Supplementary materials

1. Measurement of the electron transparency of SACNT film.

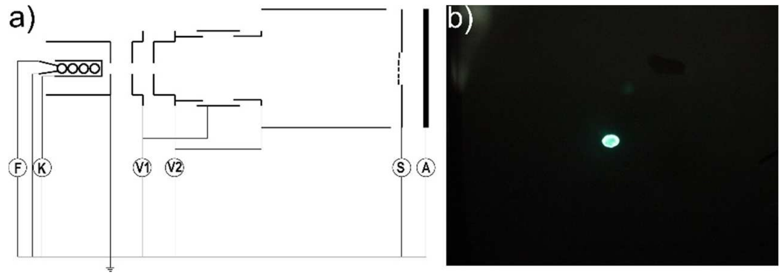

Figure S1. a) The schematic circuit of the measurement of electron transparency of SACNT film, b) a typical anode spot of electron beam passed through the SACNT film.

SACNT is substituted by the dashed line as shown in figure S 1 a). Thermionic emission electron gun is used to measure the electron transparency. The electron beam was defocused to the diameter of 3-5mm. figure S 1 b) shows a typical anode spot of electron beam after passing through the SACNT film sample.

2. Measurement of secondary electron emission (SEE) coefficient of SACNT film.

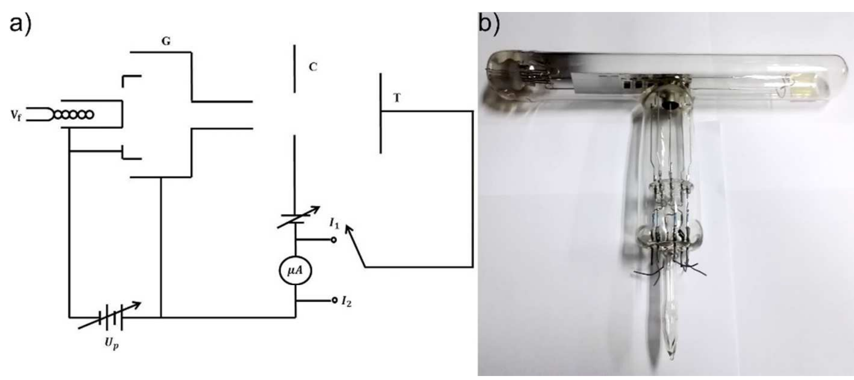

Figure S2. a) The schematic circuit of measurement of secondary electron emission (SEE) coefficient, b) the test vacuum tube of SEE coefficient of SACNT film, the SACNT samples are vacuum enveloped.

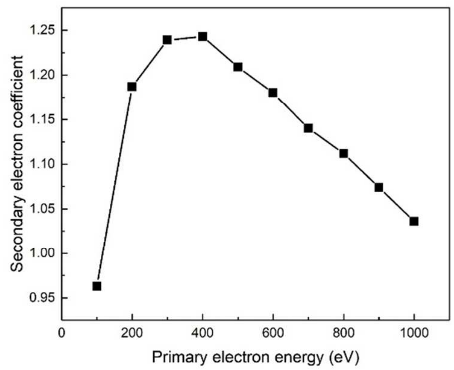

Figure S3. The measure SEE coefficient of Mo with the system in figure S2. The result is in good accordance with the reported value[1].

3. The characteristics curves of a conventional vacuum triode with metal wire gate.

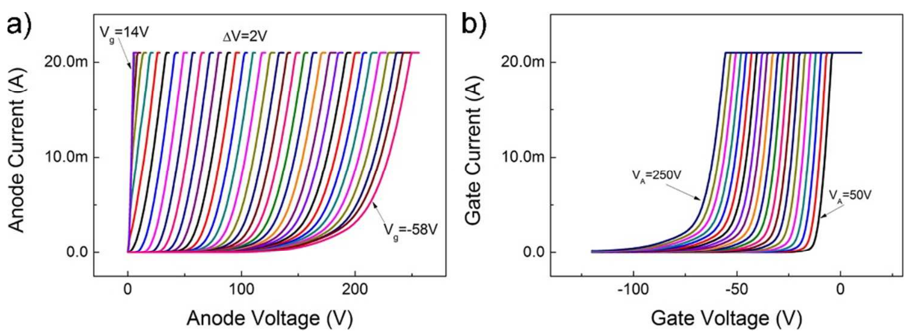

Figure S4. The characteristics of metal wire gate triode, which has the identical structure except the gate. a) The anode current variation with anode voltage at different gate voltage, b) the gate current variation with gate voltage at different anode voltage.

4. The fabrication process of the field emission structure.

Firstly, the silver cathode is screen printed on the glass substrate. Then the dielectric layer is also printed. Then the silver and dielectric are sintered at high temperature. The CNT paste was screen printed on the silver cathode, following by an activation step to enhance the field emission performance. The CNT film is coated on the substrate as a whole. The unnecessary part is removed by laser cutting.

5. The comparison measurement of CNT field emission without SACNT film gate.

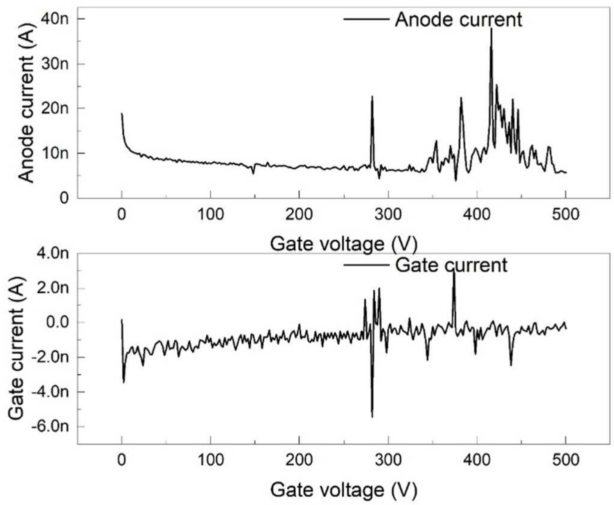

Figure S5. The measured anode and gate current of a CNT field emission structure without SACNT film gate.

6. The mechanical stability of SACNT film gate in a field emission structure.

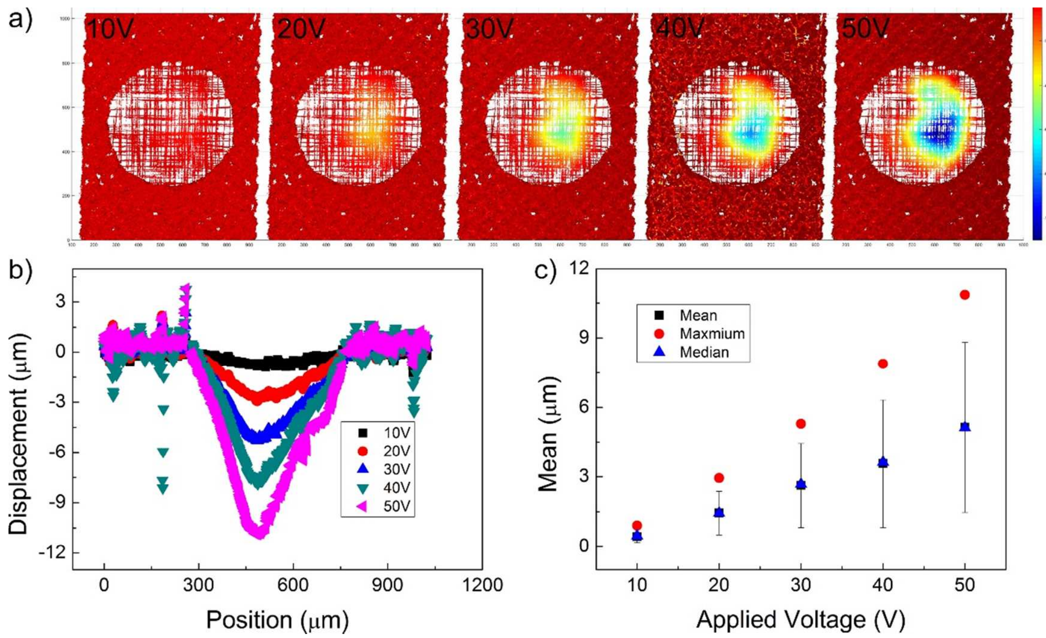

Figure S6. The mechanical stability of the SACNT film gate in field emission applications. a) The deformation of SACNT film under different voltage, b) the cross-section curve of the SACNT film gate, c) the maximum, mean, and median value of deformation of SACNT film at different voltage based on the data in figure S4 b).

Based on the thin film large deflection theory[2-3], the maximum displacement of rotational symmetry thin film under uniform load can be described as the following,

$$\mathrm{w} = \mathrm{g(c)}\left[\frac{ca^4q}{2Eh}\right]^{1/3},$$

Here, w is the maximum displacement of the film. $\mathrm{g(c)}$ is a function of c, and c is related with the Possion ratio μ. a is the diameter of thin film. q is the perpendicular force per unit area on the thin film. E is Young's modulus. h is the thickness of the film.

For the SACNT film gate structure as shown in figure 4 a) in the manuscript, the force per unit area is related with the applied voltage as the following according the Coulomb theory,

$$\mathrm{q} = \varepsilon_0 {U^2}/{d^2} \ ,$$

Here ε_0 is vacuum dielectric constant, U is the applied voltage on the SACNT film, d is the distance between the SACNT film and cathode. By substituting into the formula 1, we can see that the maximum displacement is proportional with 2/3 order of voltage. However, a linear fit for the logarithmic of voltage and deformation can find that the maximum deformation is about proportional to the 1.5 order of voltage.

By substituting the Young's modulus derived from figure 1 d) in the manuscript, and the actual dimension of SACNT film gate as shown in figure 4 a), we can get the deformation is proportional with voltage as the following,

$$\mathrm{w} = 0.0266U^{1.5347} + 0.19895,$$

$\mathrm{g(c)}c^{1/3}$ will be equal to 0.079. Considering the large Possion ratio of SACNT film[4] and negative correlation of c with Possion ratio[3], the value is in plausible range.

7. The Scanning electron microscope image of CNT field emitter and SACNT film gate in field emission structure.

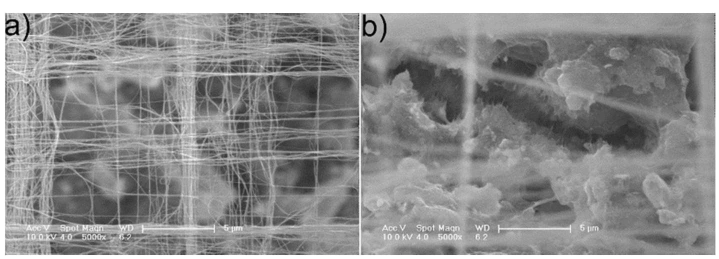

Figure S7. a) The scanning electron microscope (SEM) image of SACNT film gate in a field emission structure, b) the SEM image of the carbon nanotube field emitter.

8. The displayed characters by the SACNT film gate field emission display prototype

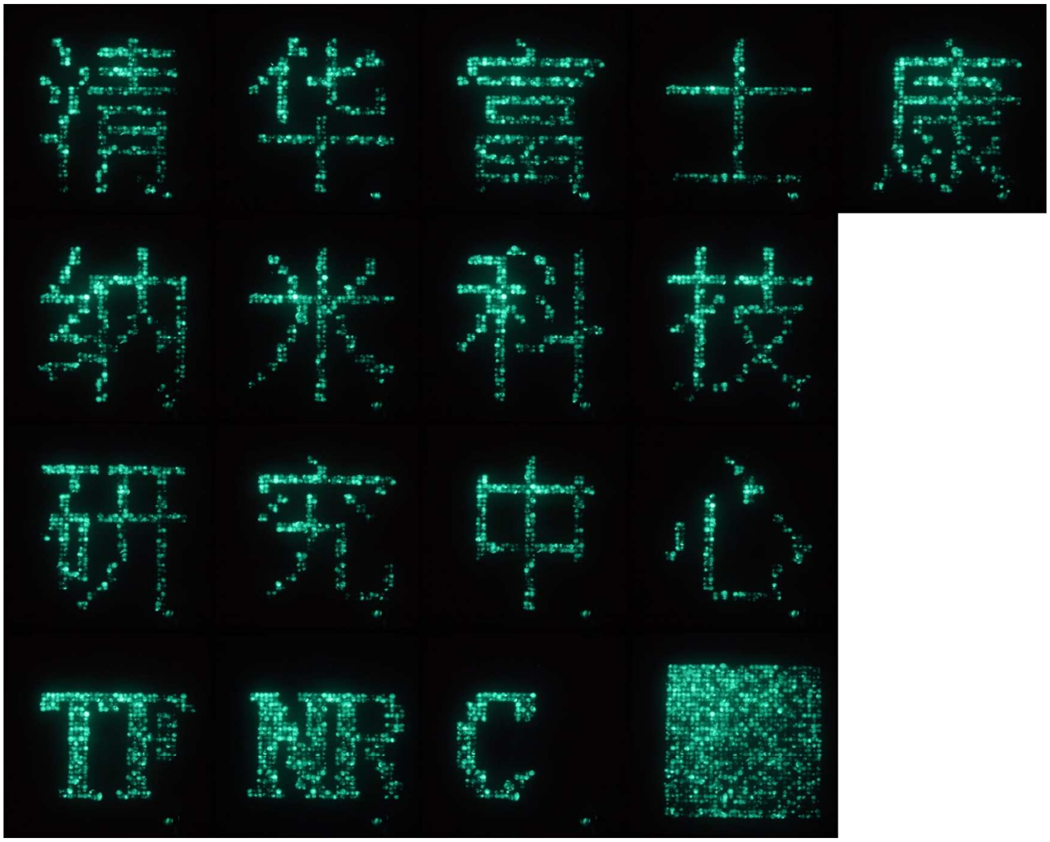

Figure S 8. The displayed characters by the SACNT film gate field emission display prototype

Reference

1. Bruining, H., Physics and applications of secondary electron emission Pergamon Pr. Ltd.: London, 1954.

2. Hencky, H., Uber den Spannungszustand in Kreisrunden Flatten mit Vershwindender Biegungssteifigkeit. *Zeit. f. Math. u. Physik.* **1915,** *63*, 311-317.

3. Qian, W. C., *Large deflection problem of elastic thin plate*. Chinese Acadmy of Science: Beijing, 1954.

4. Liu, K.; Sun, Y. H.; Liu, P.; Lin, X. Y.; Fan, S. S.; Jiang, K. L., Cross-Stacked Superaligned Carbon Nanotube Films for Transparent and Stretchable Conductors. *Adv Funct Mater* **2011,**

21 (14), 2721-2728.