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Large area plasma electron emitter: Emission behavior in long pulse electron accelerator

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Different diagnostic tools were installed at the facility GESA-SOFIE in order to investigate the plasma behavior in the cathode-grid gap. A high-resolution fast CCD camera was used to monitor the formation and evolution of the cathode and grid plasmas. A streak camera with high dynamic range delivered information on the characteristics of the plasma motion. A complex modification of the cathode block enabled admission and versatile circuiting of the plasma adjacent components.

In order to keep the beam parameters constant over the pulse duration of several tens of microseconds, it is required to prevent the expansion of the cathode plasma. This is possible in the direction of the electric field, if the plasma front reaches emission saturation prior to breakdown of the electrode gap. Several approaches were tested to reduce the excessive generation of plasma and thus to stabilize the emission front: an active voltage control to tune the emission current; manipulation of the plasma decay by offering additional contact areas; relief of the emission tips by rerouting the current.

In spite of the various measures, an influence on the continuously rising perveance of the facility was hardly achieved. The most severe issue is the expansion of the cathode plasma in the transversal, weak field direction: the increase of the effective emission area leads to a decrease of the facility impedance, which results in a more intense plasma generation. Additionally, the uncontrolled transversal expansion leads to a natural pulse duration limit –the breakdown occurs outside the acceleration gap.

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