Supporting Information

Patterned growth and field emission properties of AlN nanocones

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SI 1 Additional SEM images of the patterned AlN nanocones synthesized using two masks with different pore sizes and gaps

Figure S1. Additional SEM images of the patterned AlN nanocones synthesized using two masks with different pore sizes and gaps (Patterns I & II).

Patterned sample I : (A) enlarged image, (B) the AlN nanocones at the margin as marked in (A). It is seen that the AlN nanocones at the margin undergo a transition from dense to sparse.

Patterned sample II : (C) overview, (D) the AlN nanocones inside the block, (E) the AlN nanocones at the margin. It is seen that AlN nanocones sharply disappear. (F) the region between two blocks. AlN nanocones inside the block are quasi-aligned but no AlN nanocone could be observed in between the neighboring blocks, which is similar to the case for the patterned sample I (see Figure 1D, 1E in the main text).

The morphological difference at the margin for the two patterned samples (see B and E) may arise from the different adhesion states on the substrate for the two masks depending on the operation technique. Probably mask II was more tightly adhered on the substrate during synthesis. Anyway, the larger marginal region for the patterned sample II results in the lower screening effect, thus the better FE performance than the case for the patterned sample I .

SI 2 Magnified SEM image of the AlN nanocones

Figure S2. Magnified SEM image of the AlN nanocones. It is seen that the AlN nanocones have the diameters of ~ 10 nm at tips. The diameters at roots are estimated to be 50-60 nm.

SI 3 EDX spectrum of the patterned AlN nanocones grown on Si substrate

Figure S3. EDX spectrum of the patterned AlN nanocones grown on Si substrate. The atomic ratio of Al to N is about 1:0.93, rather near the stoichiometric ratio of AlN. The Si signal comes from the Si substrate.

SI 4 XRD curve of the AlN nanocones grown on Si substrate

Figure S4. XRD curve of the AlN nanocones grown on Si substrate. The diffraction peaks could be indexed to hexagonal aluminum nitride (PDF 76-0702). The peak at 28.5° could be attributed to the diffraction of Si substrate.

SI 5 FE images of the patterned AlN nanocones under different applied fields

Figure S5. Field emission (FE) images of the patterned AlN nanocones under the applied fields of ~ 3 kV (A) and ~ 4 kV (B), respectively. The distance between the cathode (the sample of patterned AlN nanocones) and anode (ITO glass) is ~ 200 μm . The sample margin is denoted by the dash circle.

The FE images were observed using the transparent anode of ITO glass coated with fluorescent powder. The electrons emitted from the AlN pattern bombarded the ITO glass to display the bright spots, which could reflect the emission sites of the sample (1). It is seen that generally more electrons were emitted from the edge part of the sample due to the decreased screening effect at the margin, in comparison with the central part of the sample. Due to the resolution limitation, the emission for each block could not be precisely distinguished. Anyway, in principle, due to the smaller screening effect, the edge of each block should be also easier for field emission than the inside part of the corresponding block. This is in agreement with the comparison of the FE performances for the two patterned samples with different pore sizes of the grid mask, i.e., larger marginal area leads to better FE performance as shown in Figure 3 and Table 1 in the main text.

SI 6 J-V curves of two patterned AlN samples obtained with the same growth process

Figure S6. J-V curves of two patterned AlN samples obtained with the same growth process. Their FE properties are rather similar with each other, which indicate the reproducibility of the patterned growth.

SI 7 SEM images of the AlN nanocones after FE measurements

Figure S7. SEM images of the AlN nanocones after FE measurements. No obvious morphological change could be observed compared with Figure 1 in the main text. This case is rather different from that for ZnO nanowire arrays reported by Z. L. Wang et al., where the ZnO nanowires with high density were attracted together to form bundles after field emission (2).

Reference

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- (2) Wang, X. D.; Zhou, J.; Lao, C. S.; Song, J. H.; Xu, N. S.; Wang, Z. L. *Adv. Mater.* **2007**, 19, 1627-1631.