"Fine structure" of emission I-V characteristics of nano-dispersed films

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Current characteristics of field-induced emission from nano-structured films are assumed to follow exponential dependency (or, more precisely, Fowler-Nordheim (FN) formula), as do characteristics of metallic tip emitters. Yet, the general exponential trend is usually derived from experimental data sets having substantial irregular component, associated with instability of emission properties of film emitters. Besides noise-like fluctuations, experimental curves often include instant drops of current, sometimes by as much as an order of value or more. Observation of emission images (area distributions of current) shows that some centers of active emission can be simply "turned off" at certain moments. It is natural to consider such an event as a case of destruction or de-activation of this center. However, in experiments with nano-porous carbons and other promising emitter films we discovered these current drops to be reproducible (repeating in a series of measurements) and reversible (reducing-field plot branch shows current rise at approximately the same field value).

This phenomenon of reversible de-activation of emission sites can be explained by the two-stage emission model with participation of acceptor-type transient electron states localized in a surface layer. Penetration of external electric field into emitter reduces the energy of the surface states. Electron current to the transient states (and then to vacuum) starts as this energy reaches Fermi level. Yet, with further field increase, continued downshift of surface states' energy can result in their insulation from emitter volume, which leads to interruption of emission current. "Fine structure" of emission I-V plots may be useful for reconstruction of electronic properties of emission centers (that is still unclear for many promising emitter materials). Also, current limitation can represent an advantageous property for distributed emitter systems, allowing to avoid destruction of emission sites by excessive current and to achieve more uniform emission distribution.

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