



Isulator/Base



Accessories

Core components - Function

Male contacts and female contacts form a contact pair, and the electrical connection is completed through the insertion of female and male contacts.

The shell of connector to provide mechanical protection for internal components and pins.

Ensure the insulation performance between contacts and between contacts and shell.

Structural accessories such as snap ring, locating pin, guide pin, cable clamp, sealing gasket, etc. Install accessories such as screws, nuts, spring rings, etc.

Manufacture process

Stamping



CNC



Plating

Molding

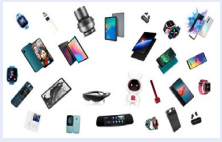




Assembly

Key differences between Telecom, Automotive, CE

Automotive and Telecom seams more fit to the IQS business approach → high threshold, high quality and reliability; CE will focus on the development of AR, VR and wearable devices

Application Field	Characteristics & Requirements	Future Opportunities	Future Developments in connector	Connector	Future Focus in connector
Telecom 	• High threshold • High interface rate & integration (高接口速率及集成度)	5G; Cloud computing; Internet of Things (IOT)	• **High Speed**	Microwave RF connector (微波射频连接器) Optical connector (光连接器) Electrical connector (电连接器)	✓ **High-Speed backplane connector，up to 32Gb/s**
Automotive 	• Closed automotive industry chain • High threshold • High quality and reliability	NEV; Automatic Driving	• **Intelligence** (add control, communication, computing) • **Increase in numbers** (connector quantities)	Electrical connector (电连接器)	✓ **High-Speed connector** • **Power-Swap connector**
Consumer electronics 	• Large market stock • Mature technology • Low industry profit • Shared by local manufactures	AR, VR; Wearable devices	• **Smaller** • **Thinner** • **High frequency stable transmission**	Electrical connector (电连接器)	✓ **BTB connector** ✓ **FPC connector** • **SIM card connector**

ZEIS IQS Solution
Software, System, Service

ZEISS Quality Suite-Software



CMM & OMM



X-Ray



Microscope



Optical system

Automation solution

Service

Requirements of manufacturing process

Mold Development › **Housing** › **Contact Pin** › **Final Assembly**



REQ: EDM Automation





DuraMax

REQ: Dimension measurement





CONTURA

REQ: Quick tool correction





METROTOM

REQ: At-line housing quality assurance





METROTOM 1

REQ: Off-line housing dimension measurement







O-INSPECT O-DETECT

REQ: Contact pin foreign matter analysis





SmartZoom 5

REQ: Contact pin coating analysis





EVO 10

REQ: Quick deformation inspection





ATOS Q

REQ: Final assembly dimension measurement







O-INSPECT O-DETECT

REQ: Final assembly analysis





METROTOM

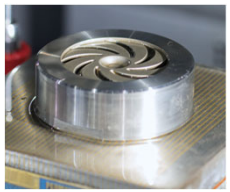
CMM&OMM for connector



REQ: EDM Electrode Dimension Measurement

EDM Automation

Application Picture



EDM Electrode

Customer's Requirements

- **Tolerance in drawing:** EDM electrode: Most are ~5µm
- Automatic generate offset program, measurement and compensation
- **Automatic** loading and unloading
- **Short** lead-times in production with **fully** information about the electrode's quality for **high productivity**

Application Analysis

With **ZEISS CLAYPSO PRESET**, generate the electrode's program automatically and with Robot achieve the **automatic loading and unloading**

Proposed Solution



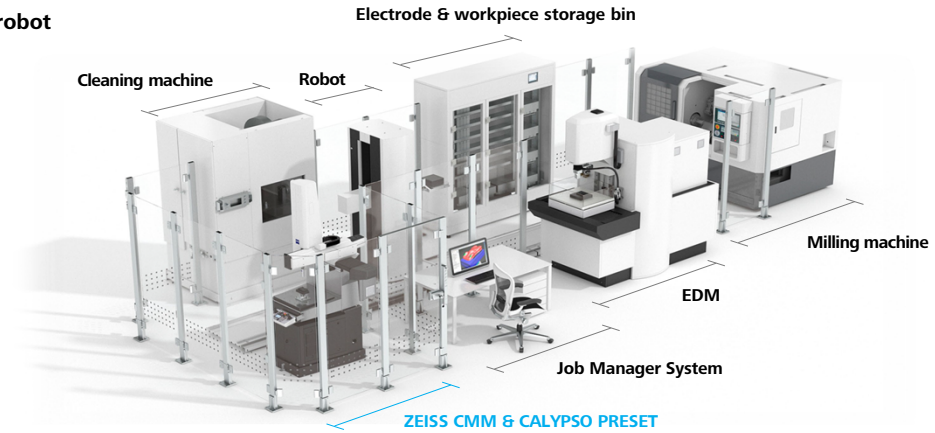
DuraMax



CALYPSO PRESET

Automated Line Example

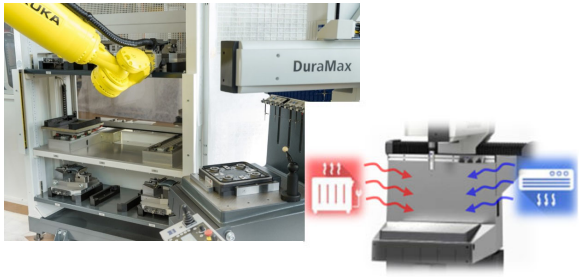
Connected to job-manger & robot



Automatic compensation of discharge eccentricity in electrode automatic detection workstation to improve the efficiency of spark machine.

ZEISS Value Proposition

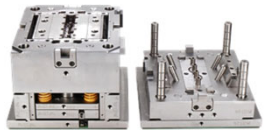
- ✓ **15%** efficiency higher of the program conversion due to the ZEISS conversion software.
- ✓ ZEISS DuraMax family can **easily** be integrated in automation systems by **using standard interfaces**
- ✓ High repeatability up to **1.7um even in the shopfloor**
- ✓ DuraMax HTG allows a **precise measurement** in a higher temperature range between **15° to 40°** which means less costs for air conditioning (DuraMax allows 18° -30°)



REQ: Mold Dimension Measurement

Quality control during the mold manufacture

Application Picture



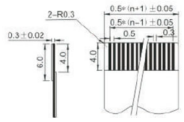
Connector Mold

Customer's Requirements

- **Tolerance in drawing**

Injection mold: Most are ~5μm (Automotive), A few of dimensions are ~ 2-3μm (High speed backplane connector)

- **High cost-performance ratio**



Application Analysis

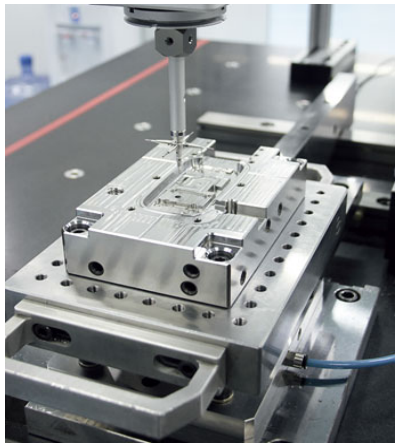
- Connector injection mold cavity should have good correlation，which require the measurement repeatability and stability, the Contura can meet the requirement in this case.

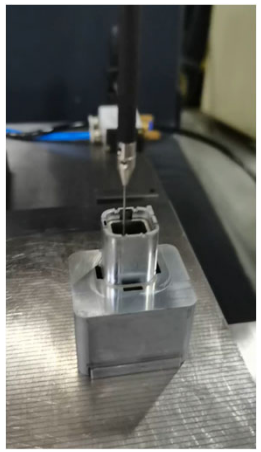
Proposed Solution



CONTURA PRISMO (optional)

Cases Example





ZEISS Value Proposition

- ✓ Accuracy acceptance on site and repeatability of the machine achieve which ensure the product quality due to the **innovation materials.**
- ✓ CALYPSO is friendly and **easy to learn and use** which can **reduce labor cost**
- ✓ High return of investment(ROI)



材料 Material	钻石涂层 DLC coating	花岗岩 Granite	钢 Steel	铝合金 Aluminum
弹性模量 E-Module (Gpa)	170~300	50	210.000	70
密度 Density (g/cm³)	1.7~2.5	3	8	2.7
热膨胀系数 Expansion α (μm/(m*K))	3.1	6	11	22
硬度 Hardness (HV)	1000~2000	900	163-200 (H13模具钢可以达到1000)	90-150
摩擦系数	0.1	0.3-0.4	0.3	0.17

ZEISS

Dimension Measurement
Multi-sensoric CMM

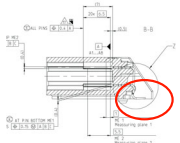
Application Picture



Assembled connector

Customer's Requirements

- **Whole dimension measurement** include distance, position and flatness etc.
- Mainly focus on the **position and height of the pin** since this characteristic impact the connection of female and male connector.



Application Analysis

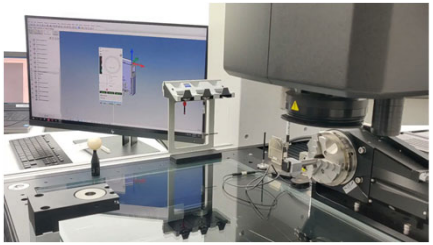
The contact pin is hided by other features which only measured by tactile and considering of the **efficiency,** O-INSPECT with RT can meet the customer's requirements

Proposed Solution

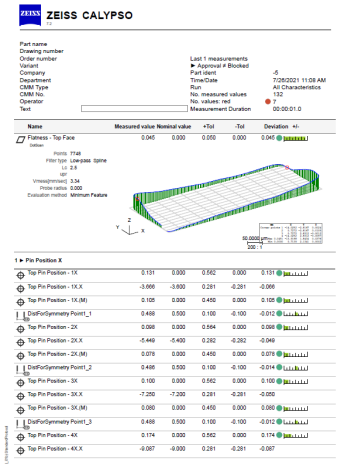


O-INSPECT 543 + RT + DotScan

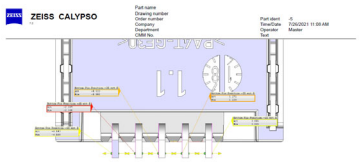
Cases Example



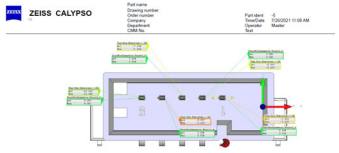
Measuring video



Standard report



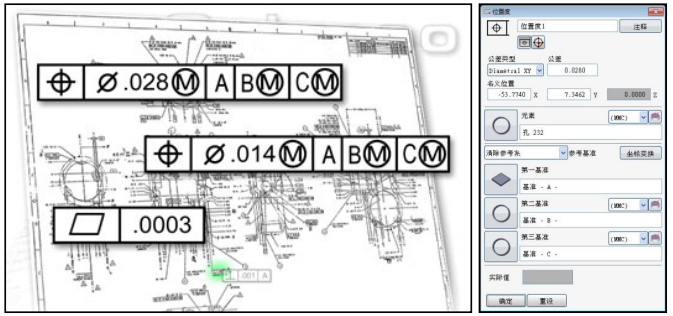
Graphical report _ Position of Pin



Graphical report _ Height of Pin

ZEISS Value Proposition

- ✓ **200% efficiency higher** with multi-sensor and rotary table together vs traditional CMM & OMM
- ✓ ZEISS CALYPSO is easy to use for the multi-sensor tasks.
- ✓ **Diversified report template** are easy for customer to understand where is the problem.
- ✓ ZVP (fast probing) functions for both tactile and optical increase the **additional 20% efficiency**.



Dimension Measurement

Application Picture



Assembled connector

Customer's Requirements

- **Position and height of the pin,** as this characteristic impact the connection of female and male connector.
- Quick measurement with tactile and optical way

Application Analysis

The O-DETECT can equipped with tactile and optical sensor, and the customer need cost-effective solution.

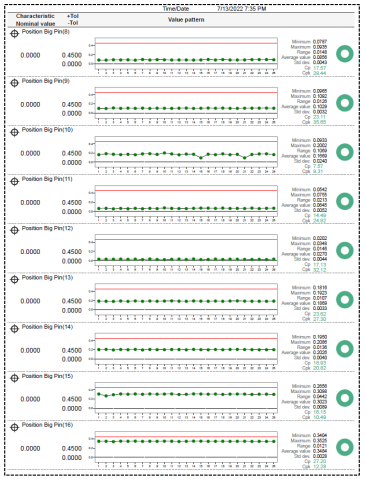
Proposed Solution



O-DETECT

Cases Example





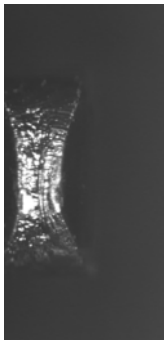
# Measure Feature	# Measure Time
56 Housing holes	8:45s
32 Big pin location & height	
24 Small pin location & height	

ZEISS Value Proposition

- ✓ High image quality and provide a **big FOV with high resolution**
  - Innovation digital camera
  - Good lighting (Diffuse Light-Optional)
  - **Less reflection noise**, better for edge point detection with diffuse light
- ✓ Convenience and visible part navigator with **overview camera**
- ✓ High Z-axis auto focusing accuracy up to 1 µm. Fast autofocus speed (~1.5s)
- ✓ **XDT tactile sensor** can be retrofitted to O-DETECT for future upgrade.
- ✓ **Smart Vision Meas.** offer friendly software interface with all the functionalities as optional configuration.

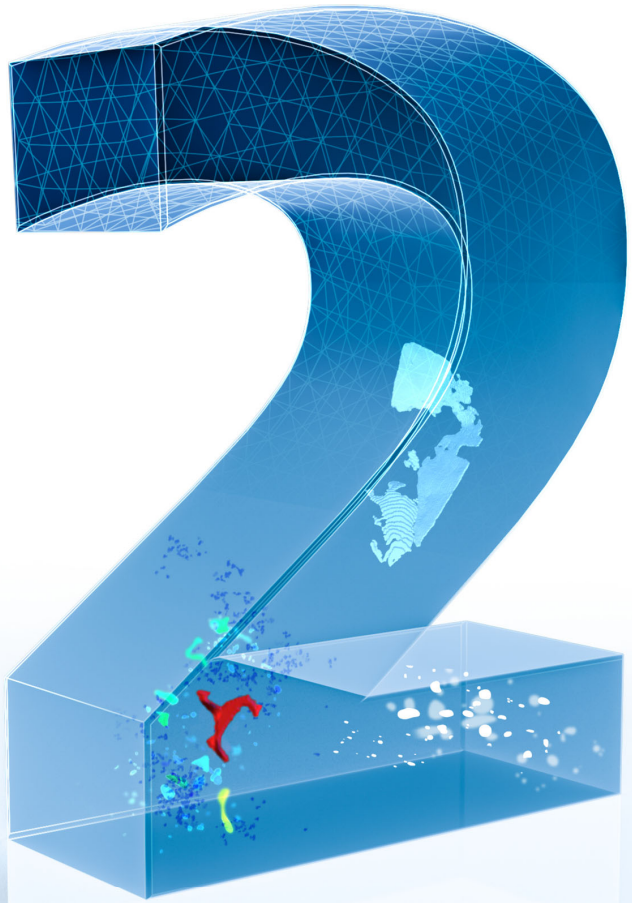


ZEISS O-DETECT

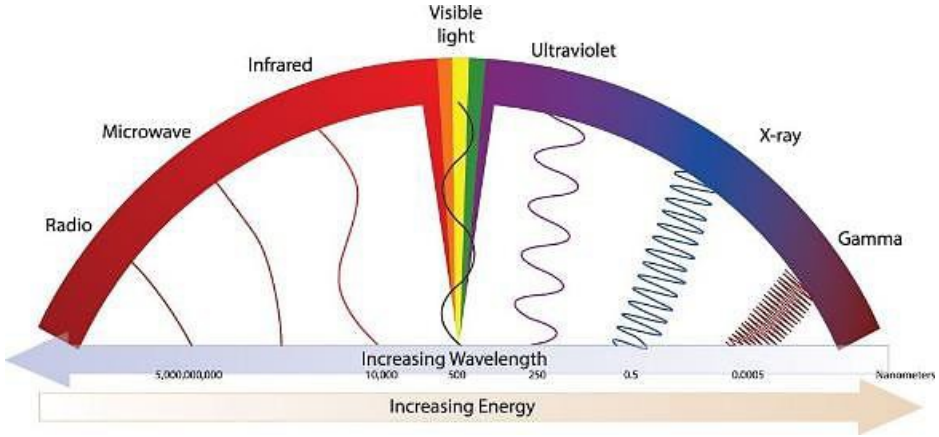


Others

CT System for connector



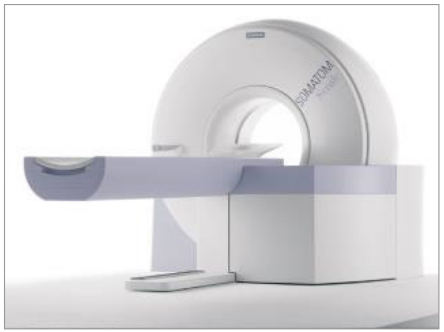
What is X-ray?



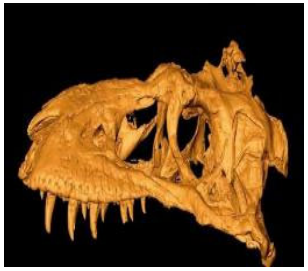


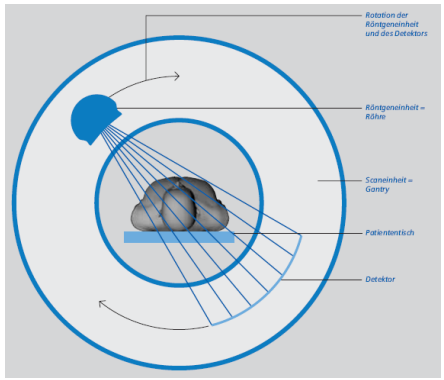


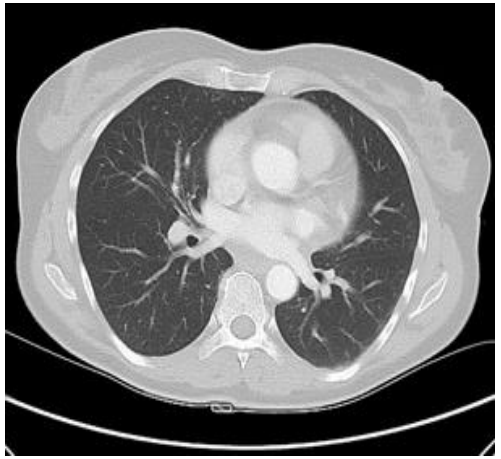
Roentgen
(1845~1923)







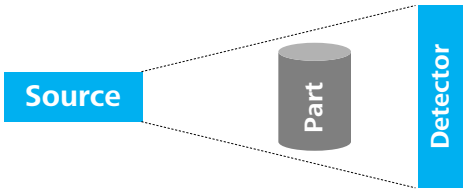




Computed Tomography Invention for medical application

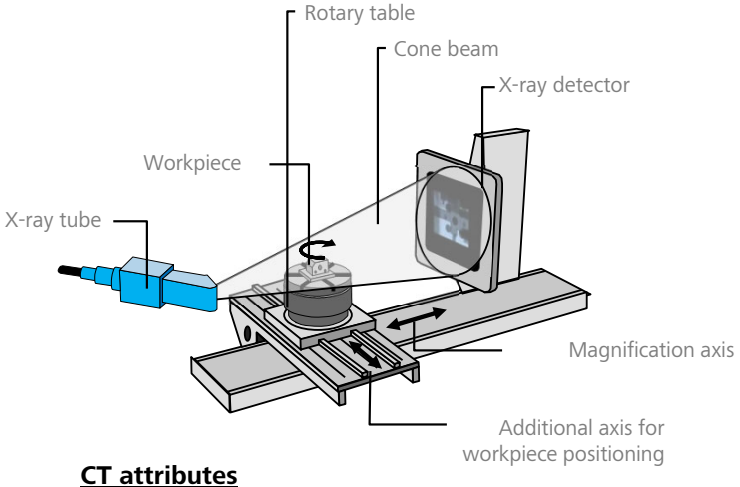
ZEISS X-Ray Series
Based on three principles

2D Radioscopy
2D 实时成像



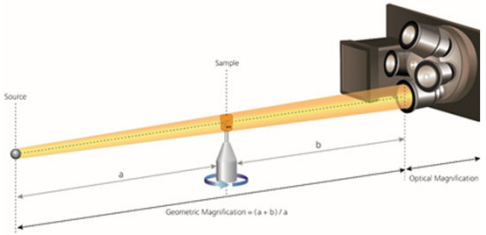
Radioscopy attributes
- 2D images with selected different projection angles through the sample
- Resolution based on geometrical magnification
- 2D X-ray image directly displayed on computer screen without previous reconstruction
- Very fast first results on quality of parts
- Application: e. g. Wheel inspection
- 不同透射角度的2D图像
- 基于几何放大的分辨率
- 无需重构而直接呈现2D射线图像于计算机屏幕
- 工件质量的快速结果呈现
- 应用：例如轮毂检测

Computed Tomography
计算机断层成像



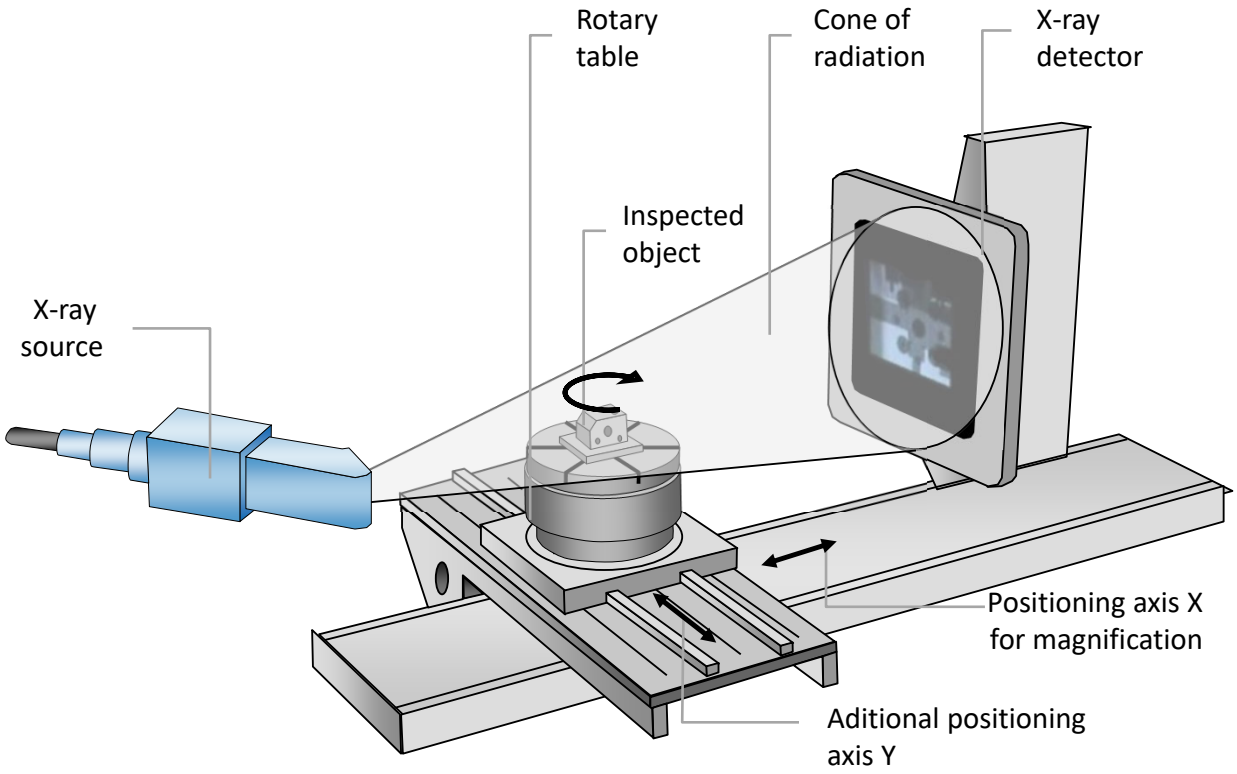
CT attributes
- Full 3D image of whole sample or detailed imaging of sub-sample
- Resolution based on geometrical magnification
- Various options for trade-off between resolution and speed
- Application: Metrology or 100% inspection of inner structures
- 样品整体3D图像或局部的细节成像
- 基于几何放大的分辨力
- 多样化选项覆盖分辨率与速度
- 应用: 测量或内部结构的 100% 检测

X-Ray microscopy
X 射线显微成像



X-ray microscopy attributes
- High resolution interior tomography imaging based on 2-stage magnification (lense coupled with detector)
- Highest resolution achieved even with large samples (no need to cut down)
- Application: High resolution imaging for material research
- 基于二级放大的高分辨力内部断层成像 (镜头结合探测器)
- 即便大样品也能获取高分辨率 (无需剖切)
- 应用: 材料研究高分辨率成像

Industrial CT system
Construction and main components



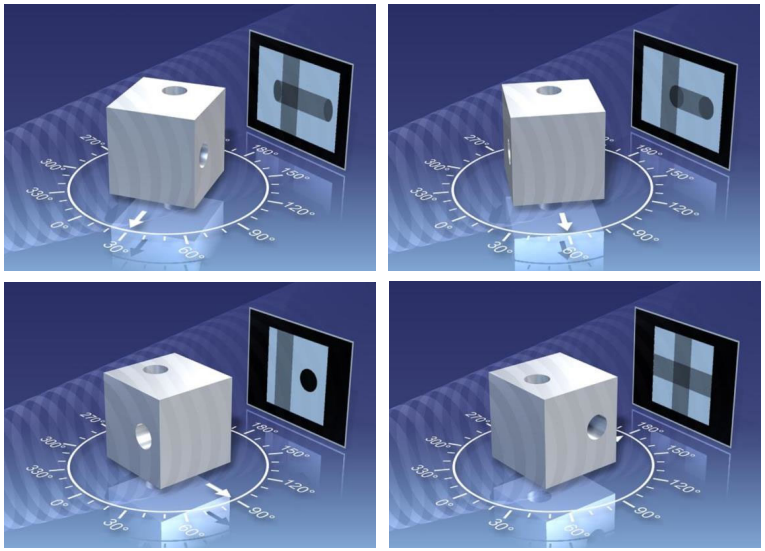
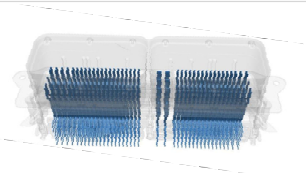


Image acquisition during rotation of the object around one axis

CT Solution for Connector

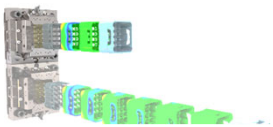
Dimensional Metrology and Failure Analysis



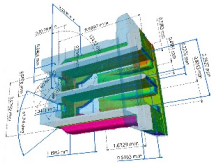
3D-Volume Data (Voxel)

1 Dimensional Metrology

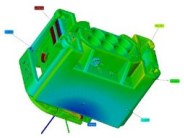
- Reverse Engineering



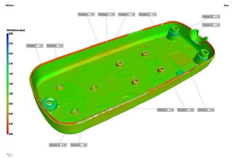
- Dimensional Feature Evaluation



- Nominal/actual comparison

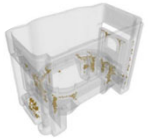


- Wall thickness analysis



2 NDT Non-destructive Testing

- Defect Control



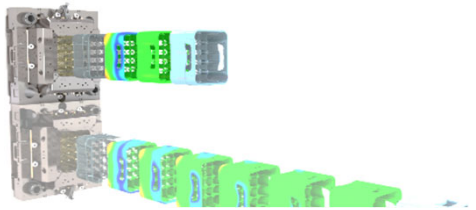
- Assembly Control

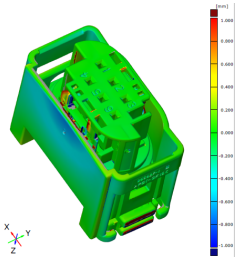


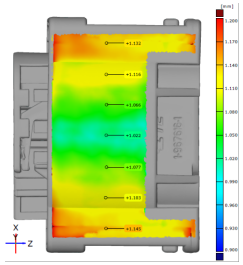
CT for Dimensional Metrology

Take a close look at every detail





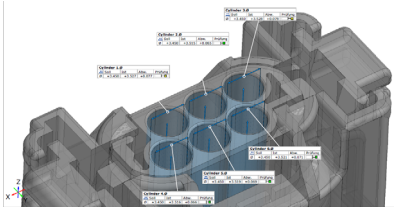


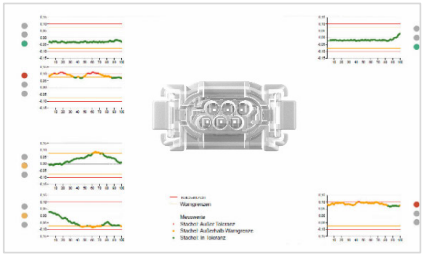


1 Quick tool correction
You can easily create CAD models from 3D volume data – significantly accelerating product development and reverse engineering processes.

2 Nominal/actual comparison
Deviations from the CAD model or master part are visualized in a false color comparison.

3 Wall thickness analysis
A color-coded representation shows the wall thickness of internal structures.

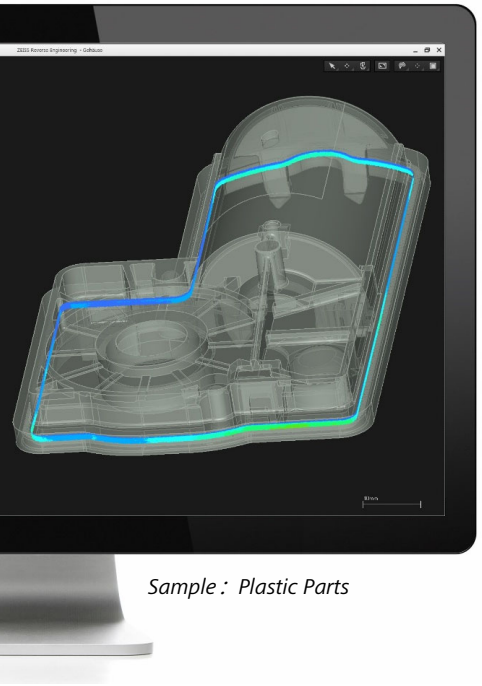




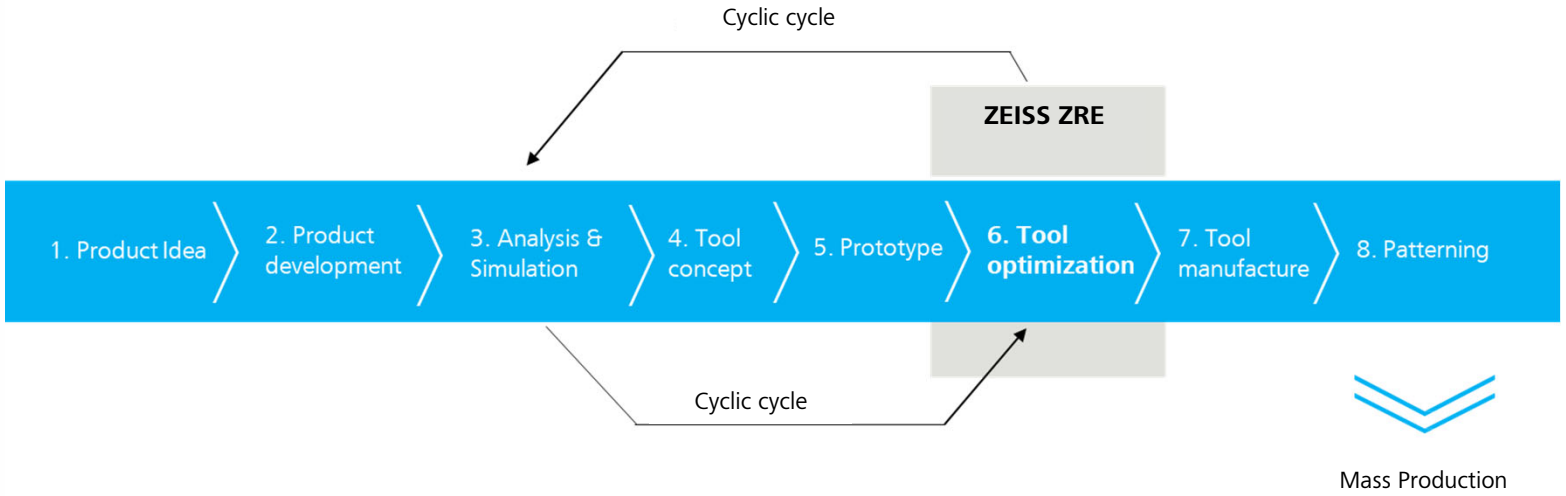
4 Dimensional control
Thanks to computed tomography, the dimensional accuracy of complex internal and external features can be checked in just one scan.

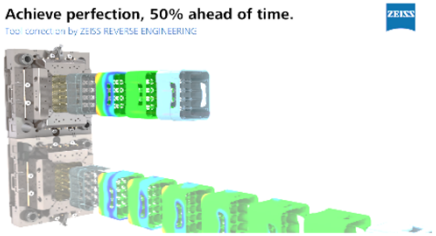
5 Tool & process optimization
A comprehensive inspection of the part provides meaningful information on the condition of the tools and the production process.

1 Quick Tools Correction
Base on the ZEISS ZRE



Sample：Plastic Parts

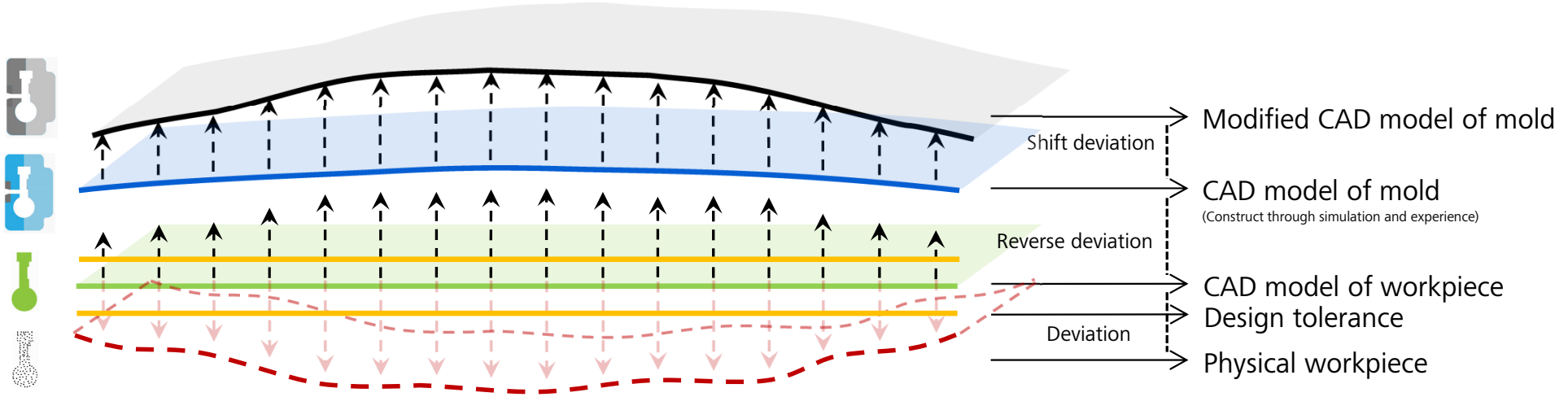


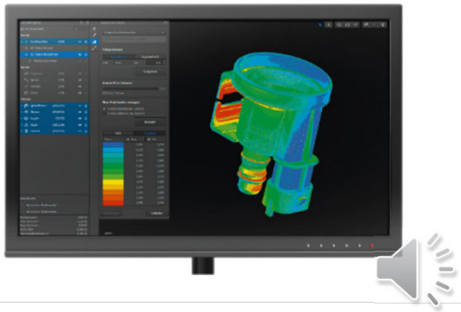


- ✓ Too much circular process before the mass production
- ✓ Previous cycles of 12 to 24 months were not conducive to product launch
- ✓ **50% time saving** for tool correction with the help of ZEISS ZRE

1 Quick Tools Correction

Base on the ZEISS ZRE

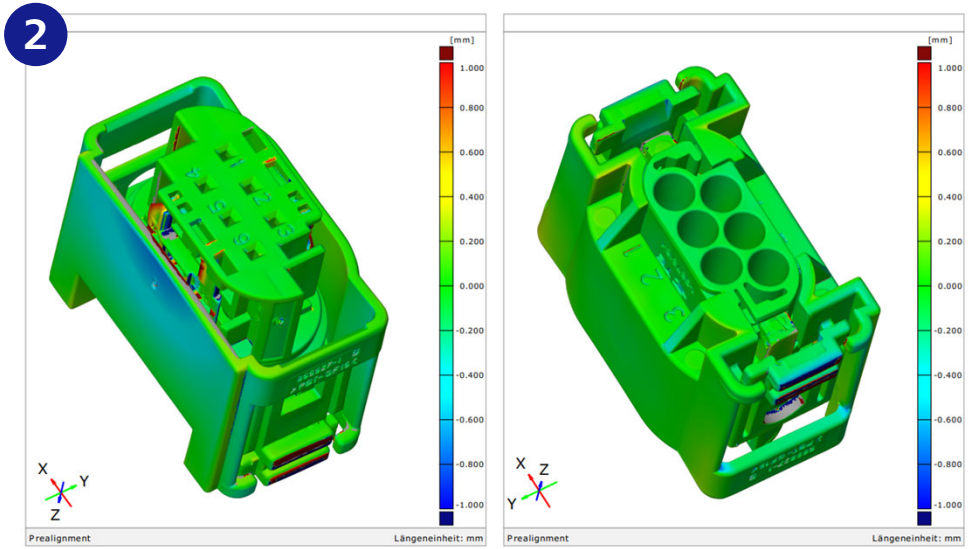




Wall thickness analysis & CAD comparison

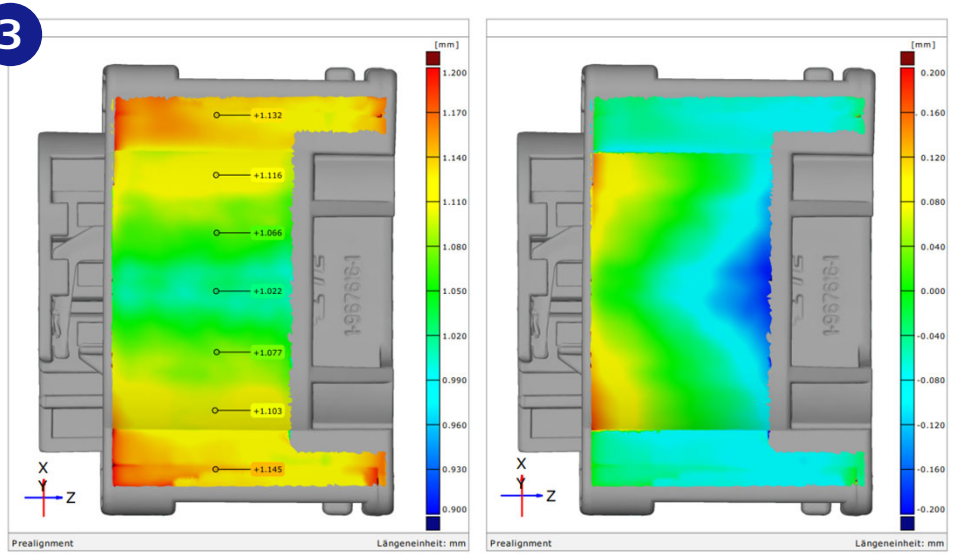
Efficient production process quality assurance

2



CAD comparison

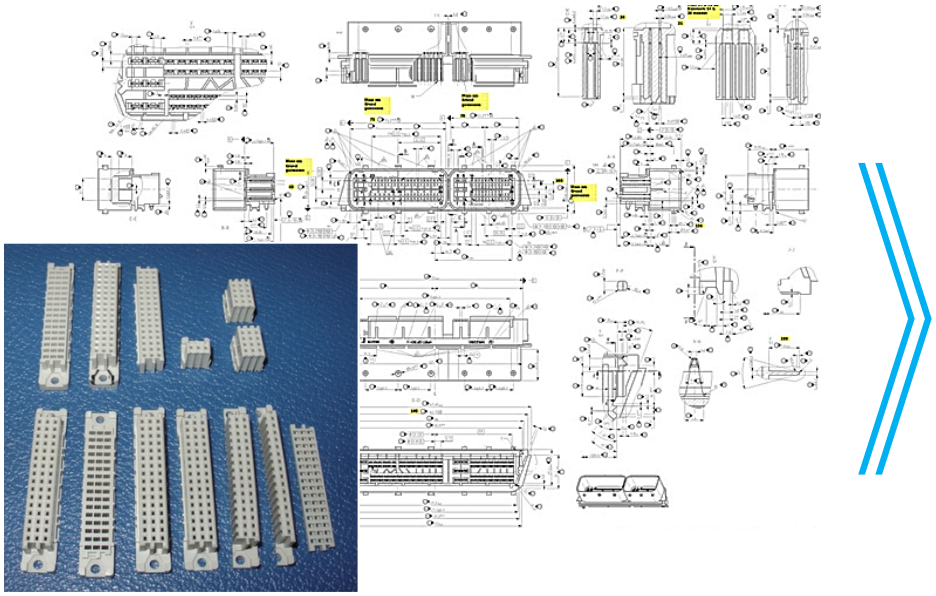
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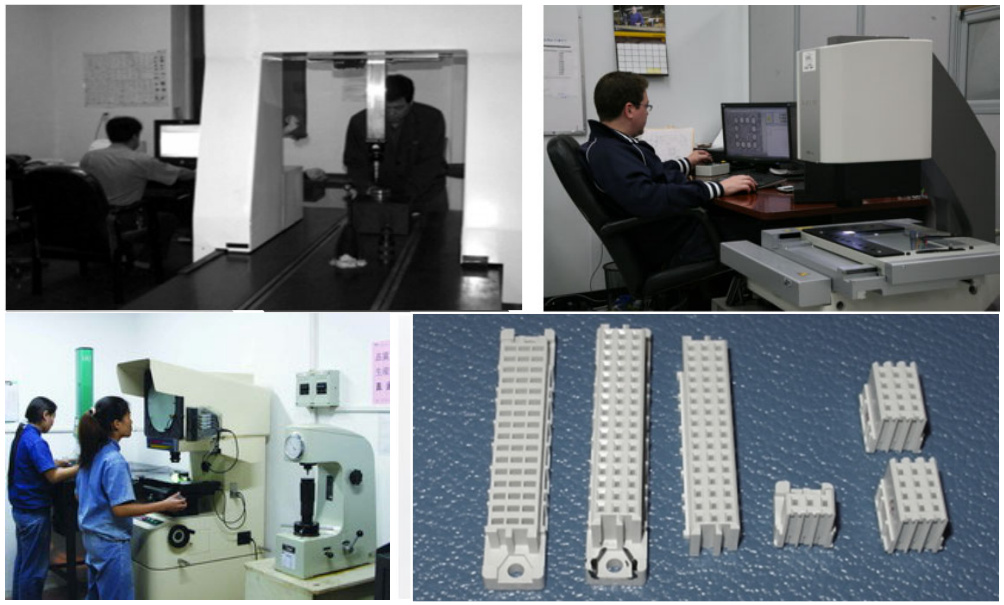


Wall thickness analysis

How to improve the efficiency of FAI

Challenges faced by the industry



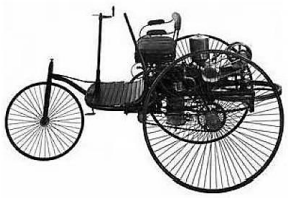


- ✓ Over 500 dimensions should be measured
- ✓ Traditional measurement

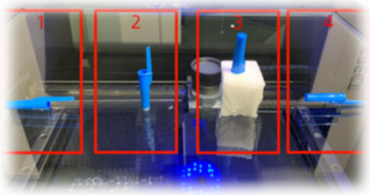
How to effectively shorten the first article inspection time

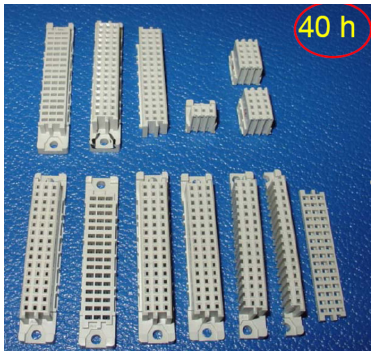
Accelerate new product launch and competitiveness

Tradition







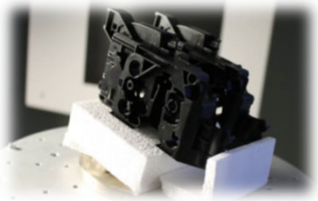


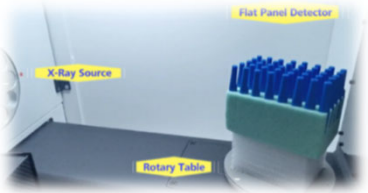


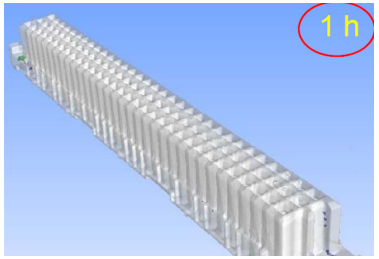
- ✓ Higher labor and time costs = cutting damage + multiple clamping positioning

Modern

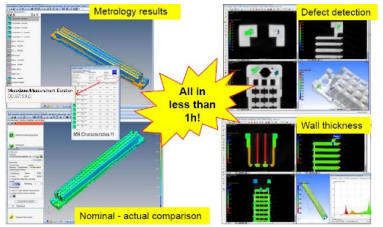








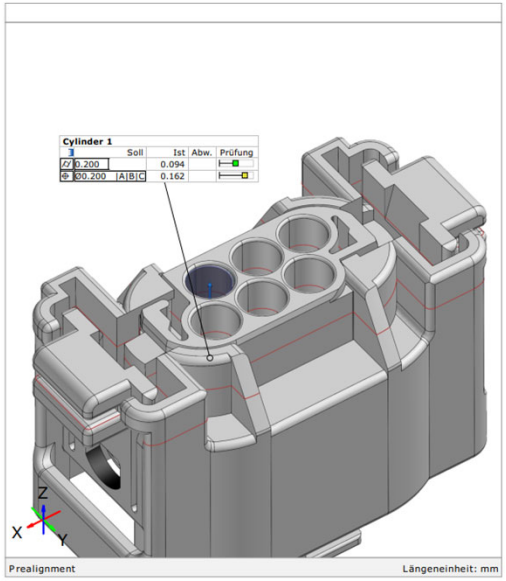


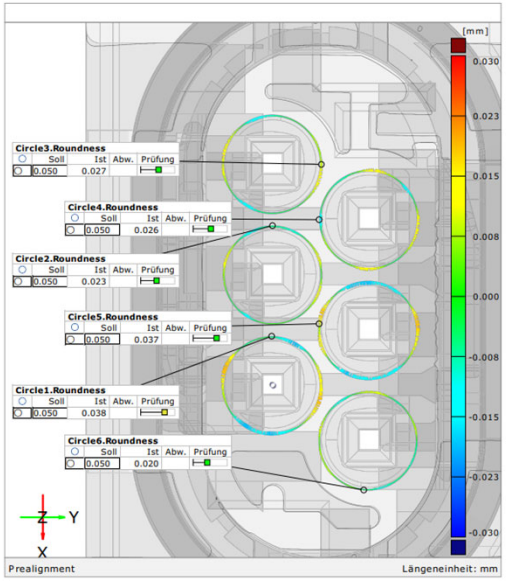


- ✓ Higher quality & efficiency = none destructive quality information + Batch efficient scanning

Quick first article inspection

Base on GOM Volume Inspect





Element	Datum	Property	Nominal	Actual	Tol -	Tol +	Dev	Check	Out
Volume defec...		Vp			-0.50	+0.50	+4.11		+3.61
Cylinder 6		Ø	+3.450	+3.521	-0.100	+0.100	+0.071		
Cylinder 5		Ø	+3.450	+3.519	-0.100	+0.100	+0.069		
Cylinder 4		Ø	+3.450	+3.516	-0.100	+0.100	+0.066		
Cylinder 3		Ø	+3.450	+3.528	-0.100	+0.100	+0.078		
Cylinder 2		Ø	+3.450	+3.515	-0.100	+0.100	+0.065		
Cylinder 1	A|B|C	⌖Ø	+0.000	+0.162	+0.000	+0.200	+0.162		
Cylinder 1		⌭Ø	+0.000	+0.094	+0.000	+0.200	+0.094		
Cylinder 1		Ø	+3.450	+3.527	-0.100	+0.100	+0.077		
Circle6		○Ø	+0.000	+0.020	+0.000	+0.050	+0.020		
Circle5		○Ø	+0.000	+0.037	+0.000	+0.050	+0.037		
Circle4		○Ø	+0.000	+0.026	+0.000	+0.050	+0.026		
Circle3		○Ø	+0.000	+0.027	+0.000	+0.050	+0.027		
Circle2		○Ø	+0.000	+0.023	+0.000	+0.050	+0.023		
Circle1		○Ø	+0.000	+0.038	+0.000	+0.050	+0.038		
A		(I)	+8.600	+8.393 / +8.680	-0.200	+0.200	-0.207 / +0.080		

✓ Graphical report

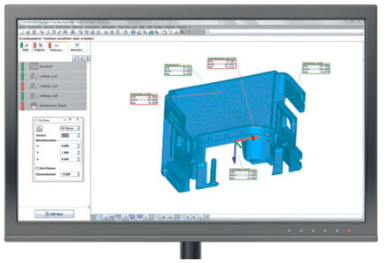
✓ Table Details

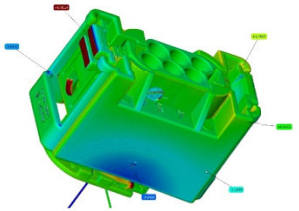
Efficient production process quality assurance

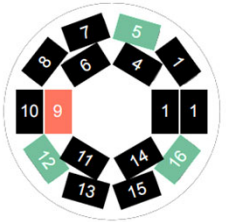
At line process control









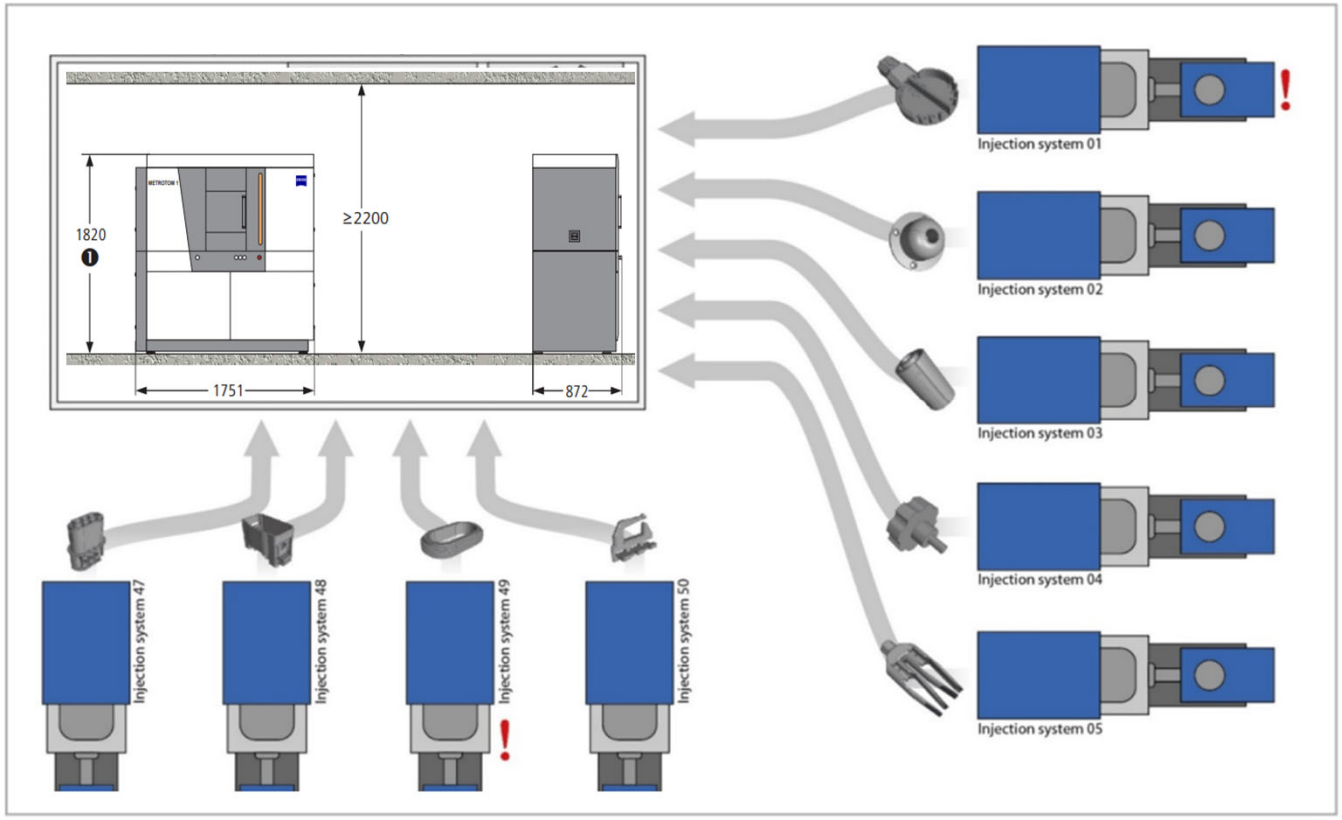


- ✓ **Multi-parts loading & unloading**
- ✓ **Automatic scanning and reconstruction**
- ✓ **Automatic splitting and analysis**

高效的生产过程质量保障

收益及优势





收益

- 非接触式测量，操作简捷高效
- 确认生产流程是否稳定
- 实现有效的人力及时间节省
- 替代检具、常规测量仪及视觉检测（披锋、气孔）

CT for Metrology
Inline Metrology



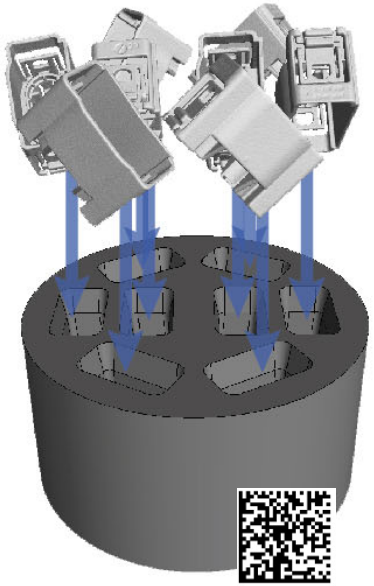
- High-Speed scan in 5 to 100 seconds
- Robustness for usage in production
- Customer specific hard and software



CT for Metrology
Inline Metrology

Scanning, Reconstruction, Separation, Inspection, Measuring, Reporting

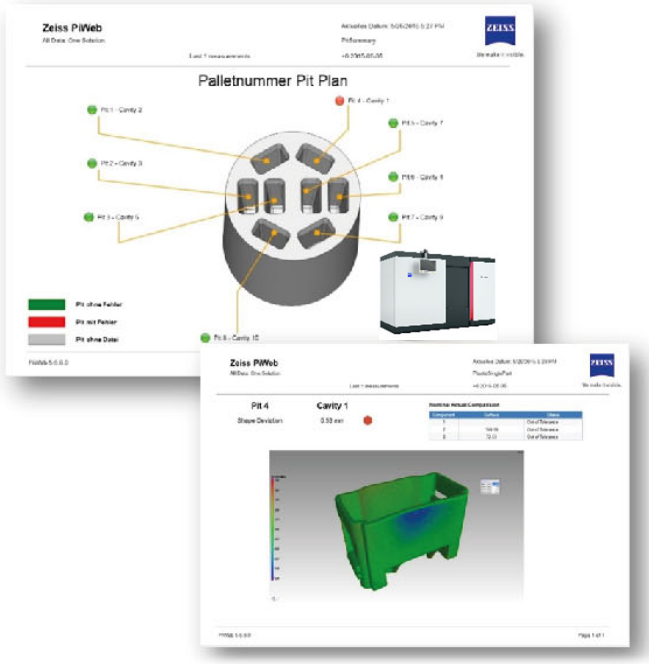
Loading parts to the fixture



Fully automated scan and post-processing



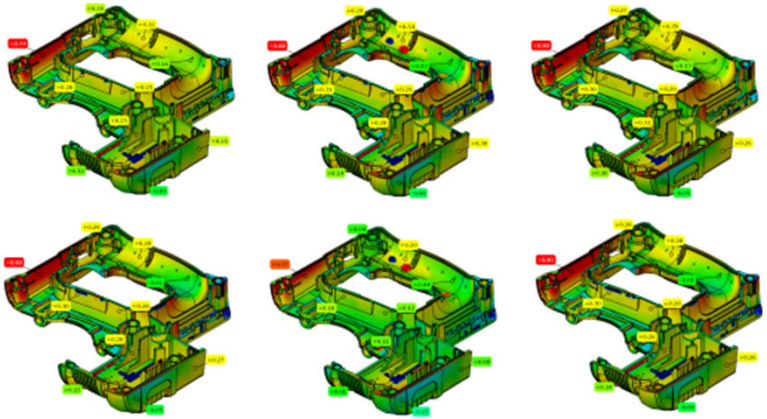
Online monitoring and reporting the results

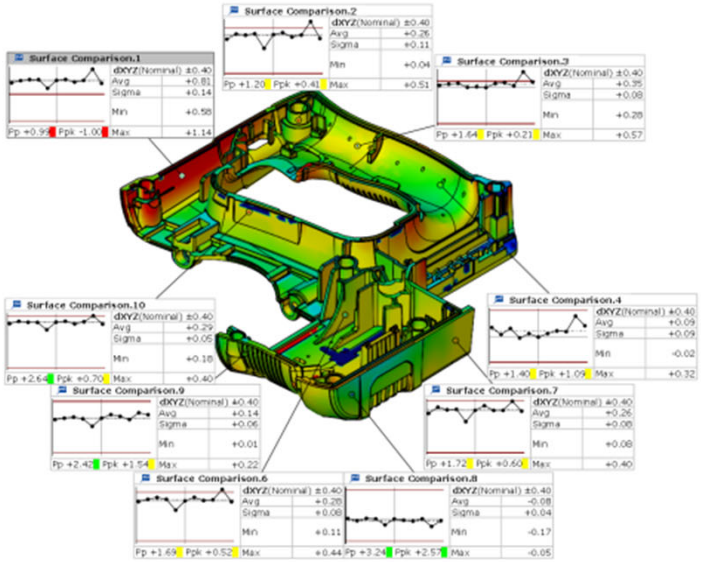


5 Tool & process optimization

Trend and statistical analysis base on the GVI software

- ✓ **Multiple components CAD comparison**
- ✓ **Nominal/actual comparison**
- ✓ **Statistical analysis base on GVI**
- ✓ **Automatic report output**





5 Tool & process optimization

Base on PiWeb Quality data management software

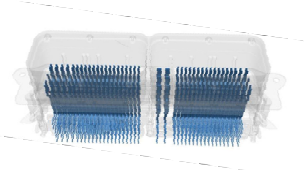




- ✓ Automatic defect analysis, classification, and visualization
- ✓ Statistical analysis and comprehensive monthly and weekly reports

CT Solution for Connector

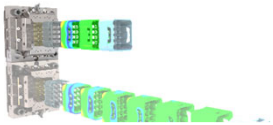
Dimensional Metrology and Failure Analysis



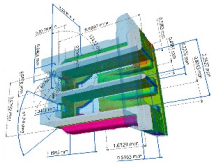
3D-Volume Data (Voxel)

Dimensional Metrology

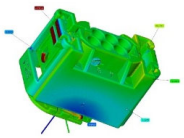
- Reverse Engineering



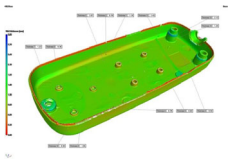
- Dimensional Feature Evaluation



- Nominal/actual comparison

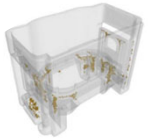


- Wall thickness analysis

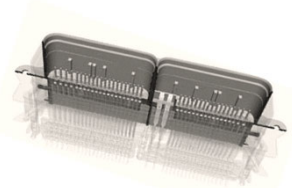


NDT Non-destructive Testing

- Defect Control



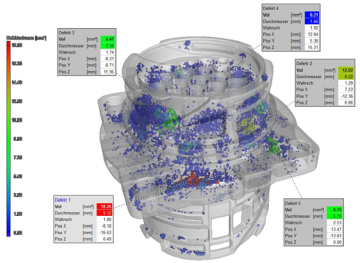
- Assembly Control



CT for Inspection & Failure analysis

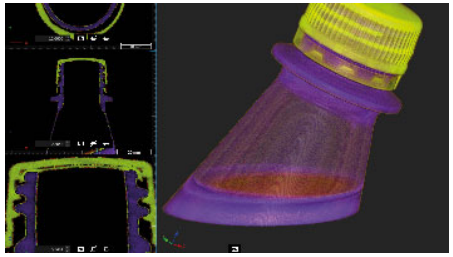
Take a close look at every detail





1 Defect analysis 3D

You can detect cavities, pores, cracks and other defects quickly and easily.

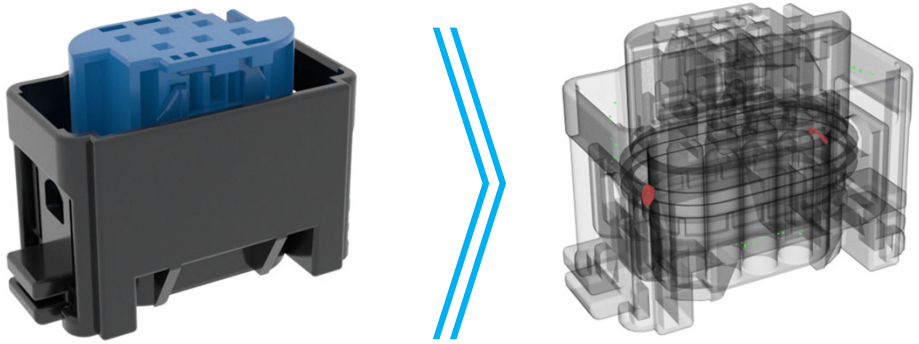


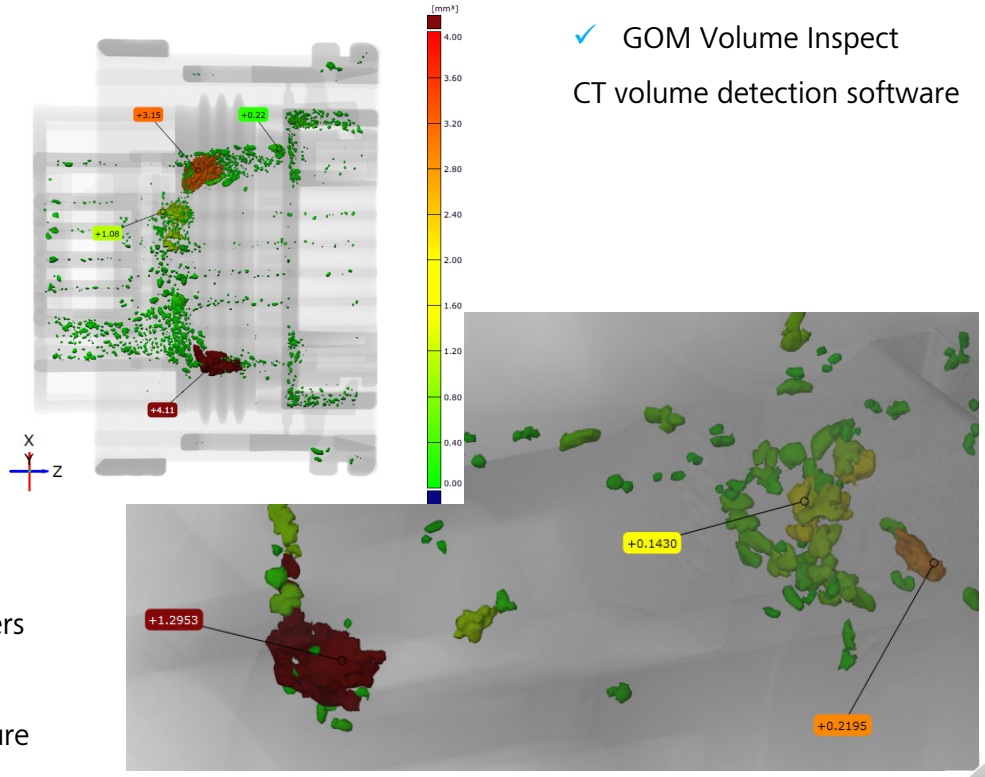
2 Assembly control

Assembled parts are checked for function and fit.

1 Defect analysis

Qualitative and quantitative intelligent analysis of porosity





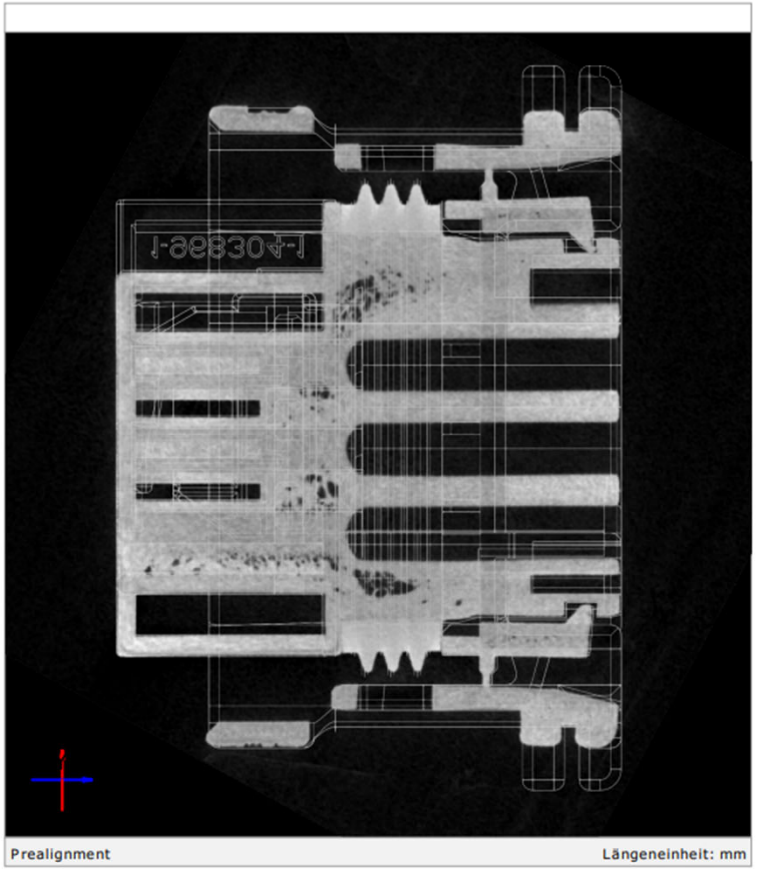
- ✓ GOM Volume Inspect

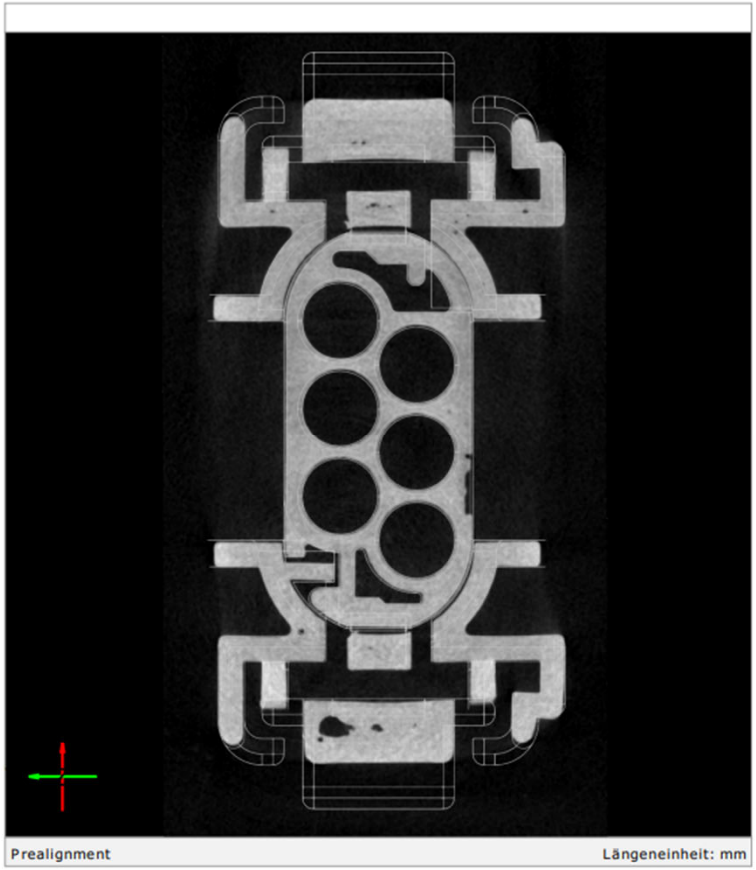
CT volume detection software

- ✓ Bubble position is not fixed -> Injection molding process is instability
- ✓ Reduction in bubble volume and quantity -> Injection molding parameters optimization
- ✓ Specific position bubbles -> Strength affected which leads to local fracture

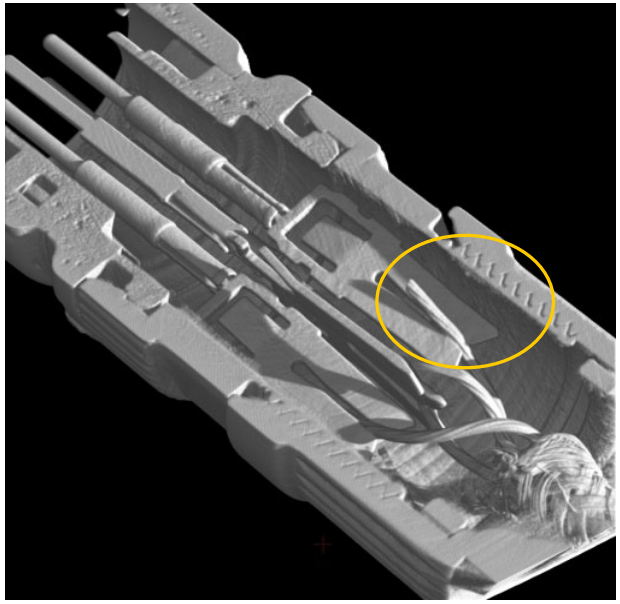
1 Defect analysis

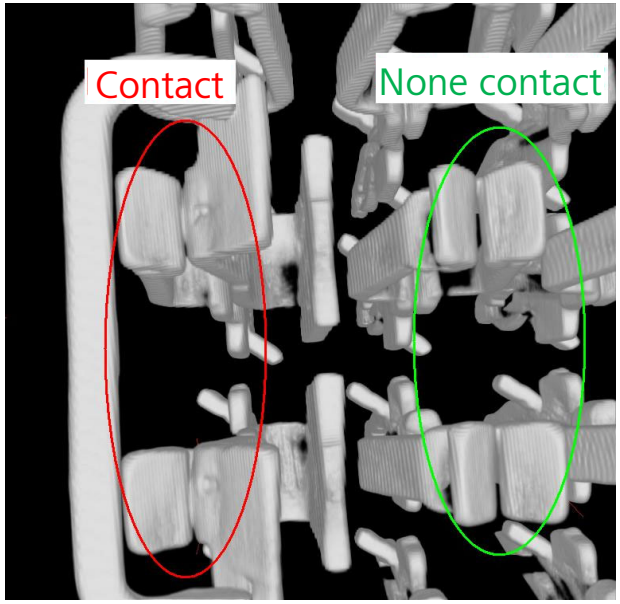
Qualitative and quantitative intelligent analysis of porosity

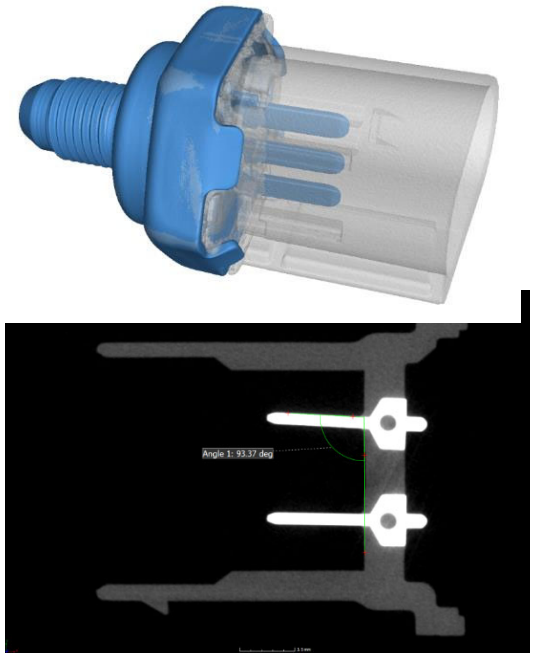




2 Assembly Control
Abnormal failure locking & analysis



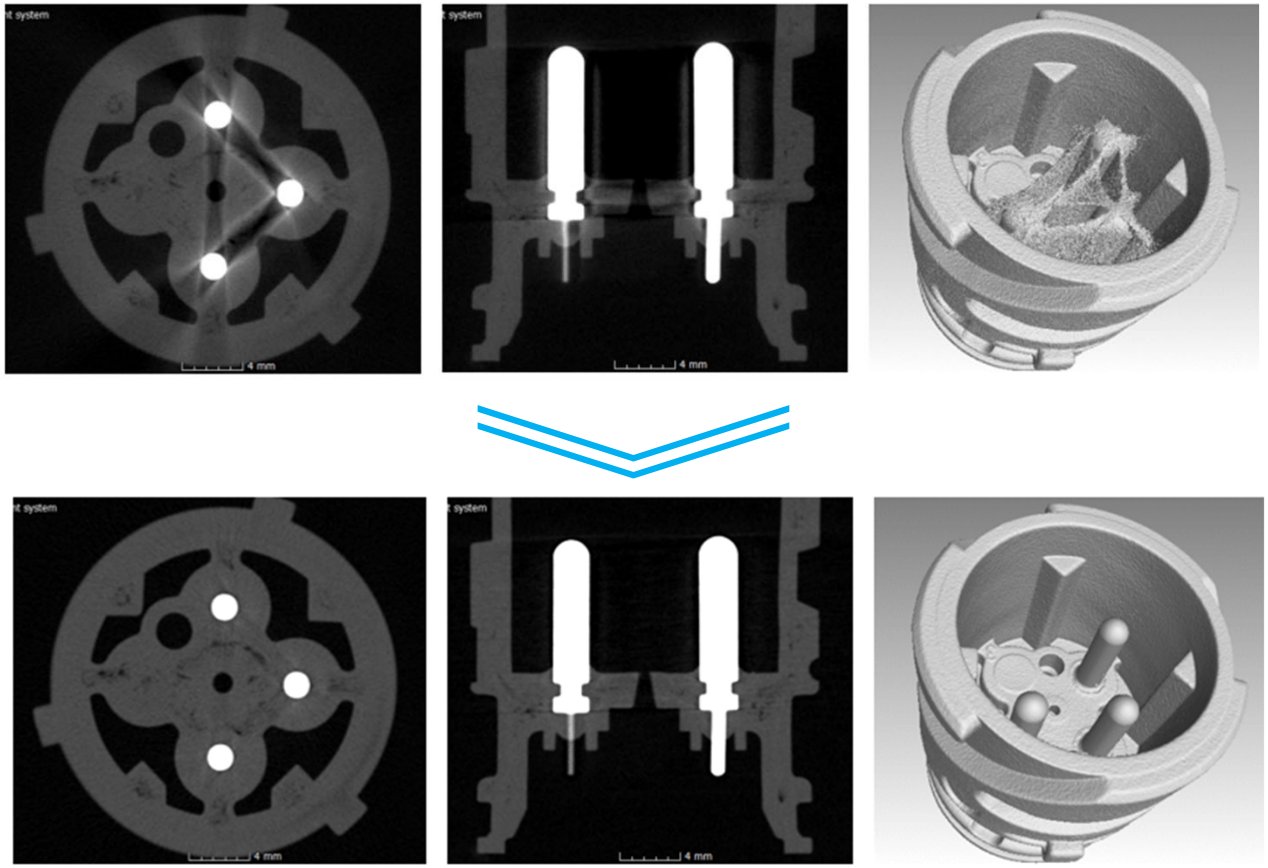




✓ Visual failure rapid analysis

2 Assembly Control Challenges and Solutions

ZEISS AMMAR Technology

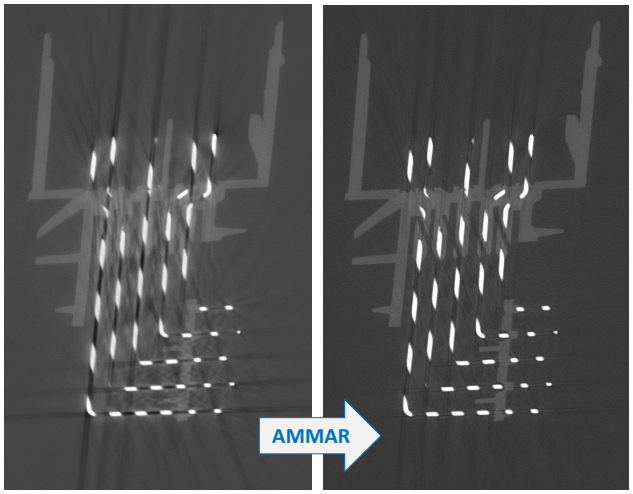


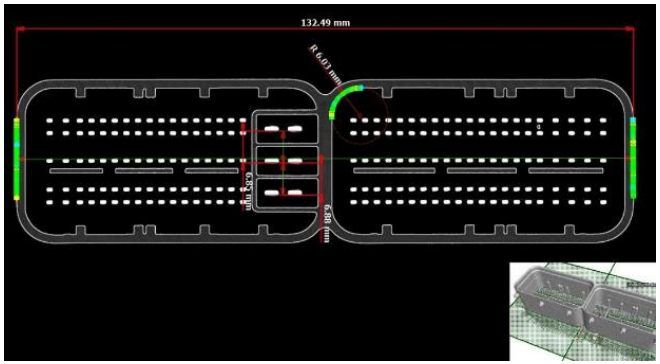
- Improving the Image Quality of multi-materials
- Focusing on the application of multi-materials, such as connectors
- More detailed information on plastic parts
- Improve the quality of defect analysis
- Clearer material boundaries
- More uniform material grayscale values

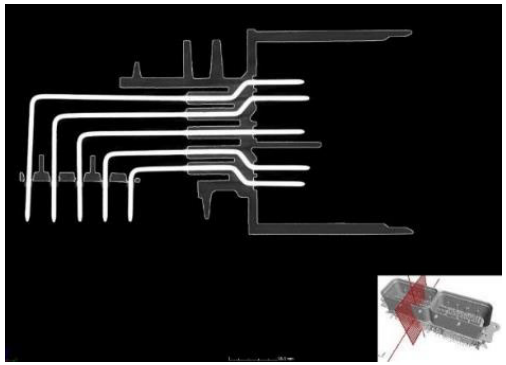
Final Assembly Inspection

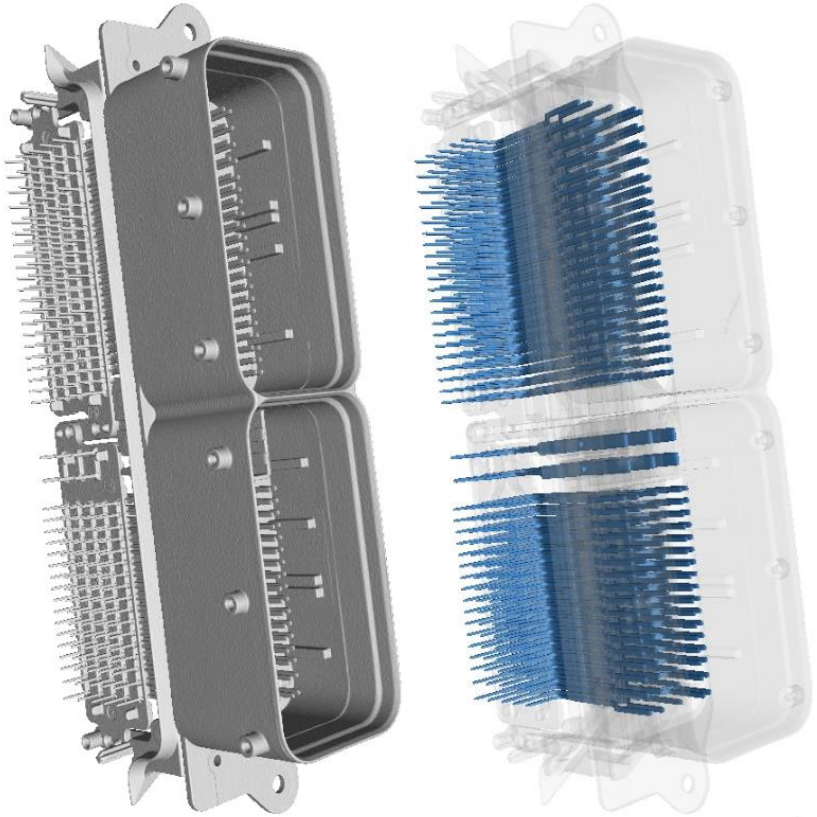
Dimension measurement & defect inspection & assemnly control with CT











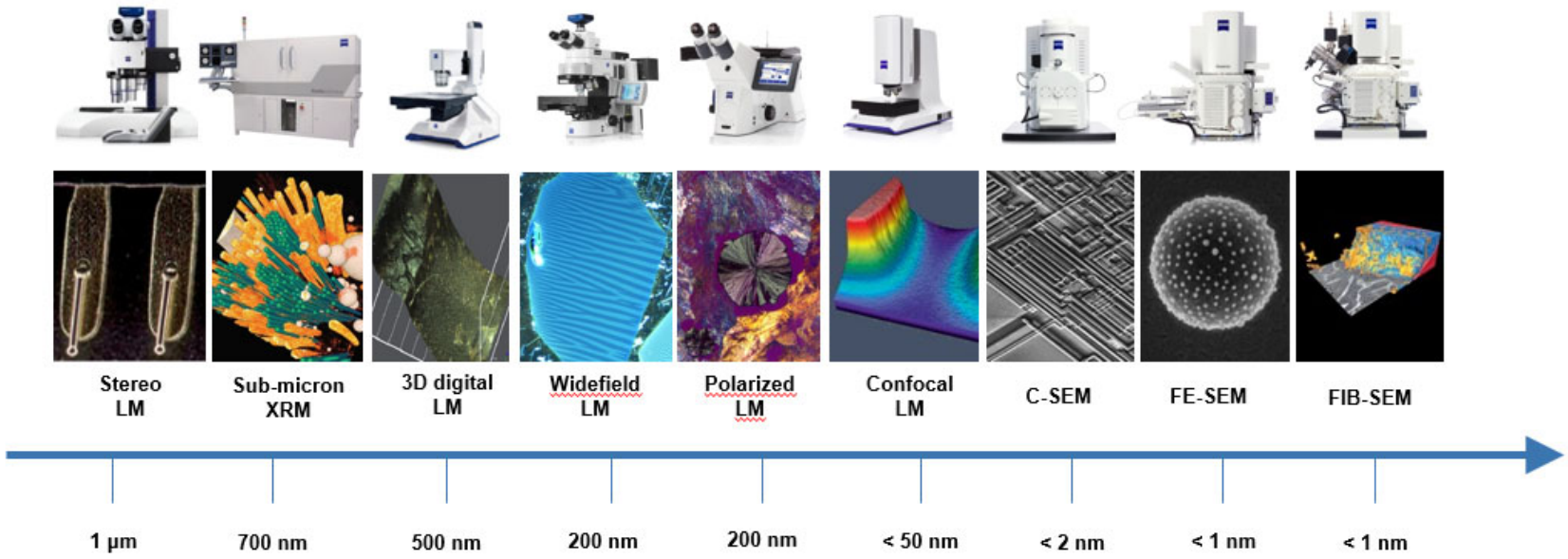
Microscope for connector



蔡司显微镜在工业质量领域的多尺度测量方案

覆盖从微米到纳米，从二维到三维的应用领域

A complete microscopy portfolio…

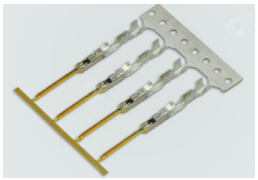


体式显微镜　X射线显微镜　3D数码显微镜　金相显微镜　共聚焦显微镜　扫描电子显微镜　聚焦离子束显微镜

…to address multi-scale research challenges.

REQ: Contact Pin Coating Analysis

Application Picture



Contact Pin

Customer's Requirements

- SST(salt spray test) and FA
  - Microscopic topography characteristic analysis
  - Elements analysis

Application Analysis

Considering of the elements analysis and resolution, EVO10 will be a good solution

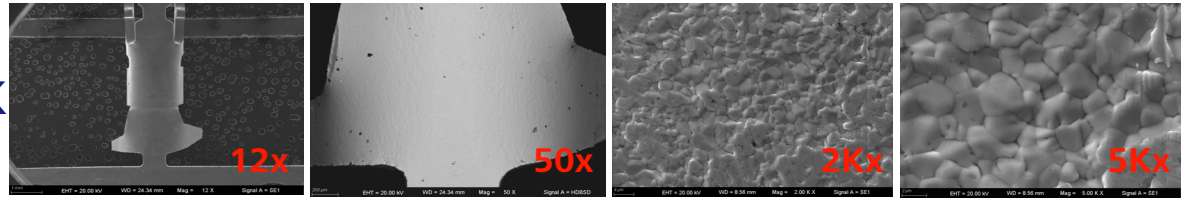
Proposed Solution



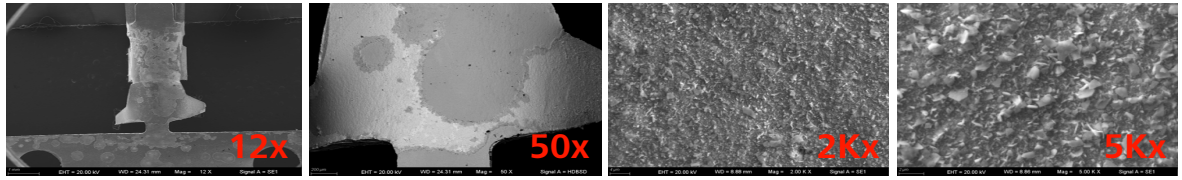
EVO 10

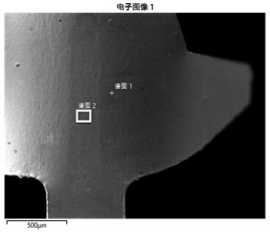
Cases Example

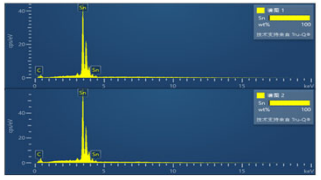
OK



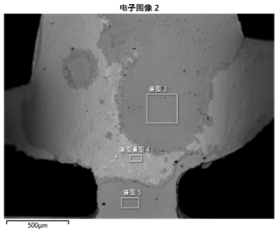
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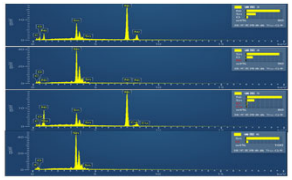






EDS analysis: Sn

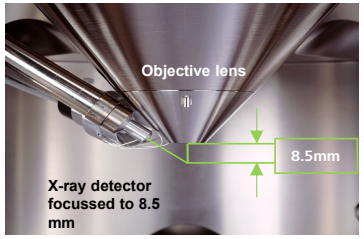




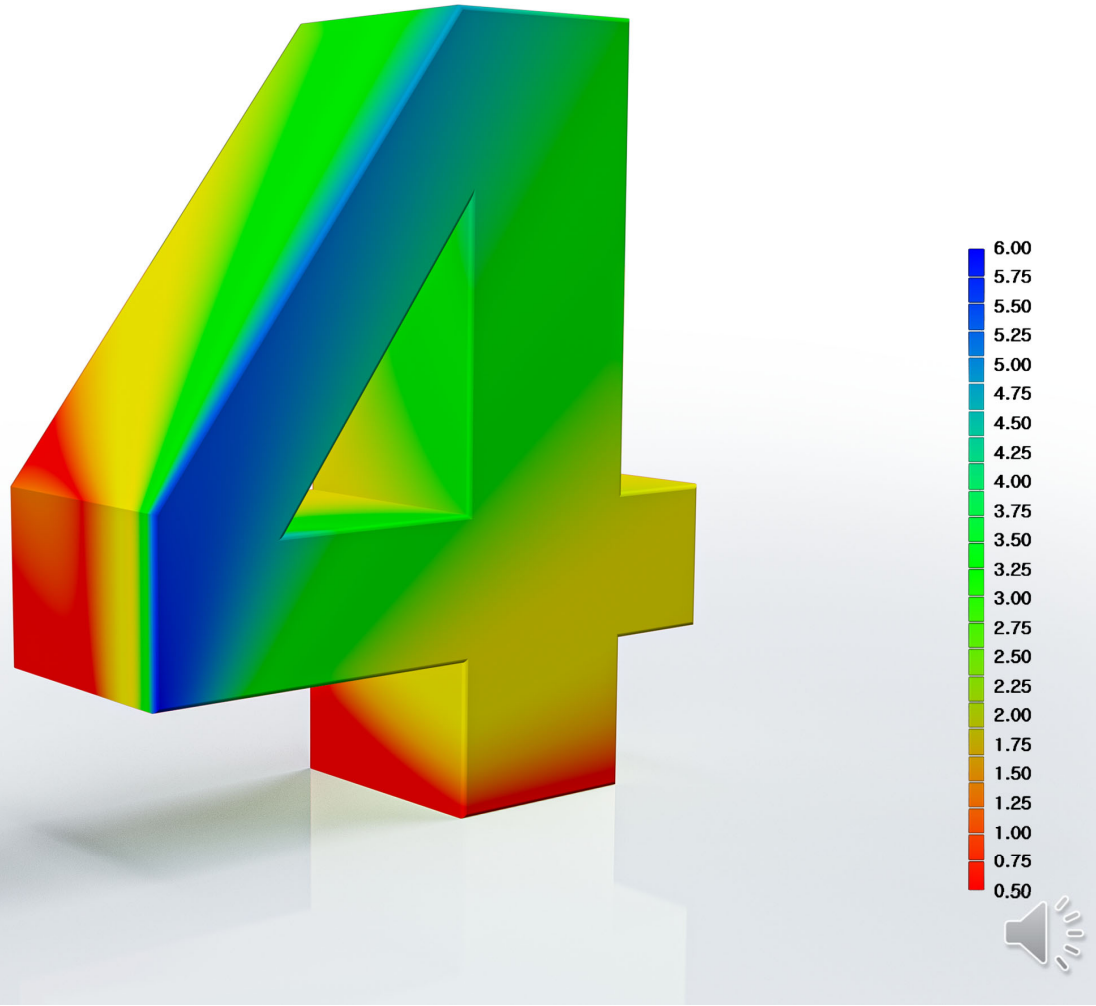
EDS analysis: Ni &Sn

ZEISS Value Proposition

- ✓ Very large sample chamber which allow maximum sample 230mm(Φ) x 100mm(h)
- ✓ 5-axes motorized stage (X =80 mm Y = 100 mm Z = 35 mm T = -10° ~ 90° R = 360°)
- ✓ Class leading X-ray geometry
- ✓ High performance electron optics (Analysis, Field, Resolution, Depth, Fisheye multiple modes)
- ✓ Ergonomic control panel and easy use for measurement

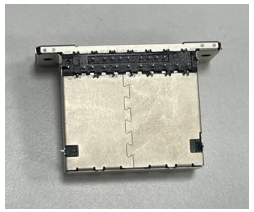


Optical system for connector



REQ: Quick Deformation Inspection

Application Picture



Consumer connector assembly

Customer's Requirements

- **Quickly detect** the deviation between the CAD & actual data and **quickly identify** the defect position during the development phase.
- **Acquire 3D contour of the entire parts and give the trend report** before the delivery

Application Analysis

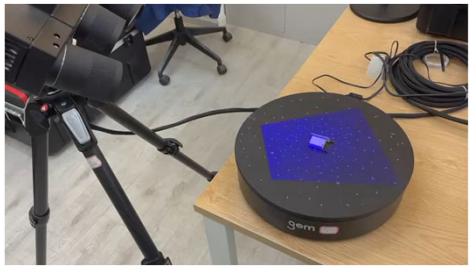
Considering of the **efficiency and the whole profile trend** focused by the customer, ATOS Q can be the best solution for that

Proposed Solution

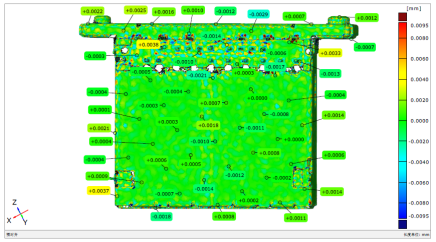


ATOS Q | ASLAI Standard Stand | 350 RT | GOM Inspect

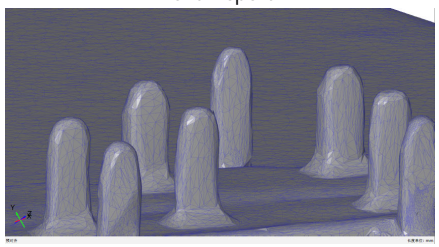
Cases Example



Scanning by ATOS Q



Trend Report



Scanning Details

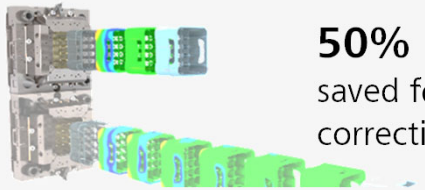
ZEISS Value Proposition

- ✓ Fringe Projection with Blue Light Equalizer for highest data quality, **point distance is up to 30µm**
- ✓ **Automatic scanning** with the support of rotary table
- ✓ Quickly capture the abnormal area vs CMM&OMM (round about 1-2 minutes/per parts, **5 times efficiency higher**)



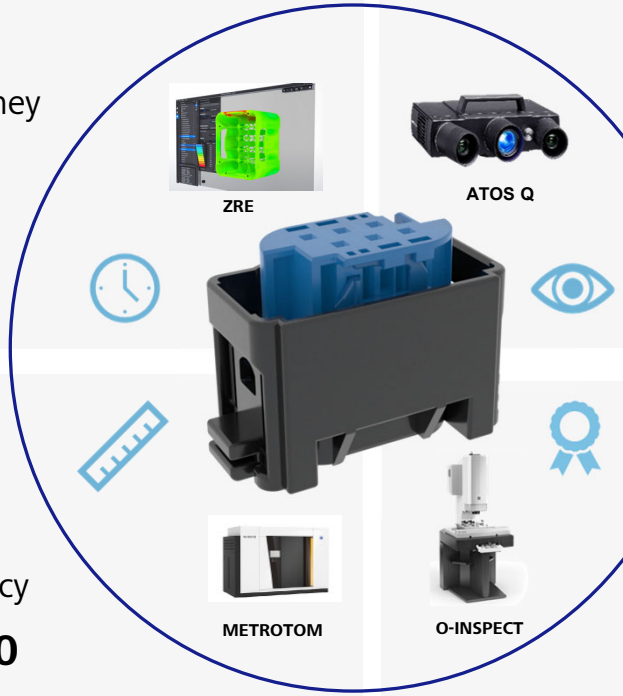
ZEISS Value Proposition for Connector

Value 1: Shorten the new mold product cycle

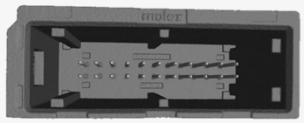


50% time and money saved for the tool correction

- Cost down for tool correction



- Full dimension inspection of first article
- Assembly analysis & defect inspection

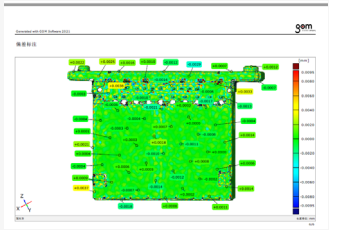


High MPE accuracy

2.9µm+L/100

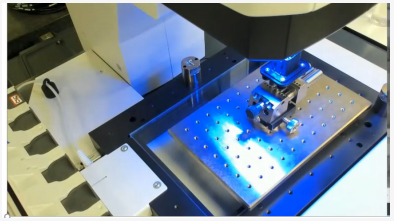
Value 2:Time to market

Reduce **20%** verification time



- Speed up the DVT & FA
- Increase the measurement efficiency

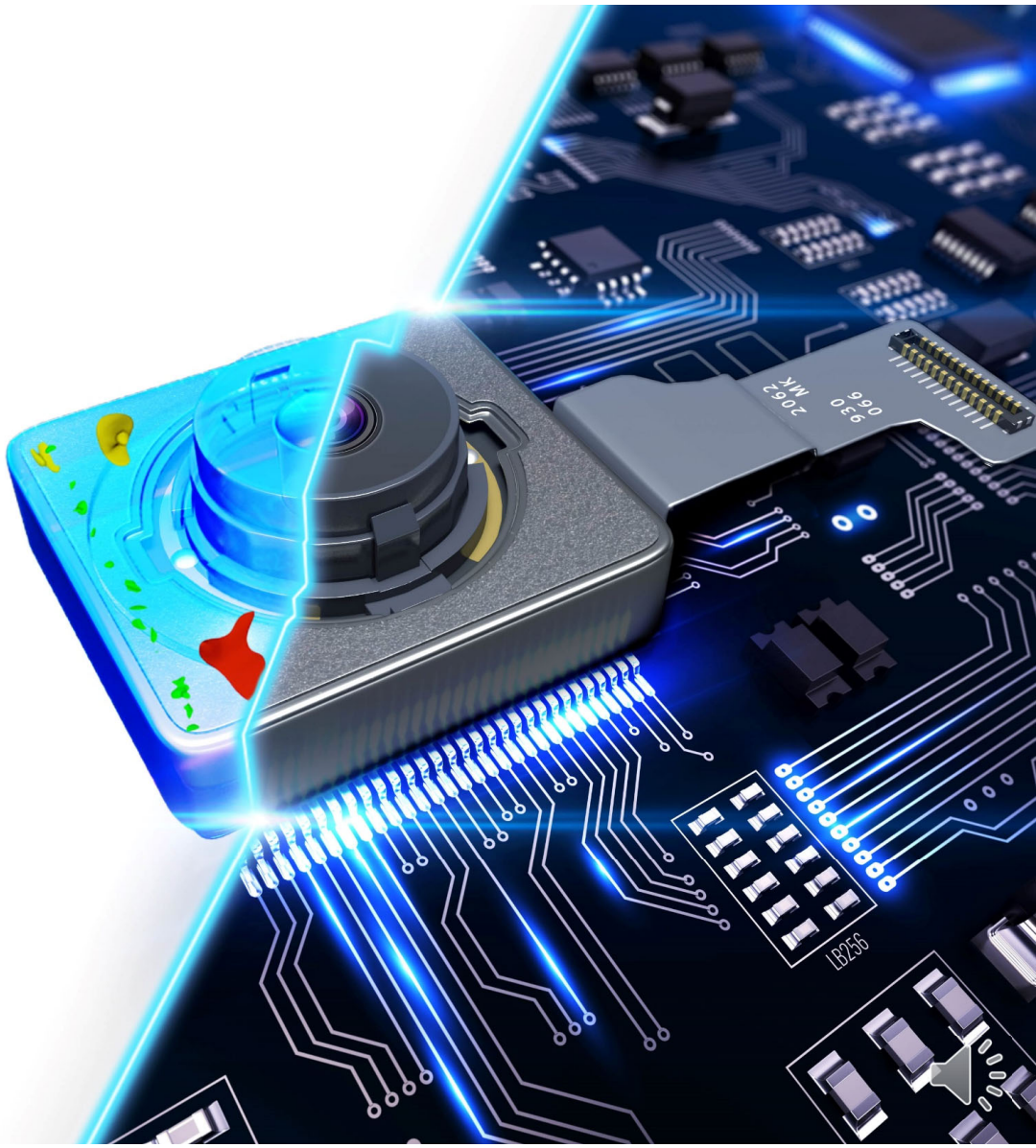
200% faster than pure optical or tactile



Value 3: Save 60% labor cost

Value 4: Save 50% labor cost

Q&A





Seeing beyond