	Experiment title: Reinforcement Mechanism Determination in Hierarchical Nanoengineered Aerospace Composite Materials	**Experiment number**: ME-1425
Beamline:	**Date of experiment**: from: Nov 2nd to: Nov 4th	**Date of report**: 02/10/2017
Shifts:	**Local contact(s)**: Elodie Boller	*Received at ESRF:*

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Report:

New thin-ply prepreg laminates have been developed that show an improvement in mechanical performance over traditional laminates; at the lamina level, thin-ply prepreg laminates offer an improvement of the compressive strength, whilst at the laminate level they appear to delay delamination and other forms of damage in tensile loading.

This experiment performed at the ID19 reports the *ex situ* and *in situ* vizualization of the damage formation and growth using synchrotron radiation computed tomography (SRCT) . Visualization during mechanical loading provided *in situ* mechanistic observation of damage progression in thin ply, especially the suppression of large microcracks and sub critical damage. We have studied the different mechanisms of the 3D failure in thin ply laminates using *in situ* SRCT. Based on a double edge notched quasi isotropic $(0/90/\pm45)_s$ CRFP loaded in tension we have reduced the region of interest to the stress concentration created by the notch reducing in turn the volume to analyze.The damage propagation was captured in 3D scans at increasing load steps up to catastrophic failure. Comparison of the type and propagation of damage in the different material when loaded at 80% of the ultimate tensile strength (UTS) show significant differences. Standard CRFP develops splits in the 90° plies that spread across the volume sample as well as matrix cracks in the ±45° plies. Typical splits in the 0° plies associated with the disconintuous fibers around the notch are also present within the damage observed at 80% UTS. The addition of CNT nanostitch in Figure 1b doesn't seem to have a significant effect as typical failure under tension involves more fiber breaks and translaminar cracks than delamination. Mode 1 and 2 should be considered as the ultimate testing configuration to highlight the effect of the CNT in the delay and supression of delamination. However, the damage profile in

the thin ply laminate presents striking differences. Minor cracks and splits seem to develop around the notch that remain concentrated at the edge and do not extend through the width of the samples unlike in standard CRFP. No delaminations are observed. This give us a clear insight on the different mechanism of failure involved in thin ply morphology. Moving forward, more analysis will be done to qualify the types of damage present at discrete load steps preceding failure.

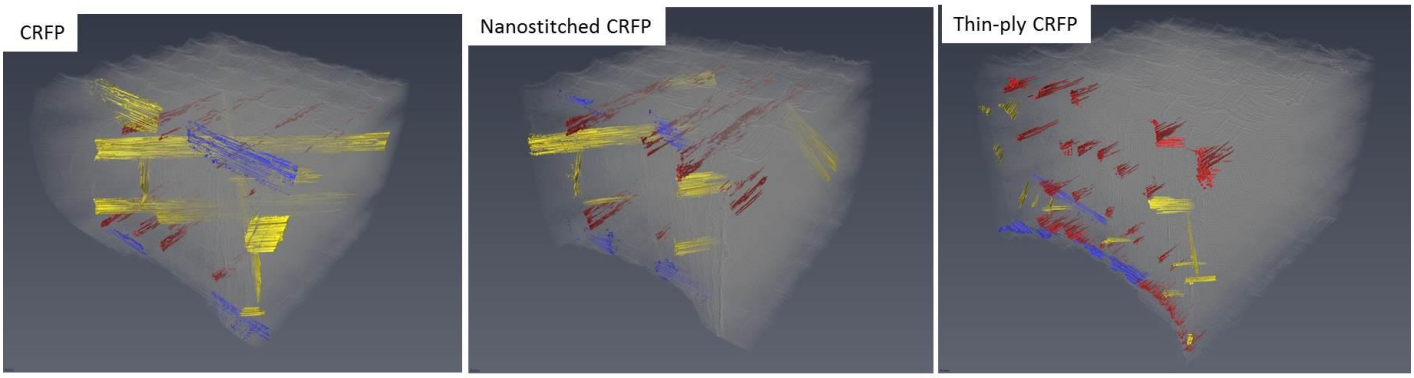

Figure 1: Damage observed in CRFP, nansotitched CRFP and thin-ply CRFP. The colors red, blue and yellow represent cracks in a 90, 0 and ±45 ply.

This work will be featured in 3 conference papers that will be presented at the ICCM in August 2017

"Damage Modeling of Thin-ply Nano-reinforced Composite Laminates," Carolina Furtado, Xinchen Ni, Estelle Kalfon-Cohen, Albertino Arteiro, Brian L. Wardle, and Pedro P. Camanho, submitted to *21st International Conference on Composite Materials (ICCM)*, Xi'an, China, Aug. 20-25, 2017.

"Interlaminar Reinforcement of Carbon Fiber Composites Using Aligned Carbon Nanotubes," Xinchen Ni, Estelle Kalfon-Cohen, Carolina Furtado, Albertino Arteiro, Gabriel Valdes, Travis Hank, Nathan Fritz, Reed Kopp, Gregor Borstnar, Mark N. Mavrogordato, S.M. Spearing, Pedro P. Camanho and Brian L. Wardle, submitted to *21st International Conference on Composite Materials (ICCM)*, Xi'an, China, Aug. 20-25, 2017.

"Synergetic Effects of Thin Ply and Nanostitching Studied by Synchrotron Radiation Computed Tomography," Estelle Kalfon-Cohen, Reed Kopp , Xinchen Ni, Nathan Fritz, Albertino Arteiro, Gregor Borstnar, Mark N. Mavrogordato, S.M. Spearing, Pedro P. Camanho, and Brian L. Wardle, submitted to *21st International Conference on Composite Materials (ICCM)*, Xi'an, China, Aug. 20-25, 2017.