

Analysing the arc formation and burn-back phenomena in fast industrial fuses at high di/dt

J.-M. Chaix^{1*}, X. Just¹, M. Olbinado², P. Lhuissier¹, J.-L. Gelet³, A. Rack², O. Bonnefoy⁴, G. Thomas⁴, L. Millière³, R. Dendievel¹

*jean-marc.chaix@simap.grenoble-inp.fr

¹Univ. Grenoble Alpes, CNRS, Grenoble INP, SIMaP, F-38000 Grenoble, France

²European Synchrotron Radiation Facility, F-38000 Grenoble, France

³MERSEN France SB, F-69720 Saint Bonnet de Mure, France,

⁴Ecole des Mines de Saint-Etienne, LGF, F-42000 Saint Etienne, France

Fuses are old but key devices in electrical technology [1]. They are constituted by conducting blades (Ag, Cu) with locally restricted cross sections (notches), surrounded by compacted silica sand in a protective ceramic cartridge. In case of short circuit, the metal melts and opens the circuit. In practice, the current does not instantaneously fall down to zero: an electric arc appears and transiently maintains the current. During this arcing period, the arc length increases (metal “burn back”) and induces various phenomena (pressure waves, sand melting...). The increasing use of DC current and semi-conductor-based power converters requires fast fuses able to face short circuit situations and stop the current in times of some tenths of microseconds (high di/dt). Understanding the onset, development and end of the arc in such cases is of key importance for designing efficient fuses.

Radiography is a suitable way for *in situ* studying the fuse blade behaviour during breaking, by viewing the highly absorbing metal through the sand and cartridge. High speed radiography (up to $5 \cdot 10^6$ images/s) results were obtained during high di/dt fuse breaking tests at ESRF [2.3]. They enabled getting information at different time scales on various aspects such as the end of pre-arcing period (Fig.1-a) or the effect of sand (Fig.1-b). This paper will discuss scientific and technical issues for fuses understanding and design.

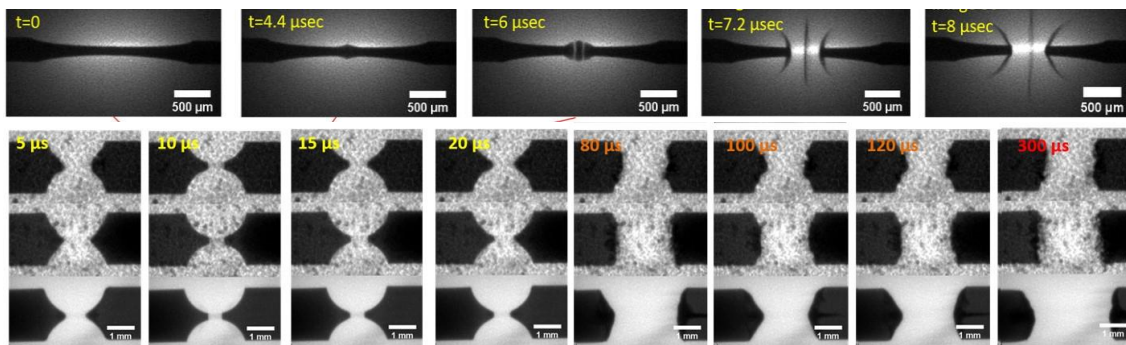


Figure 1: Arc onset without sand (top); burn-back with packed sand, loose sand, without sand (bottom)

References

- [1] - J.L. Gelet, “To the origins of fuses”, International Conference on Electrical Fuses and their Applications, Clermont-Ferrand, 2007.
- [2] – J.-L. Gelet, J.-M. Chaix, X. Just, P. Lhuissier, G. Thomas, O. Bonnefoy, A. Rack, M. Olbinado, Observation of Arcing inside a Fuse under VSI Short Circuit Conditions using $5 \cdot 10^6$ Frames per Sec. X-ray Imaging, Proc. of COSYS-DC 2017 – Int. Conf. on Components and SYStems for DC Grid, Grenoble, France
- [3] – M. P. Olbinado, X. Just, J.-L. Gelet, P. Lhuissier, P. Vagovic, T. Sato, R. Graceffa, M. Scheel, J. Morse, A. Rack, MHz frame rate hard X-ray phase-contrast imaging using synchrotron radiation, Optics Express, Vol. 25, Issue 12, pp. 13857-13871 (2017)