ESRF	**Experiment title:** Mechanical behaviour of carbon fibre bundles	**Experiment number**: IN977
Beamline: ID19	**Date of experiment**: from: 26/06/2017 to: 27/06/2017	**Date of report**: 05/09/2017
Shifts: 3	**Local contact(s): Vincent Fernandez**	*Received at ESRF:*

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1. Introduction

For several years, carbon/carbon composites have been increasingly used to replace metallic part in the aeronautic industry as they allow lightening the final structures. The final properties of the products are strongly influenced by the fibrous architecture which itself strongly depends on its processing. During the production of the composite, carbon fiber bundles, constituted of thousands of single carbon fibres, are weaved in 3D to form a carbon fibre mat and therefore undergone various mechanical solicitation such as traction, compression, shearing and bending. In order to improve the weaving simulation software, it is necessary to understand and model the structural and mechanical behavior of a fibre bundle at the fibre scale. A possibility to carry out such an analysis is to monitor in 3D the mechanical behavior by X-ray microtomography. The first part of this proposal is to develop the methodology to carry out such an analysis and the second part will be dedicated to the mechanical characterization. The present report presents the problems that we faced while imaging these structures (section XXX) and the preliminary results (section XXX).

2. Imaging setups

a. Problems raised by imaging fibre bundles

i. Shape and dimensions

A carbon fibre bundle has an elliptic cross section of 2 mm and 0.5 mm for the major and minor axis, respectively. It is also constituted of 10 000 to 50 000 parallel carbon fibers, the diameter of which is 5 µm on average. This huge difference between the dimensions of the constituents of the fibre bundle make it challenging to image.

ii. Monitoring

In order to monitor the tensile and shearing behavior of fibre bundle, a fibre bundle with a 3-mm length was prepared and inserted in the mini tensile device dedicated to the imaging of these materials (developed during LTP ME704, figure 1a). When the fibre bundle is installed in its vertical state, it acts as an interferometer which makes difficult to find appropriate imaging set-ups (energy, distance between the rotation axis and the detector).

b. Proposed set-up

i. Monitoring

An energy of 35 keV coupled with a short exposure time was found to be the more appropriate to limit the radiation damage on the studied samples. This was coupled with phase contrast imaging at an appropriate distance to limit the Moiré effects.

ii. Shape and dimensions

A multiscale approach had to be used: pixel size of 1.6 µm, 0.6 µm and 0.3 µm were chosen, leading to an in-plane field of view of 4 mm x 4mm, 1.6 mm x 1.6 mm, 0.8 mm x 0.8 mm, respectively.

3. Results

a. Preliminary remark

This set up optimization lasted about 1.5 shifts. A beam cut of about 0.5 shift occurred. Only one shift was therefore dedicated to the experiment itself.

b. Preliminary results

Figure 1 illustrates the obtained images for a fibre bundle during a tensile test.

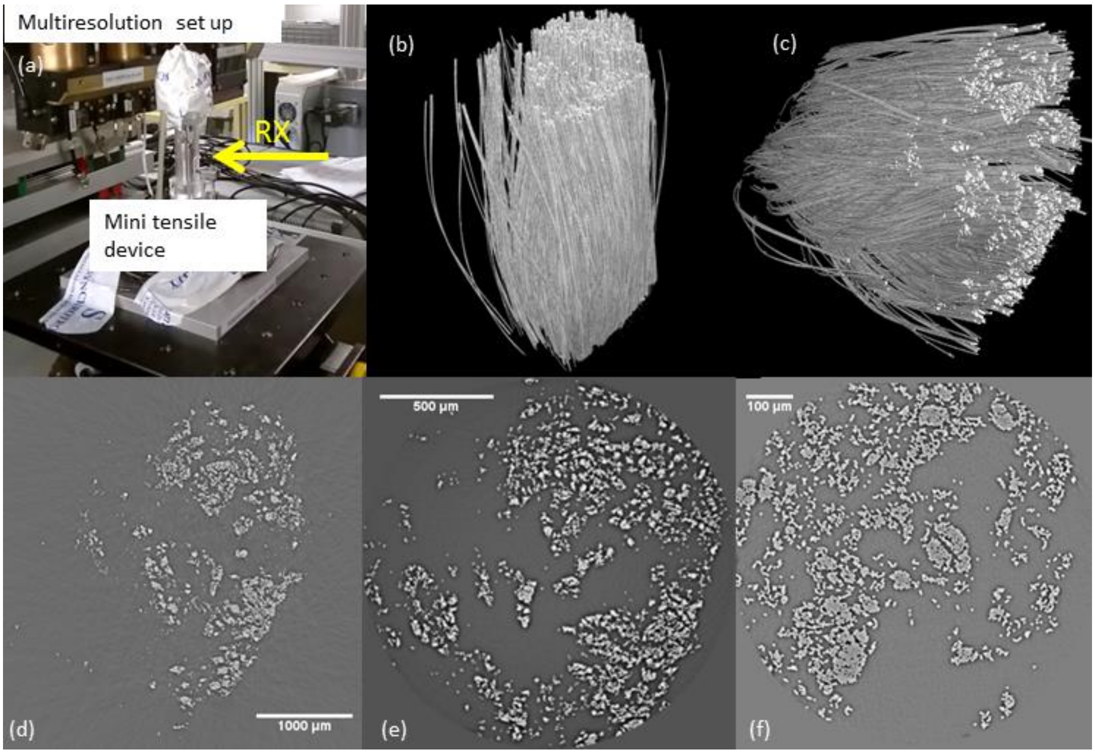

Figure 1 : (a) Experimental set-up. (b) 3D view of a fibre bundle at a pixel size of 1.6^3 µm^3. (c) 3D view of the same fibre bundle at a pixel size of 0.66^3 µm^3.(d-f) In-plane slices obtained at a pixel size of 1.6^3, 0.66^3 and 0.3^3 µm^3, respectively.

c. Qantification of the microstructure

Images analysis routines are currently developed to quantify the microstructural descriptors that are relevant for the fibre bundle, as well as their evolution upon loading.