Contribution ID: **19**

Type: **Poster**

Multi-Pulse Nanosecond Electrical Breakdown in Perfluorinated Liquids at 140 kV

Monday 19 June 2017 13:30 (1h 30m)

Perfluorinated liquids are attractive for use in high-voltage devices because of their chemical stability under electrical discharges. For applications like liquid spark gaps, the breakdown velocity is an important parameter. In this work, we present the results of measurements of the anode-initiated electrical breakdown velocity at 140 kV in perfluorinated liquids of several chemical classes. The experimental setup [1] comprised of a nanosecond generator, breakdown cell, and digital oscilloscope. The generator impedance is 50 Ω, with a stored energy of 0.8 J and voltage under no-load of 140 kV. The pulse duration is 8 ns under load-matched conditions, and the rise time is less than 0.5 ns. We used a point-to-plane configuration of electrodes with positive point. We show that perfluorinated esters have close values of breakdown velocity over a wide range of gaps, and demonstrate relatively low jitter in gaps for which time to breakdown (up to 30 ns) is comparable to pulse duration. Measured breakdown velocities in these liquids are $5 \cdot 10^6$–$1.3 \cdot 10^7$ cm/s for gaps up to 2 mm, which is 3–8 times higher than in transformer oil under the same conditions [2]. The differential velocity of breakdown front propagation for all tested liquids substantially decreases in gaps wider than 1.5–2 mm, and is about $(2\text{–}3) \cdot 10^6$ cm/s. The time to breakdown in wider gaps grows linearly up to 6 mm. As soon as the differential velocity of breakdown remains nearly constant for a wide gap range, it can be considered as an electrophysical characteristic of the dielectric liquid under these pulsed conditions.

[1] Punanov, I.F., Emlin, R.V., Kulikov, V.D. et al. Tech. Phys. (2014) 59: 503. DOI:10.1134/S1063784214040197

[2] Punanov, I.F., Emlin, R.V., Morozov, P.A. et al. Russ Phys J (2012) 55: 191. DOI:10.1007/s11182-012-9794-5

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Session Classification: Poster session I - Pulsed Power Physics and Technology, Components and HV Insulation

Track Classification: Pulsed Power Physics and Technology, Components and HV Insulation