# Electrical breakdown phenomena of dielectric elastomers

**Yu, Liyun; Mateiu, Ramona Valentina; Skov, Anne Ladegaard**

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Liyun Yu, Ramona Valentina Mateiu, Anne Ladegaard Skov*
Technical University of Denmark, The Danish Polymer Centre
al@kt.dtu.dk

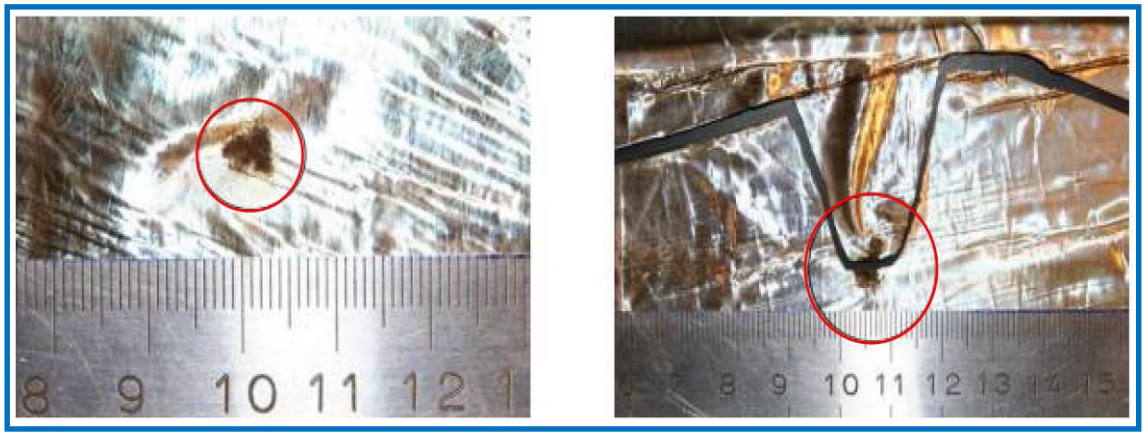

**Figure 1.** Electrical **breakdown** causes a **pinhole** formation on DEs film leading to major damage of the DE based devices.

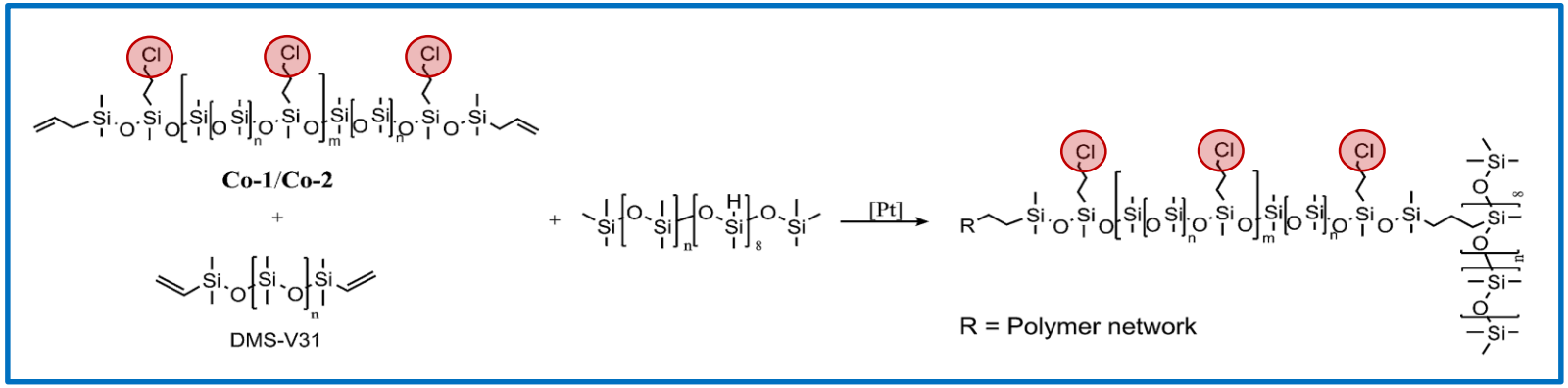


**Figure 2.** The structure of **chloro propyl** functional silicone elastomer.[1]

[1] F.B. Madsen, L. Yu, A.E. Daugaard, S. Hvilsted, A.L. Skov. *RSC Adv.* **2015**, *5*, 10254-10259.

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## Scanning Electron Microscope (SEM) - Morphology

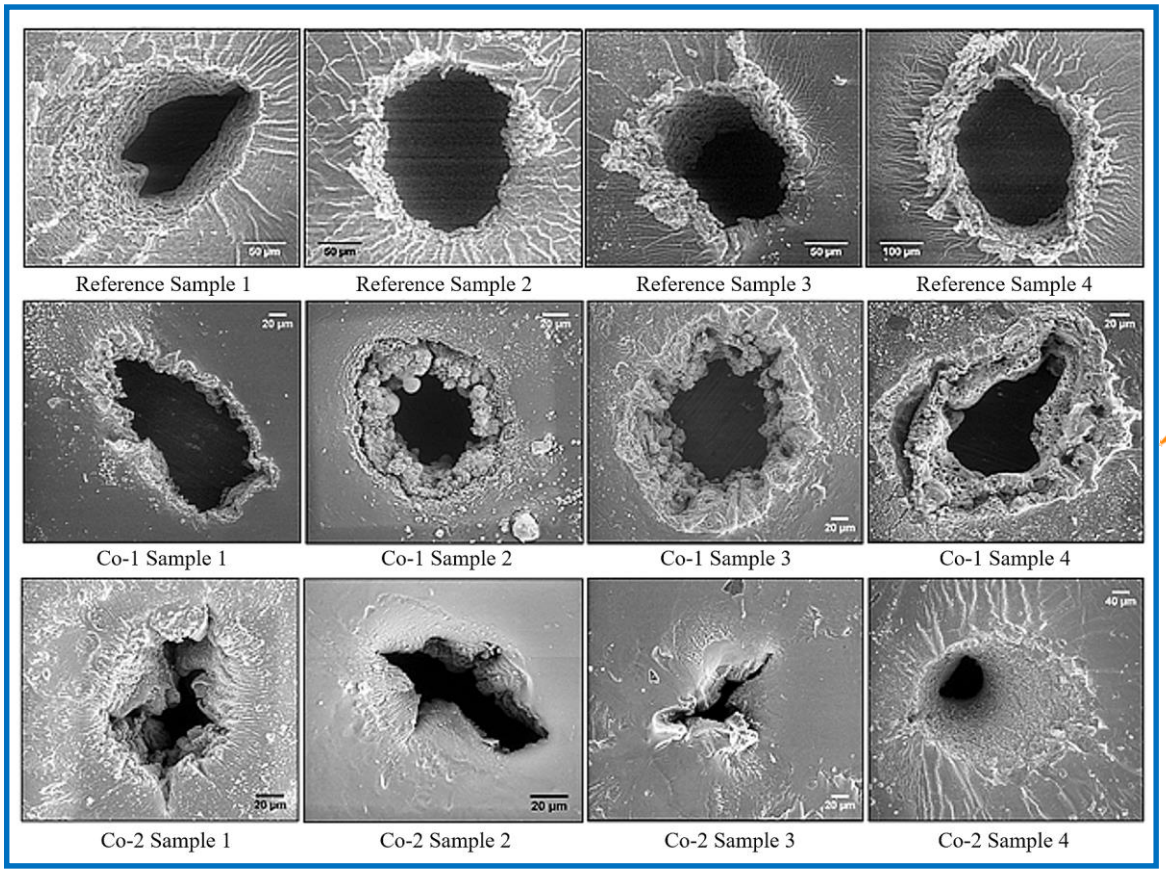


**Figure 4.** SEM images of breakdown zones for **reference samples**, **Co-1** and **Co-2** silicone elastomers. The black areas correspond to areas where the elastomer was completely removed during breakdown, i.e. pinholes.

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

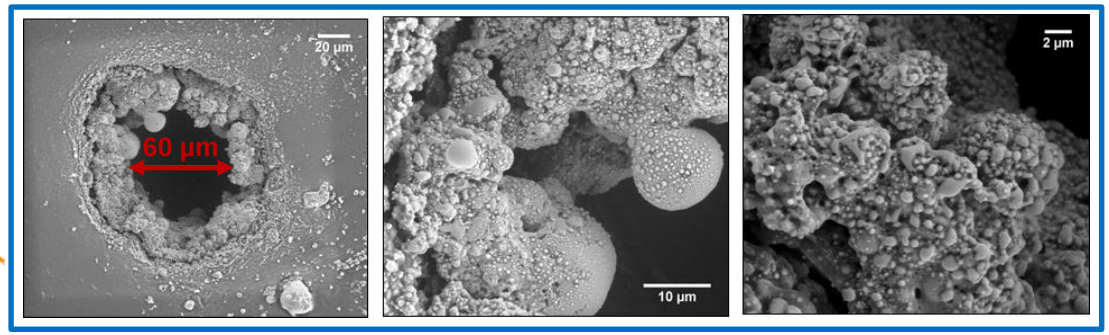


**Figure 5.** Illustration of **boiling nature** of the crosslinked copolymer **Co-1** in different magnifications. Droplets of condensing degradation products are formed on the surface of the breakdown zone.

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## Energy Dispersive X-Ray Spectroscopy (EDS) - Elemental Distribution

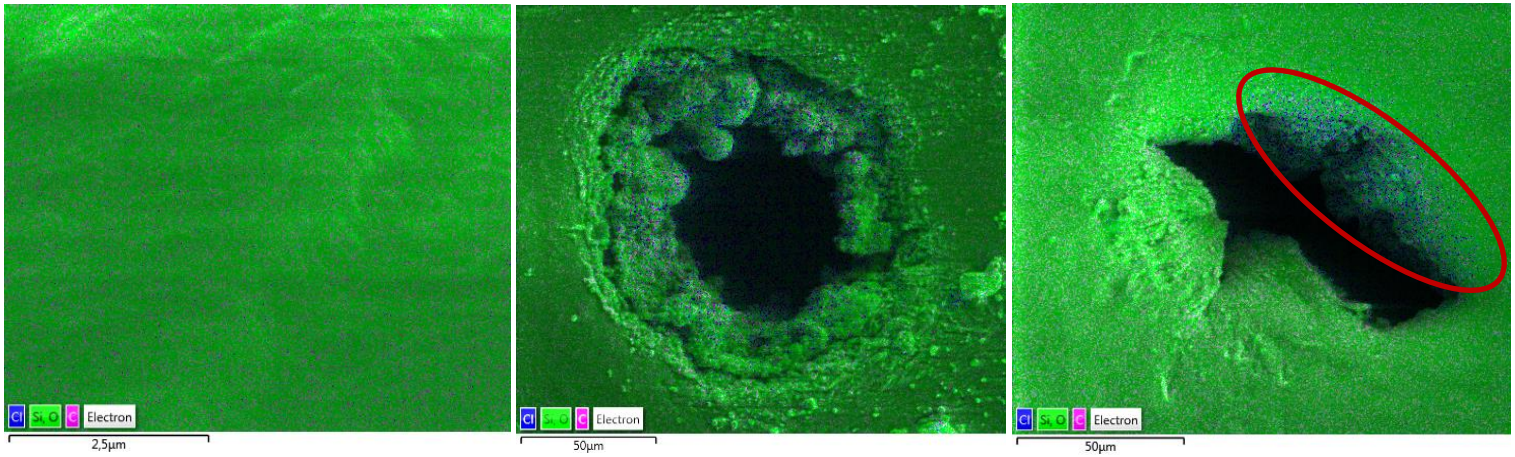


**Figure 6.** EDS mapping of **Co-2** elastomer surface where **Cl** is **uniformly distributed** (left), breakdown zones for **Co-1** (**middle**) and **Co-2** (**right**). The material in the **vicinity** of the **void** contains excess of **Cl** (blue color), which support the hypothesis that *silicon-containing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

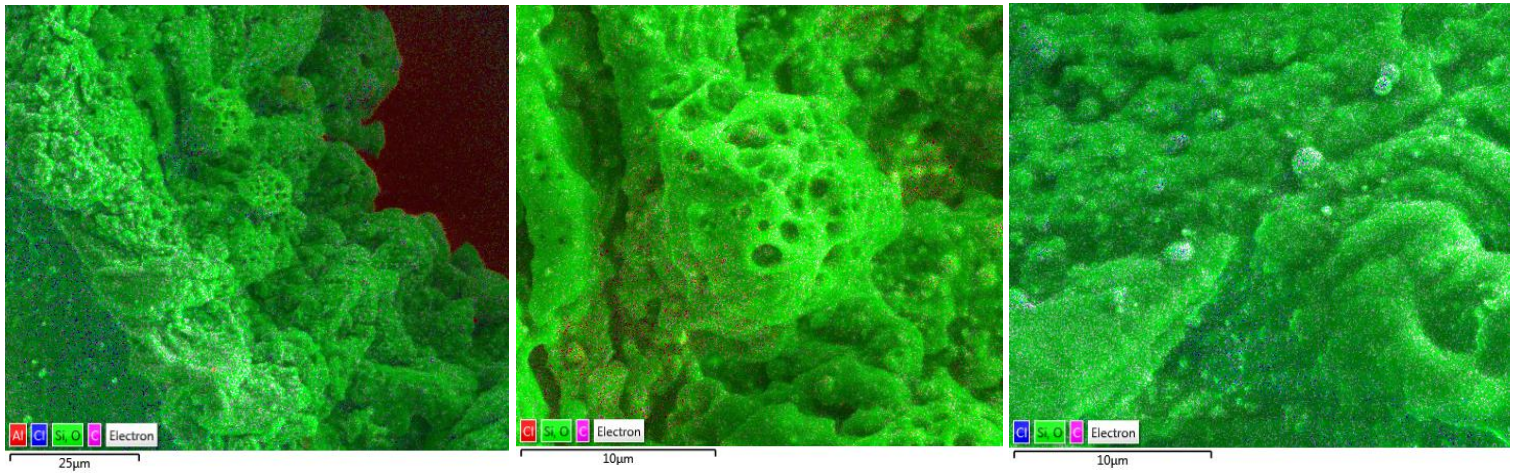


**Figure 7.** An increased concentration of Cl is recorded at the breakdown zones for the crosslinked copolymer Co-1.