Peculiarities of Ba scandate cathodes and constituents of a model

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Abstract:

A feature, which is common for electron emission of scandate and oxide cathodes, is their so-called anomalous Schottky behavior, which can be observed in their current voltage (I/U) characteristics; it also exhibits no clear transition from space charge limited (SCL) emission to saturation. For Ba scandate cathodes I suggest to call it “pseudo space charge behavior” in the transition region, which one can observe in double logarithmic plots of I/U characteristics. It is observed, that scandate cathodes with increasing voltage, after deviation from SCL, follow a power law $I = \gamma U^x$, with x being smaller than 1.4 or the respective SCL power. This behavior has been observed for LAD top-layer scandate cathodes [1] and also for scandia doped dispenser (=SDD) cathodes [2]. During activation and early life (about 100 – 200h) of LAD scandate cathodes [1] one could see, that the characteristic (in the 100 A/cm^2 range; operating temperature ~ 960 °C$_b$) is first approaching the space charge limit, then staying there for some time, and then with increasing operating time falling below SCL with decreasing slope; the same can be observed during accelerated aging by ion bombardment. Yet in the discussion of the Schottky behavior one forgets, that also for impregnated (I) cathodes a closed theoretical description of the transition range between space-charge limit and Schottky saturation is missing. This gap was closed by Hasker via an approximation [3] and by Scott [4] by numerical calculations and was applied by Manenschijn et al. to Os/Ru-I cathodes [5]. Based on measurements of I/U characteristics as a function of temperature and the respective Richardson plots of Ba scandate cathodes and of I cathodes, a superposition model of highly emitting patches is presented, which can explain the "pseudo-space-charge" behavior of Ba scandate cathodes in the transition range, but also incorporates features of a semiconductor model as first described by Maloney [6]. It is compared with high resolution characterization results of Ba scandate cathode surfaces including SAM elemental mappings, which also indicate the occurrence of highly emitting patches after some operation time. Possible problems arising from inappropriate use of Schottky extrapolations and of Richardson plots are also addressed. It is hoped that the above model stimulates new efforts for a theoretical description of Ba scandate emission behavior.

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