Integrated System and Proof of Concept of X-ray Phase Contrast Imaging for Inspection of Composite Materials

V. Revol, A.-M. Madrigal, T. Stadelmann, P. Niedermann, S. Droz, W. Glettig

The European project EVITA aims at bringing Grating-based Phase Contrast X-ray imaging technology [1] to non-destructive evaluation and inspection of thick aeronautical composite structures. The demonstrator built within the project started operation in January 2015. The results confirm the high expectations on the applicability of this technology to the detection of critical defects in composite components such as cracks, porosity, missing plies and fiber waviness. Other industries (automotive, electronics or luxury) are also showing sign of interest.

Within the project EVITA [2] (www.evita-project.eu), the requirements and needs of the aeronautics industry in terms of the non-destructive inspection of thick and thin composite components were collected and analyzed. From there, a customized demonstrator was designed and realized in order to benchmark this novel technique against the following non-destructive inspection (NDI) techniques: water jet ultrasonic, phased array ultrasonic, thermography and computed tomography.

Figure 1: Picture of the EVITA demonstrator at CSEM in Alpnach.

The demonstrator built within the project is depicted in Figure 1. The Phase Contrast X-ray imaging system is enclosed in a radiation protection cabinet to ensure the user safety. The measurement and the reconstruction of the images can be done entirely from the remote control desk.

The key parameters of the demonstrator are listed below.

	Parameters
Source acceleration voltage	40 – 70 kV
Maximal sample thickness (CFRP)	50 mm
System length (source to detector)	1.45 m
Measurement area (stitching mode)	1 m x 0.5 m
Effective pixel size	50 – 60 µm

Figure 2 shows the results obtained with a carbon fiber reinforced polymer sample, where the mid-plane ply was cut across the width of the laminate. The artificially induced defect can be detected in the scattering image using the EVITA demonstrator (red arrows). This result was confirmed by the measurements done with the phased array ultrasonic system.

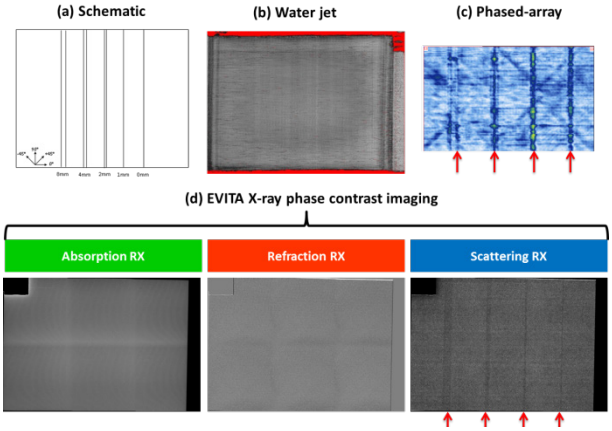

Figure 2: Results obtained on a sample with cut fibers (a) with the EVITA demonstrator (d) and with the benchmarking methods (b-c)

By increasing the level of detectability of defects in composite structures compared to standard non-destructive testing methodologies, this novel technique will play a major role during the whole life cycle of composite components, reducing their inspection cost and increasing their reliability endnote [3].

The interest is now growing in other application domains, such as for the inspection of music instruments (see Figure 3).

Figure 3: Scattering image of a carbon fiber reinforced trumpet bell provided by the company DaCarbo, Switzerland.

Target industries for this method are:

- Aeronautics and aerospace
- Automotive
- Electronics and packaging
- Material science.

[1] V. Revol, *et al.*, NDT&E International 58 (2013) 64–71

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[3] V. Revol, *et al.*, Proceedings EASN workshop (2015)