INLINE COMPUTATIONAL IMAGING

AIT Inline Computational Imaging (ICI) is a novel single sensor technology for simultaneous 2D and 3D inline inspection for challenging inspection tasks.

OPPORTUNITIES

- Combined 2D and 3D inspection
- Enhanced 2D imaging, e.g. gloss / shadow reduction, all-in-focus, high-dynamic range, etc.
- 3D measurements down to μm range
- Advanced inline inspection for 2D and 3D features for materials with challenging surface properties
- Inspection of optically variable devices and holograms
- Detection of defects and fine surfaces structures

ADVANTAGES

- Reliable, fast and accurate
- Simple and compact, using only one camera
- Works for objects with different surfaces (matt / glossy, structured / unstructured) at the same time
- Inspection in motion (no stop-and-go required)
- Dynamic adaptable to changing requirements in terms of speed, accuracy and surface quality
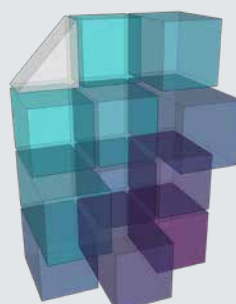- Patented technology

ICI SENSOR SYSTEM

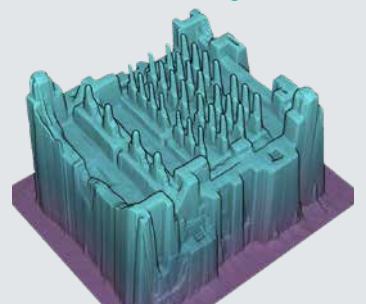Single Sensor Technology for Simultaneous Light Field and Photometric Stereo Capture
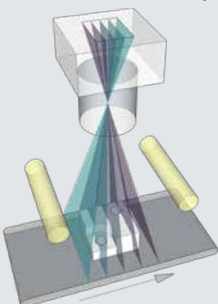
ICI SOFTWARE

Generic Computational Imaging Library for 2D/3D Tasks

ICI SOLUTION (2D & 3D)

3D Point Cloud
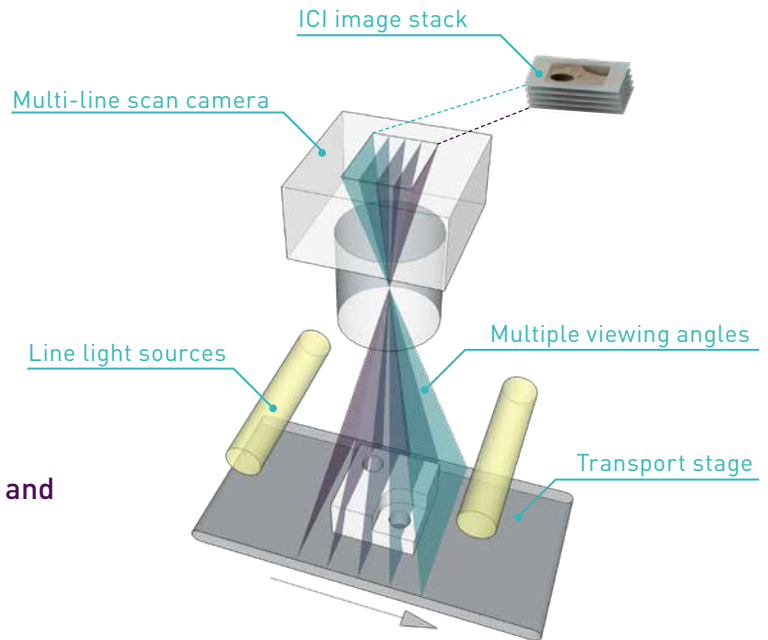2.5D Depth Map
Enhanced 2D Images

INLINE COMPUTATIONAL IMAGING

Inline Computational Imaging (ICI) is a novel single sensor technology capable for simultaneous 2D and 3D inline inspection. It combines the advantages of light field imaging and photometric stereo into one compact solution. ICI technology is a new type of image acquisition system combined with smart algorithms for high resolution and high speed 2D and 3D inspection.

AIT ICI SENSOR SYSTEM

The ICI sensor system consists of one multi-line scan camera fitted with a standard endocentric lens, two line light sources and a moving sample part. Each of the lines act as an individual line scan camera that captures the corresponding image line by line while the object moves underneath the camera. This results in an ICI image stack consisting of multiple images each seeing the object under a slightly different viewing and illumination angle.

AIT ICI is a smart combination of light field imaging and photometric stereo.

ICI image stack

Multi-line scan camera

Line light sources

Multiple viewing angles
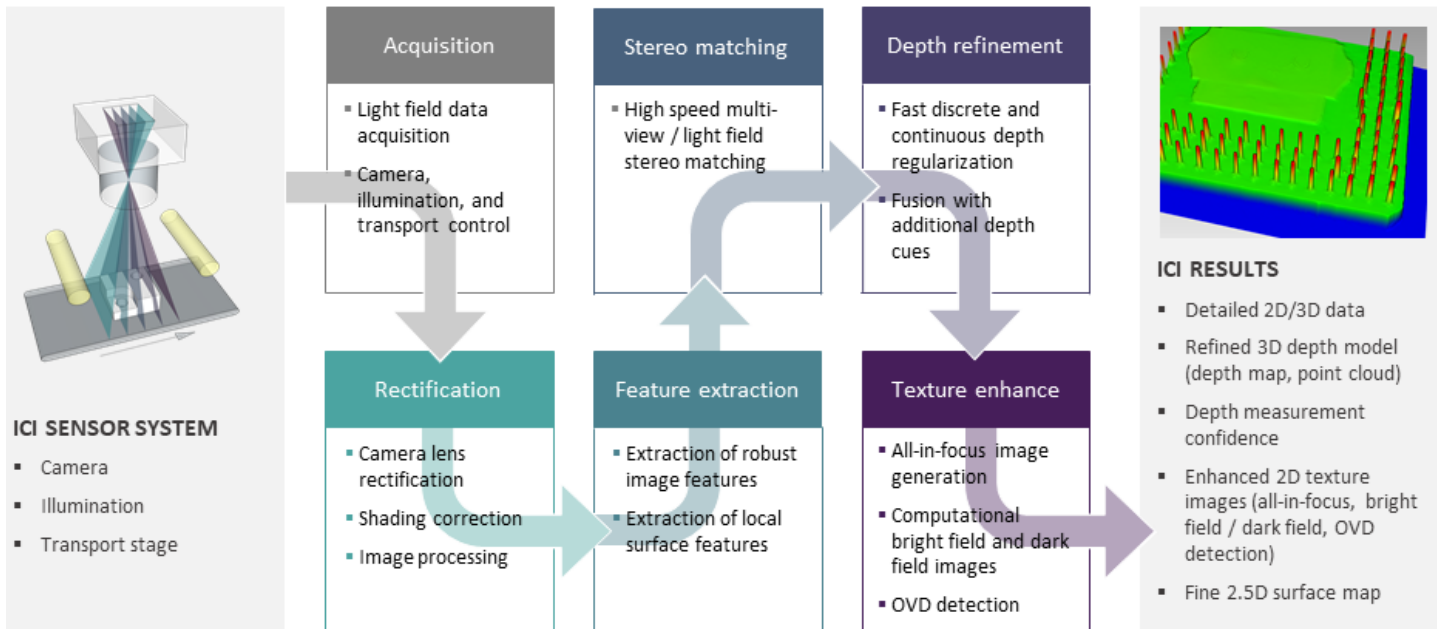
Transport stage
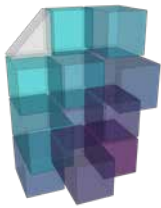
AIT ICI SOFTWARE

The AIT ICI algorithms have been designed specifically to work with the ICI sensor system and provide enhanced 2D images together with a high definition 3D reconstruction. All algorithms are highly optimized for high processing speed and best results quality. They are largely independent from computer and imaging platforms and support decentralized processing and reporting.

AIT ICI is a new technology for high resolution and high speed 2D and 3D inspection.

AIT ICI PROCESSING PIPELINE

ICI SENSOR SYSTEM
- Camera
- Illumination
- Transport stage

Acquisition
- Light field data acquisition
- Camera, illumination, and transport control

Rectification
- Camera lens rectification
- Shading correction
- Image processing

Stereo matching
- High speed multi-view / light field stereo matching

Feature extraction
- Extraction of robust image features
- Extraction of local surface features

Depth refinement
- Fast discrete and continuous depth regularization
- Fusion with additional depth cues

Texture enhance
- All-in-focus image generation
- Computational bright field and dark field images
- OVD detection

ICI RESULTS
- Detailed 2D/3D data
- Refined 3D depth model (depth map, point cloud)
- Depth measurement confidence
- Enhanced 2D texture images (all-in-focus, bright field / dark field, OVD detection)
- Fine 2.5D surface map

INLINE COMPUTATIONAL IMAGING – BETTER, FASTER, STRONGER, …

Inline Computational Imaging makes use of multiple viewing and illumination angles simultaneously. By using Inline Computational Imaging, it is possible to solve problems and tasks where traditional industrial imaging systems fail.

HIGH DEFINITION 3D RECONSTRUCTION

Pin height measurement

Print inspection

Crack detection
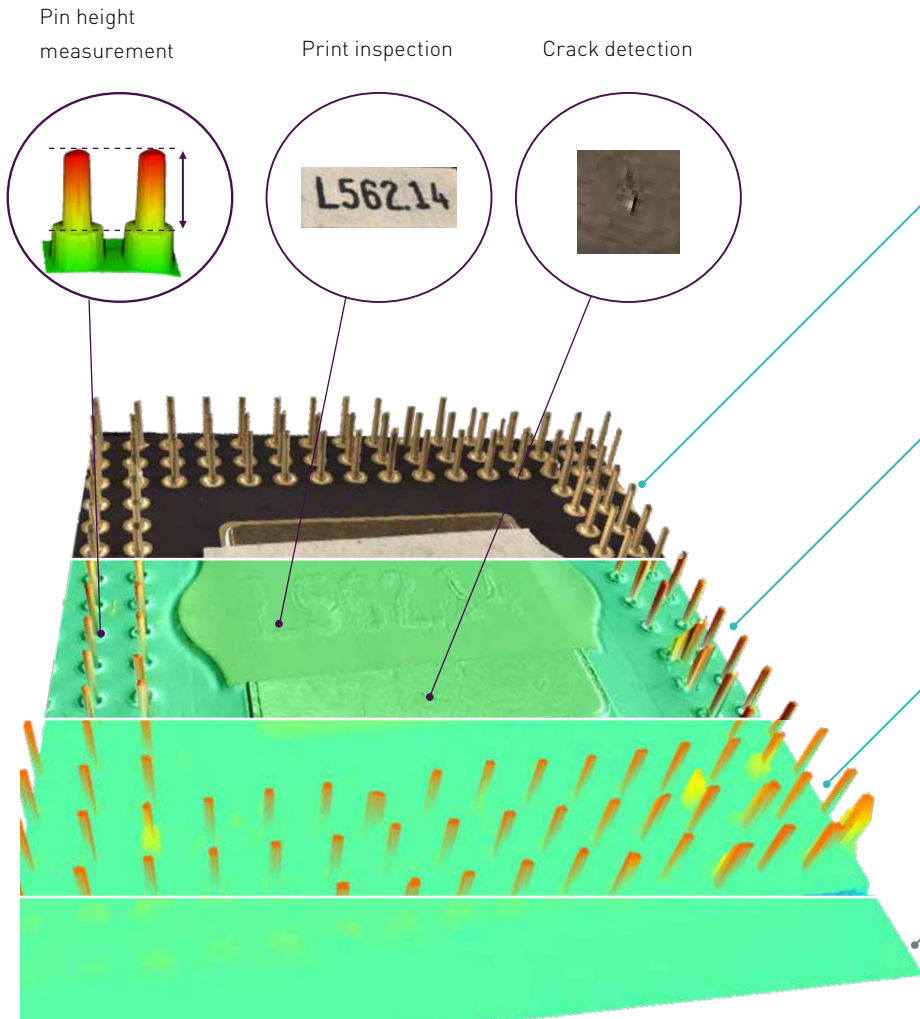
INLINE COMPUTATIONAL IMAGING

- Increased signal-to-noise ratio
- Enhanced 2D imaging
- Flexible dark / bright field imaging

LIGHT FIELD & PHOTOMETRY

- 3D from multiple viewing and illumination angles
- Globally correct and high details
- Robust for all material types

LIGHT FIELD ONLY

- 3D from multiple viewing angles
- Globally correct but low details
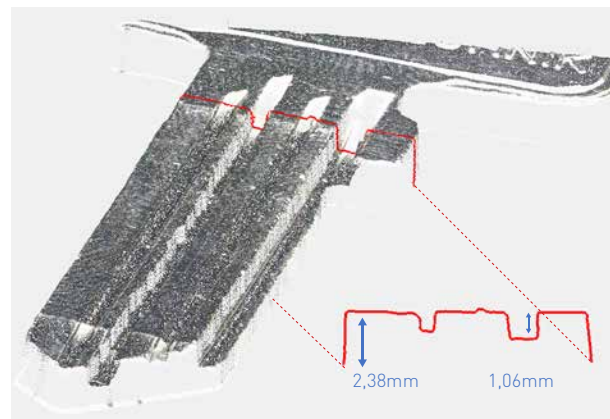- Robust for many material types

State-of-the-Art Stereo

- 3D from 2 viewing angles
- Error prone and low detail
- Difficulties with dark and reflective materials

COMPUTATIONAL IMAGE ENHANCEMENT

all-in-focus

darkfield

OVD detection

bright field
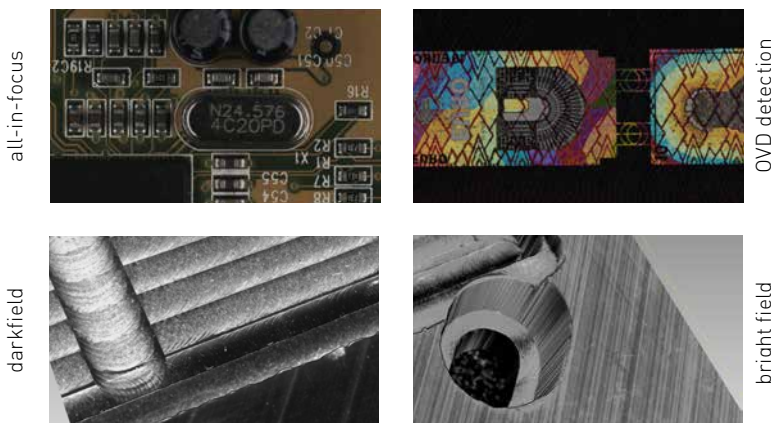
PRECISE 3D MEASUREMENT

2,38mm   1,06mm

FLEXIBLE AND SCALABLE FOR INDUSTRIAL NEEDS

The AIT ICI technology can be tailored to fit various applications and meet their specific requirements concerning optical and depth resolution, working distance and acquisition speed and result quality. The optical configurations listed below provide possible examples for standard, micro and large scale 2D & 3D inspection with AIT ICI.

SCALABLE OPTICAL RESOLUTION

	STANDARD SCALE		MICRO SCALE	LARGE SCALE
Sensor	Multi-line scan 2k		Area scan 2k	Multi-line scan 2k
Optics	45 mm f/4		10x microscope NA = 0.28	20 mm f/2.8
Working Distance	108 mm		34 mm	590 mm
Field of view	46 mm		1.6 mm	464 mm
Depth range	7.2mm		160 μm	700 mm
Lateral Sampling	20 μm/px		700 nm/px	200 μm/px
Lateral Optical Resolution	42 μm		4 μm	420 μm
Optimal Number of Views	13		17	33
Depth Resolution	19 μm	10μm *	1 μm	61 μm
Max. Acquisition Speed	500 mm/s	250 mm/s	27 mm/s	2 m/s
Depth Sensitivity **	< 8 μm		N/A	N/A

*) increased depth resolution via double-oversampling in the transport direction
**) using Multiplexed Light
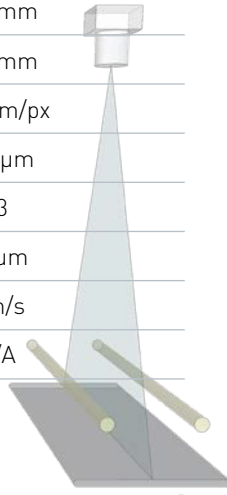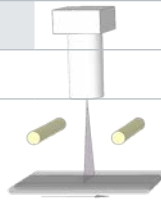
All numbers are in accordance with the „Fair Data Sheet".

FLEXIBLE TO CHANGING REQUIREMENTS IN SPEED AND ACCURACY

The AIT ICI technology is a multi-line-scan technology which works with any number of lines. This makes the technology easy adoptable for varying speed and accuracy requirements just by changing the number of constructed views. The more views, the higher the accuracy, lower number of views enable for higher inspection speed.

High number of views are ideal for inspection of
- Complex geometries
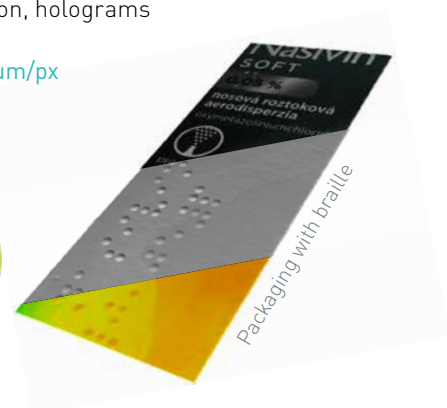- Shiny materials
- Challenging tasks
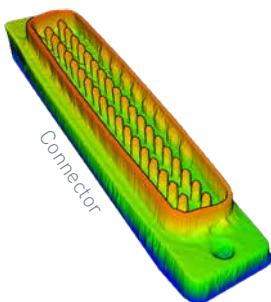
High speed can be used for inspection of
- Flat and textured objects
- Printed matter with embossing
- Security print inspection, holograms

13 views | 500 mm/s | 20μm/px

3 views | 2000 mm/s | 20μm/px
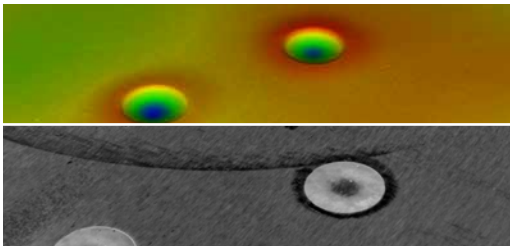
Connector

1 € coin

Embossing

Packaging with braille

... SMART INSPECTION WITH ICI:INSPECT

# INLINE COMPUTATIONAL IMAGING CAN BE USED FOR ...

Metal surface

METAL PARTS

- Robust solution for metallic surfaces due to several viewing angles
- Simultaneous 3D measurement and surface quality inspection
- Crack, pore and scratch detection
- Distinguish between machining traces and scratches, cracks, etc.
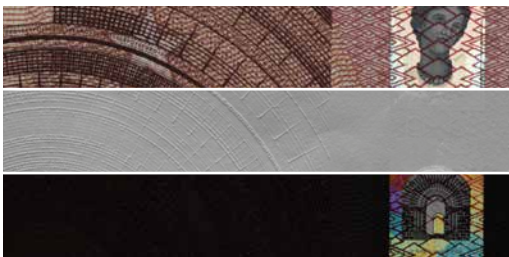
ELECTRONIC PARTS & PCB INSPECTION

- Inspection of glossy and dark matt materials at the same time
- Solder inspection, detection of bad solder spots
- Assembly control including 3D inspection for pin heights
- Wafer inspection (e.g. cracks)
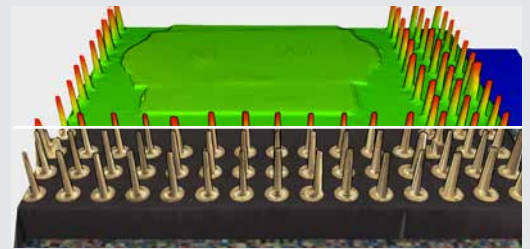

Chip with pins

10 € banknote

SECURITY PRINT INSPECTION

- Inline hologram inspection, including to check for the correct color shifting effects
- Quality inspection of intaglio print and tactile elements (3D depth)
- Inspection of embossing, braille writing, seals, etc.
- Inspection of decor elements

INSPECTION OF CHALLENGING MATERIALS

- Robust solution for challenging objects, like highly glossy, unstructured and even dark materials
- High quality 2D and 3D inspection with one system
- Flexible parametrization for inspection speed and accuracy
- Works well with challenging reflectance properties
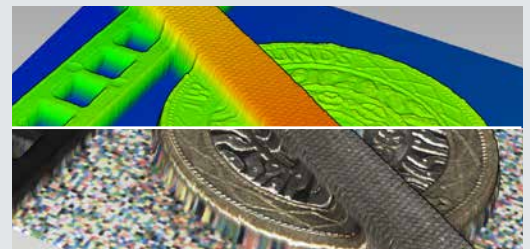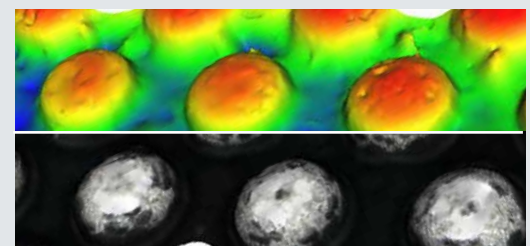

Coin, file, cable tie

Wirebond
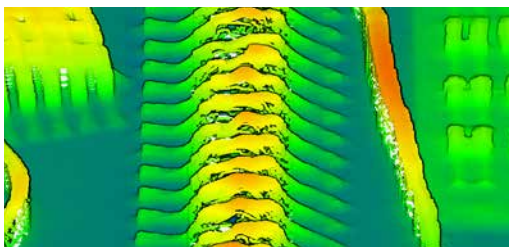
INSPECTION OF COMPLEX GEOMETRIES

- Inspection of complex geometries and thin/repetitive structures
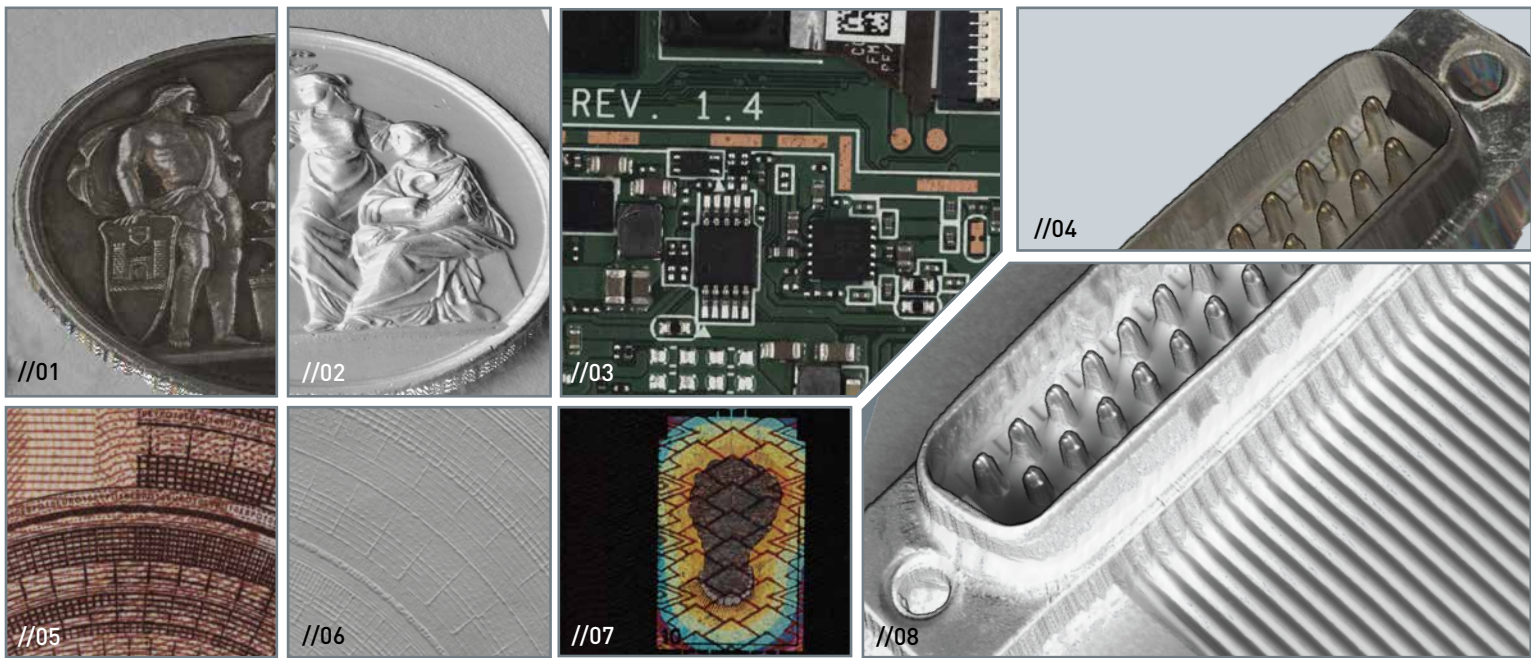- Wire bond inspection
- Connector pin inspection

INSPECTION OF MICRO-STRUCTURES

- Ball grid arrays
- PCB traces
- Solder spots

BGA Ball Grid Array

ICI:INSPECT IN A NUTSHELL

- Easy - to install, use and maintain.

- Flexible - to changing requirements in speed and accuracy.

- Robust - against variations within the production process.

- Reliable - for high system availability.

- Multi modal - for simultaneous 2D and 3D inspection plus enhanced 2D imaging.

- Universal – works with different materials, no matter if matt, glossy, bright or dark.

METAL

//01 Coin 3D + texture
//02 Coin 3D

ELECTRONIC

//03 PCB all-in-focus image
//04 Connector 3D + texture
//08 Connector 2.5D

SECURITY PRINT

//05 10 € banknote detail
//06 10 € banknote intaglio print
//07 10 € banknote Hologram

PRICE-WINNING TECHOLOGY:

Inline Computational Imaging was awarded TOP INNOVATION 2019

AIT AUSTRIAN INSTITUTE OF TECHNOLOGY GMBH
Petra Thanner
Tel +43(0) 50550 2802
petra.thanner@ait.ac.at
Dorothea Heiss
Tel +43(0) 50550 3162
dorothea.heiss@ait.ac.at
Giefinggasse 4, 1210 Wien
www.ait.ac.at/hpv