ESRF	**Experiment title:** In-situ megaframe-rate X-ray radioscopy of a high speed electrical fuse breaking	**Experiment number:** MA2990
Beamline: ID19	**Date of experiment:** from: 2016/03/23 to: 2016/03/26	**Date of report:** 2016/09/12
Shifts: 9	**Local contact(s):** Alexander RACK	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):
Pierre LHUISSIER (SIMaP - CNRS - Univ. Grenoble Alpes)
Xavier JUST (SIMaP - CNRS - Univ. Grenoble Alpes)
Jean-Marc CHAIX (SIMaP - CNRS - Univ. Grenoble Alpes)
Jean-Louis GELET (Mersen)

Report:

Aims: In order to understand the phenomena involved during a fuse break in situ megahertz radiography experiements have been carried on industrial fuses. Practical aims were :

- to evaluate the kinetics of the electric arc and its effect on the granular medium during a fuse break with high current variation
- to evaluate the effects of the various parameters (granular medium, silver blade shape, tension and current...) on the fuse break.

Experiments: Industrial fuses with varied parameters have been produced. The type of sand (large granulometry, small granulometry, no sand), the cohesion of the sand (silicated or not) and the silver blade (plate, wire, notch type) have been varied. Contrast agent (1% of zircon grains mixed with the silica grain) have been added in order to make easier the sand motion characterization.
An experimental device reproducing fuse break with high current variation has been synchronised with a megahertz X-ray radiography setup on ID19. It required a smart triggering of the shutter, the Shimadzu detector and the electrical circuit closure. Two radiographies acquisition conditions have been used :

- $7\mu m$ pixel size with frame rate between 1 and $5MHz$ to characterize the kinetic of the electric arc (during the first $100\mu s$)
- $14\mu m$ pixel size with frame rate between 0.01 and $1MHz$ to characterize the whole fuse break (time from $100\mu s$ to $10ms$)

Electrical signal (tension and current) was simultaneously recorded during the experiment.
For each configuration, fuse break was imaged several times from a side view and from a front view.
About 270 fuse breaks have been imaged during the experiment.
The last shift of the experiment have been dedicated to post-mortem tomography of a part of the tested fuses in order to improve the understanding of the 2D views.

Results: Figure 1 presents examples of obervations.

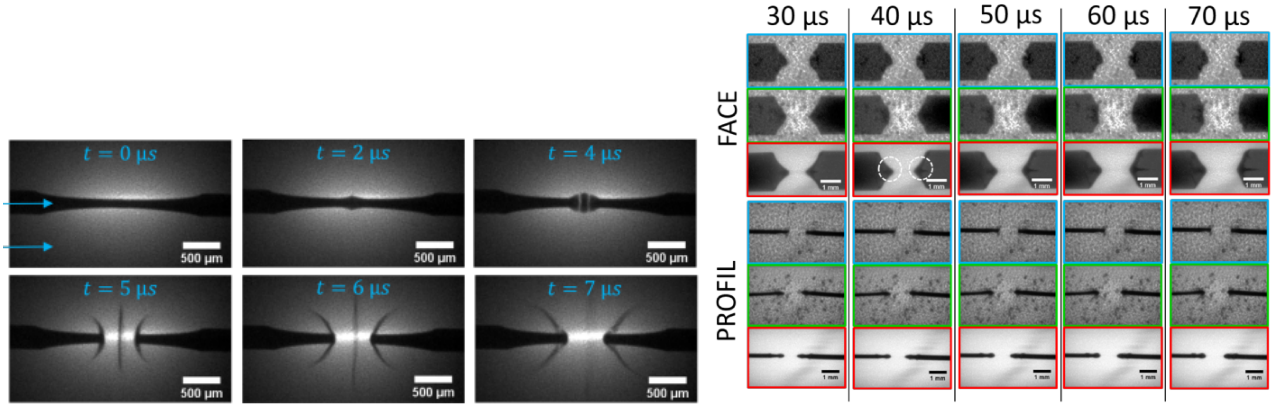

Figure 1: Example of pre-arc transition in a fuse without sand and example of the effect of the filling material on the silver blade evolution.

The experiment allowed to show that in the case of fuse containing non silicated sand the arc canal formation is partially due to a collective motion of the sand grains.
Coupling of in situ radiography and electrical signal measurments allowed to get clues about the behaviour of the electrical arc depending on its environment, and vice-versa the effect of the arc on its environment. Main conclusions are the following :

- the electrical arc generate an important overpressure which is responsible of sand grains motion and of liquid silver expulsion;
- fuses containing silicated sand ensure the best absorption of the energy of the electrical arc;
- the sand packing allow to confine the pressure and avoid the fuse explosion.

Measures have been realised on the kinetics of the phenomena :

- velocity of silver blade erosion (burn-back) and energy of electrical arc required for this 'silver consumption' (these data will be used for modeling);
- characteristic times : the arc canal appears during the 20 to 30μs after the arc generation.

Valorisation: This experiment is a substantial part of the PhD of Xavier JUST (to be defended November/December 2016). The experiment is still currently under analysis. Materials and methods, results and conclusions will be compiled in his PhD report. Publication of the results is planed.