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Theoretical study of field emission from dielectric coated surfaces

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Electron field emission plays an essential role in a wide range of applications, such as, electron microscopes, X-ray sources, high power microwave sources and amplifiers, vacuum micro-electronics, and emerging nano-electronics [1-5]. Ultra-thin coatings are fabricated onto metallic cathodes to provide chemical and mechanical protection, and longer current stability, smaller turn-on electric field and enhanced current emission due to the lowering of the effective potential barrier [6], [7]. There is still lack of systematic analysis on the parametric scaling of field emission from coated surfaces and the interplay of various parameters to optimize the design of coated field emitters.

In this study, we develop an exact analytical theory for field emission from the dielectric-coated cathode surface, by solving the one-dimensional (1D) Schrödinger equation subject to the double-barrier introduced by the coating layer. The effects of dc electric field, cathode properties (i.e. work function and Fermi level) and dielectric coating properties (i.e. dielectric constant, electron affinity and thickness) are analyzed in detail. It is found the emission current density can be larger than the uncoated case in certain coating conditions. Our quantum model is also compared with a modified Fowler-Nordheim equation [8], [9] for double-barrier, showing qualitatively good agreement in the scaling of the emission current density. The model is also extended to study photoemission and photo-assisted field emission from coated emitters [7]. The theory provides insights for designing field emitters with higher efficiency and better stability.

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