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The smooth transition from field electron emission to glow discharge (as a pre-stage of glow-to-arc transition) - a novel approach for the detection

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An underestimated phenomenon in the operation of field electron emission is the smooth transition to glow discharge as a significant pre-stage of vacuum arcs, which usually occur more frequently at higher operation vacuum pressures and higher emission currents in the range of normal glow discharge (> 0.1 mA). This phenomenon can be understood by investigating the transition from field electron emission (FE) to glow discharge (GD). It is important to note that the detection of the transition using the electrical parameters is not easy, because field electron emission and glow discharge have the same voltage range during a transition (in contrast to arc transition with sudden voltage breakdown). In order to confirm this transition from field electron emission to glow discharge a graphical four-step evaluation method was developed and proposed for detection with electrical parameters [1, 2]. These four steps are:

1st step: I-V semi-logarithmic diagram (typical of the FE diagram with many current decades),

2nd step: I-V linear diagram with linearity test for measurements of $V = f(I)$ and calculation of serial R ($I > 0.1$ mA),

3rd step: I-V linear diagram with R voltage correction, and for glow discharge is $V = \text{constant!}$

4th step: V-I linear diagram (typical of the GD diagram in plasma physics).

A detailed description and explanation of this evaluation method is a topic of this contribution. Additionally, we present different optical observations of the cathode-anode distance with typical blue luminous effects of glow discharges and change of color and brightness during the glow-to-arc transition.

References:

[1] D. Wenger, W. Knapp, B. Hensel, S. T. Tedde, „Transition of Electron Field Emission to Normal Glow Discharge“, IEEE Transaction on Electron Devices 61 (11), p. 3864 (2014).

[2] W. Knapp, “Energetic evaluation of the transition from field electron emission to plasma discharges with extended use of the Fowler-Nordheim plot”, Oral contribution, IVNC 2017, 10-14 July, Regensburg, Germany.

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