X-ray Phase Contrast Imaging: from High Resolution to High Speed

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CSEM's X-ray phase contrast imaging (XPCI) facility was extended in 2016 and now covers non-destructive imaging from high resolution to high speed. Non-destructive inspection (NDI) is increasingly used in prototyping, manufacturing and repair of critical components such as aeronautical structures, automotive components, medical implants and opto-electronic packages. Beyond ensuring safety and reliability, the benefits of NDI include shorter development and validation cycles, improved production yield, reduced waste, lower part weight and better understanding of failure modes. CSEM's XPCI facility is accessible for external users; the technology is available for licensing to NDI equipment manufacturers.

Compared to conventional X-ray systems, X-ray phase contrast imaging (XPCI) brings the following advantages

- Higher contrast for lightweight materials
- Sensitive to micro and macrostructures

These advantages translate into better detectability of critical defects within the structure under inspection.

In the project ZEFIPACK—performed jointly with the Lucerne University of Applied Sciences and Arts—a new XPCI system was designed and realized at CSEM (see Figure 1). This system can achieve high resolution (down to 4 µm voxel size) by using a micro-focus X-ray source from Hamamatsu and a dedicated geometry.

Figure 1: The high-resolution XPCI system.

The system has been characterized on opto-electronic packages and polymer parts made by micro-injection. Figure 2 shows the results obtained on a hermetic sapphire package with embedded electronics. Defects can be observed in the bonding line (see yellow framed inset). This information allows optimizing the process parameters to maximize yield and hermetic sealing quality.

Typical XPCI applications are:

- Detection of defects in composites, polymers, aluminium and ceramic / CMC components (typical defects include porosity, cracks, fibre waviness, and moisture) [1]
- Analysis of crack propagation
- In-situ monitoring of wetting in porous materials or textiles
- Characterization of precious stones and pearls [2]
- Quality control of opto-electronic packages

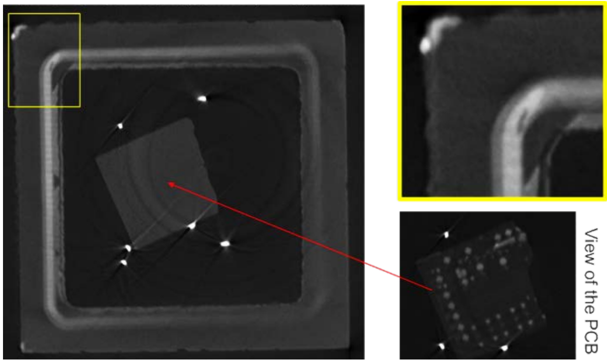

Figure 2: Example of cross-section images obtained with the high-resolution XPCI system. Defects can be observed in the bonding line (yellow-framed inset).

The new system complements the existing XPCI systems listed in Table 1. With this addition, the XPCI facility can now provide solutions to industrial and academic partners for a broad range of applications in lightweight materials NDI.

Table 1: Summary of XPCI systems available at CSEM

Large-size radiography system	
Mode	XPCI Radiography (2D)
Sample size	Up to 100cm x 75cm
Energy range	40 - 70keV
Voxel size	Typ. 55 - 110µm
Versatile tomography system	
Mode	XPCI tomography (2D/3D)
Sample size	Up to 30x30cm
Energy range	20-70keV
Voxel size	Typ. 45 - 90µm
High-resolution tomography system	
Mode	XPCI tomography (2D/3D)
Sample size	Up to 3x3cm
Energy range	20-100keV
Voxel size	Typ. 5 - 25µm

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[1] C. Hannesschläger, V. Revol, B. Plank, D. Salaberger, J. Kastner, "Fibre structure characterisation of injection moulded short fibre-reinforced polymers by X-ray scatter dark field tomography", Case Studies in Nondestructive Testing & Evaluation 3 (2015) 34.

[2] V. Revol, C. Hanser, M. Krzemnicki, "Characterization of pearls by X-ray phase contrast imaging with a grating interferometer", Case Studies in Nondestructive Testing & Evaluation 6 (2016) 1.