Biasing Effects On The Emission Characteristics BST-Coated Silicon Tips

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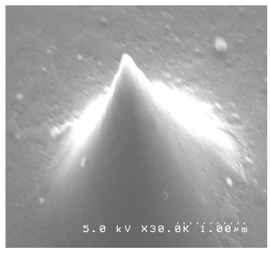
ABSTRACT

Field emission characteristics of Sol-Gel $(Ba_{0.67}Sr_{0.33})TiO_3$ (BST) ferroelectric thin film coated silicon emitters have been systemically investigated. The effects of BST coating and biasing at BST-silicon junction on field emission characteristics of BST coated silicon tips have been studied.

BST coated silicon tips were fabricated through three major fabrication steps: (a) fabrication of silicon emitter arrays, (b) preparation of the sol-gel BST solution, and (c) coating silicon tips with BST ferroelectric by spin coating. As seen in Fig. 1, a tip radius to ~ 30 nm and tip height of 2 μm with a uniform BST film thickness of ~30 nm were obtained through this fabrication process.

The I-E plots of uncoated silicon tips along with BST coated silicon tips are shown in Fig. 2. From Fig. 2, it can be seen that the BST coated silicon tips have low turn-on electric fields ranging from 4 to 9V/um, which are significantly lower than that of the uncoated silicon tips with the turn-on electric field of around 70V/um. A linear set of F-N plots confirmed that the emission from BST coated and uncoated silicon tips conform to F-N behavior and also revealed work functions of 4.1 eV for the uncoated silicon tips and ~1.1 eV for the $(Ba_{0.67}Sr_{0.33})TiO_3$ coated silicon tips. The low work function value agrees with the corresponding reduction in turn-on electric field as a result of BST coating.

We have found that the electron field emission characteristics of BST coated silicon tips can be improved upon application of bias to the BST/silicon junction. Fig. 3 shows the effect of the bias on I-E plots of BST coated silicon tips with no bias, 0.75V bias and 1.35V bias, respectively. From Fig. 3, it is obvious that bias on BST-silicon junction improves the emission characteristics of BST coated silicon tips significantly. The turn-on electric field decreases from around 19V/um with no bias to 9V/um, and 7V/um with 0.75V bias, and 1.35V bias accordingly. The corresponding F-N plots are shown in Fig. 4. Since the F-N plots are linear and conform to F-N emission, the effective work functions can be estimated by the same method as discussed before. Table I shows the calculated values. Table I demonstrates that electron field emission characteristics from BST coated silicon tips were improved significantly upon biasing the BST-silicon junction. Figure 5 shows the current time plot of BST coated silicon tips under different anode biasing electric fields. The current fluctuation is less than 20% at high emission current of 2.5 μA and less than 15% at low emission current of 0.5 μA, which is considerably better than conventional silicon tips that typically have 50% current fluctuation.



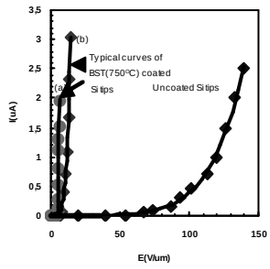
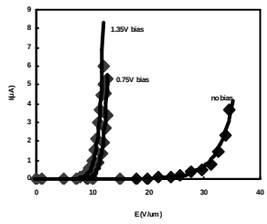


Fig. 1: BST-coated Si tip
Fig. 2. Typical I- E plot



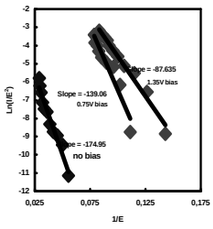
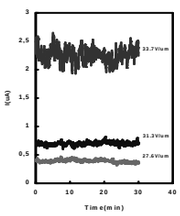


Fig. 3. Bias effects on I-E plot
Fig. 4. F-N plot with bias effect



Ferro bias	$(FNSL_{ferro}/FNSL_{si})^{2/3}$	4.1eV * $(FNSL_{ferro}/FNSL_{si})^{2/3}$ Effective work function
No bias	0.712	2.92eV
0.75V	0.611	2.5eV
1.35V	0.449	1.84eV

Table I. Bias effects on device parameters

Fig. 5. Emission stability