

Evidence for semiconducting behavior of Scandate cathodes

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Abstract: A new theory of emission is offered for scandia doped dispenser cathodes [1, 2]. It is based on data collected at ebeam and the University of Kentucky from 2016 to 2024. The data confirms that scandate cathodes do exhibit certain features of semi-conductor cathodes, such as the anomalous Schottky effect in the temperature limited regime, which is much higher than expected from normal Schottky emission. But they also exhibit some of the features of metallic cathodes, such as insensitivity to duty factor variations. The conventional understanding [3, 4] is, that an approximately 80 nm thickness of scandium rich material lies on the surface of these cathodes, and this accounts for their semiconductor properties. However, this layer was not found on any of the cathodes constructed at ebeam. This finding is based on SEM/EDS, XPS, TEM and Auger in situ studies presented here.

However, a 4-6 nm layer of scandium-rich material was detected on the surface of all tungsten particles in the matrix of activated and emission tested cathodes. This layer was observed using TEM (transmission electron microscopy) on thin cross-sections. It was also detected on the emitting surface of activated cathodes operated at normal emission and temperature by in situ Auger studies.

As a result of these experimental results a new theory of emission is offered. It assumes a thin film semiconductor exists on each tungsten particle in the matrix. These particles in aggregate seem to constitute a thick film semiconductor such as is seen on oxide cathodes, theoretically described by Wright and Woods and Morgulis [5, 6]. This approach was used to fit the anomalous Schottky characteristic by M. Caplan [2], resulting in a Debye length of 1.5 μm .

Keywords: Scandate Cathodes, electron emission, electron guns, thermionic emission, vacuum electron devices.

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