Abstract

An Introduction To The Physics And Applications Of Electron Sources

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Models of thermal, field, photo, and secondary emission, as well as space charge limited current flow, have existed since the 1920's. With the realization that such sources were crucial to Radar and communications, research in harnessing their capabilities greatly accelerated, and now they are key components of cutting edge applications such as High Power Microwave generation and x-ray Free Electron Lasers. Although the processes behind the emission mechanisms (namely, heat, electric field, photoemission effect, and ejection of secondaries due to a high energy primary beam) appear distinct, they can all be understood collectively using simple models from quantum mechanics, condensed matter physics, and electrostatics. A description of the theoretical models and some history behind each mechanism, examples of the kinds of emitters that employ those mechanisms, and the challenges to utilizing the beams generated by various electron source candidates (particularly with respect to beam parameters such as current density, space charge, emittance, and brightness) will be covered. A full description of the canonical emission equations of thermal (Richardson), field (Fowler-Nordheim), photo (Fowler-DuBridge), and secondary (Young) equations is given – but even more interestingly, a demonstration of how the equations are fundamentally related is explored. Processes that affect emission, such as electrostatic shielding, coatings, space charge (Child-Langmuir), and complications due to material properties (metal versus semiconductor) shall be described.