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Electrical breakdown phenomena of dielectric elastomers

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Figure 1. Electrical breakdown causes a pinhole formation on DEs film leading to major damage of the DE based devices.

Figure 2. The structure of chloro propyl functional silicone elastomer.[1]

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Scanning Electron Microscope (SEM) - Morphology

Figure 4. SEM images of breakdown zones for reference samples, Co-1 and Co-2 silicone elastomers. The black areas correspond to areas where the elastomer was completely removed during breakdown, i.e. pinholes.

Breakdown zones vary dimensionally with narrowest width to largest width:
Reference: 100-300 µm
Co-1: 60-100 µm
Co-2: 20-80 µm

Figure 5. Illustration of boiling nature of the crosslinked copolymer Co-1 in different magnifications. Droplets of condensing degradation products are formed on the surface of the breakdown zone.
Energy Dispersive X-Ray Spectroscopy (EDS) - Elemental Distribution

Figure 6. EDS mapping of Co-2 elastomer surface where Cl is uniformly distributed (left), breakdown zones for Co-1 (middle) and Co-2 (right). The material in the vicinity of the void contains excess of Cl (blue color), which support the hypothesis that silicon-containing substances have been evaporated off.

Figure 7. An increased concentration of Cl is recorded at the breakdown zones for the crosslinked copolymer Co-1.