ESRF	**Experiment title:** **High Resolution X-Ray Tomography Observation of Damage Accumulation In Materials Deforming Heterogeneously**	**Experiment number**: ME 389
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Shifts: 12	**Local contact(s)**: Elodie BOLLER (e-mail: boller@esrf.fr) Dr. Peter CLOETENS (e-mail: cloetens@esrf.fr)	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

Mr. Justin GAMMAGE* McMaster University, Ontario, Canada
Dr Jean-Yves BUFFIERE* INSA Lyon, France
Dr. J.D. EMBURY McMaster University, Ontario, Canada
Dr. Eric MAIRE* INSA Lyon, France
Dr. David WILKINSON McMaster University, Ontario, Canada

Report:

During this experiment, a total of twenty-nine X-ray microtomography scans were performed on four model metal matrix composite samples. This composite, fabricated for the PhD research of J. Gammage, consists of a ductile aluminum metal matrix (AA6111-T4) reinforced with varying average volume fractions (6 to 20%) of spherical Al_2O_3 particles.

The damage mechanisms of model material have been studied using in situ tensile tests coupled with high resolution X-ray tomography. This technique revealed that the number of pre-damaged particles varied with both the volume fraction and heterogeneity of the distribution. Damage evolution during in situ loading was quantified using the reconstructed three dimensional images produced at the ESRF. The evolution of damage, defined as the fraction of cracked particles at a given load increment, has been extracted for use in the determination of the Weibull parameters of the particles. In addition, thresholding of the images has allowed for the quantification of the effects of particle shape and size on the damage rate. The experiments have also revealed that the brittle particles undergo multi-stage cracking events and the multi-cracked particles elongate more than expected throughout the deformation process. Tomography images of the cracked particles will be used to calculate the crack opening displacement of the particles at each stage of deformation. Both the quantitative and qualitative information is currently being used to develop a comprehensive model that will improve the prediction of the mechanical response of heterogeneous materials.

The processing route used to manufacture the model material results in significant chemical reaction between the Al_2O_3 particles and the Mg in the matrix alloy. Microtomography on the samples has allowed for qualitative assessment of the effects of particle distribution and volume fraction on the severity of chemical reaction. Quantitative information of the relationship between the severity of reaction and the degradation of the mechanical properties will be established by comparing the

Weibull parameters of three particle sets; i) those undergoing minimal reaction, ii) those undergoing partial reaction and iii) those that have undergone complete transformation via chemical reaction.

Three reconstructed images are shown below to complement the report. They show the same reconstructed volume at two deformed stages (initial state and the partially deformed state) and a third image, a reconstructed slice showing the varying degree of the chemical transformation of the particles.

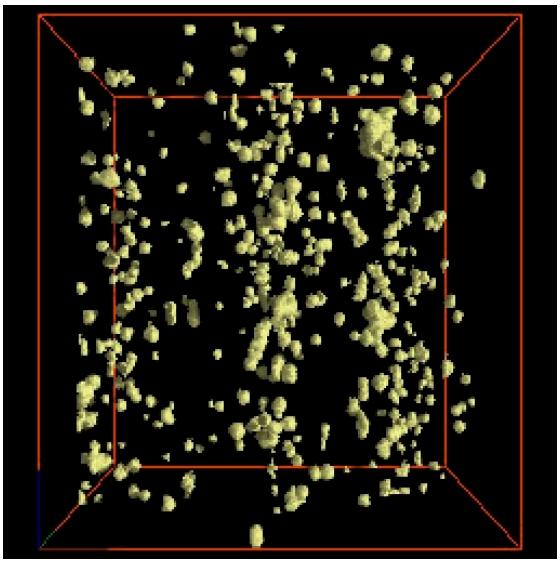

Figure 1. Sample with 10% volume fraction of Al_2O_3 prior to deformation. All particles in the volume (shaded yellow) are undamaged.

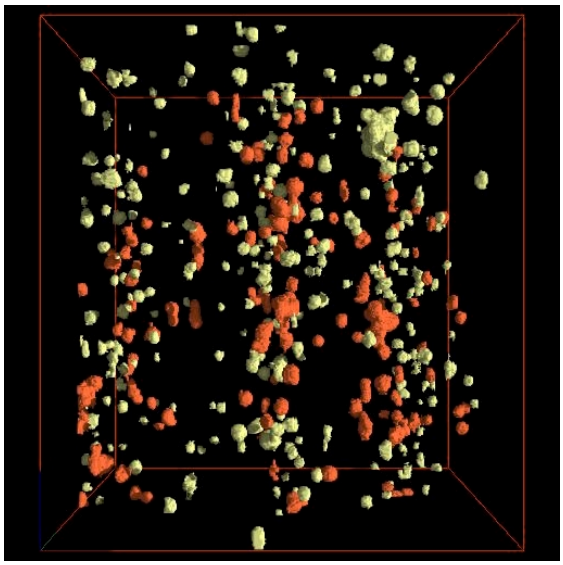

Figure 2. Same reconstructed volume as shown in Figure 1. Particles shaded in red have fractured while those shaded in yellow remain undamaged. Deformed to a stress of 150 MPa.

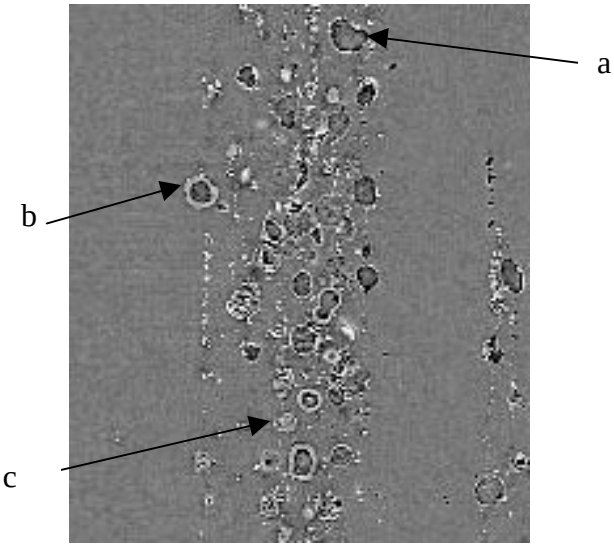

Figure 3. Illustration of the three degrees of reaction; a) minimal reaction, b) partial reaction and c) complete reaction.