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NOTE - On the Mechanism of Surface Flashover in Vacuum

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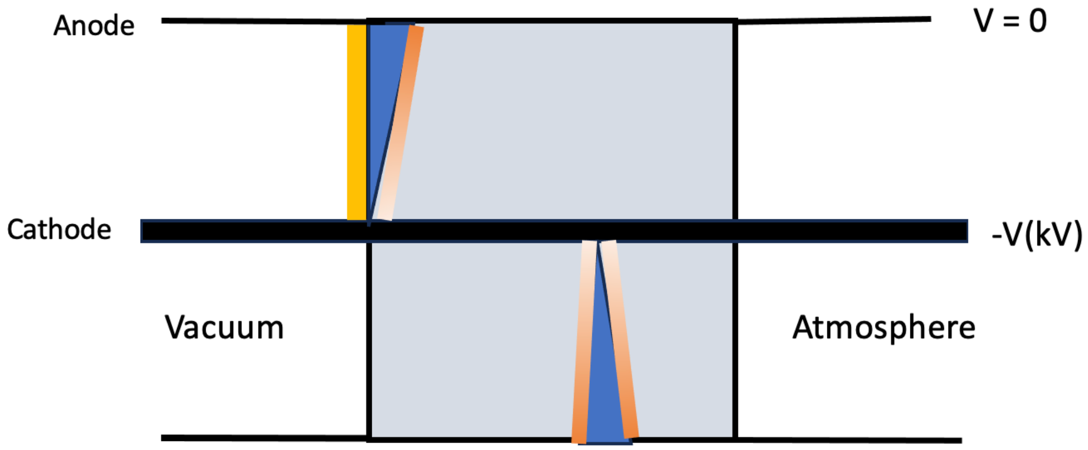
As discussed in the recent comprehensive review by Zhen et al [1], the phenomenon of surface flashover continues to pose a major technical challenge across a wide range of disciplines; not least in the case of the vacuum regime where the dominant historical explanation has been based on the secondary electron emission avalanche theory (SEEA) in which electrons are assumed to hop along the insulator surface and, in the process, desorb sufficient gas to promote a discharge event [2]. However, the findings of an early optical study by the author's group [3] called into question the general validity of the SEEA theory, and, as discussed in [1], a similar concern subsequently led to the emergence of a range of alternative possible mechanisms to account for the presence of surface gas, most of which were backed up by detailed spectroscopic measurements. It is in this context, and a recent informal advisory association with a commercial company that re-awakened the author's latent historic interest in the subject, and the present contribution to the debate.



For this purpose, consider the above self-explanatory schematic of a concentric electrode geometry consisting of an earthed outer metal cylinder (the anode) and a central cathode rod (the cathode) with an amorphous bridging insulator; i.e. corresponding to the generic regime employed in high voltage vacuum feed-throughs. The basic assumption of the proposed flashover mechanism is that there will be a multitude of potential metal-insulator micro emission sites distributed along the surface of the cathode, similar to those extensively studied with both broad-area nude cathodes [1] [4], and dielectric coated electrodes [6] [7] [8]. Such sites are commonly associated with the presence of micro-impurities such as carbon, but in the present case could also be associated with a negative affinity junction effect arising from the local metal-insulator micro-geometry. In both cases, electrons are able to overcome the work function barrier of the metal substrate and be subsequently heated by the field existing in the insulating medium. The other important characteristics of these emission sites is that they all have individual switch-on fields, and that some subsequently give rise to a stable field-dependent emission characteristic, whilst others give rise to an unstable explosive switch-on characteristic.

Against this background, it is firstly proposed that stable emission sites give rise to the measured pre-breakdown I-V characteristic. The second proposal is that an unstable site situated within the bulk of the insulting bridge will give rise to current avalanches (shown blue in the above diagram), and are observed as "dark" discharge events superimposed on the steady pre-breakdown current. Such events will also give rise to a burst of gas (shown orange in the above diagram) which will subsequently diffuse towards the vacuum interface under the influence of the pressure gradient existing within the amorphous insulator. The third proposal is that when an unstable site occurs adjacent to the vacuum interface, i.e. close to the triple junction, it will give rise to a burst of gas along the insulator surface, and hence create the necessary conditions for a gas discharge to occur, with an associated flash of light [5].

From a technical perspective, it would firstly be necessary to identify the type of micro-localised junction effect that enables electrons to be injected into the amorphous insulating medium. Then, with this information to hand, it should be possible to re-engineer the cathode surface to eliminate the presence of potential emission sites.

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