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Enhanced field emission stability of vertically aligned carbon nanotubes through anchoring for X-ray imaging applications

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S1. SEM images of the CNT film anchored at 900 °C

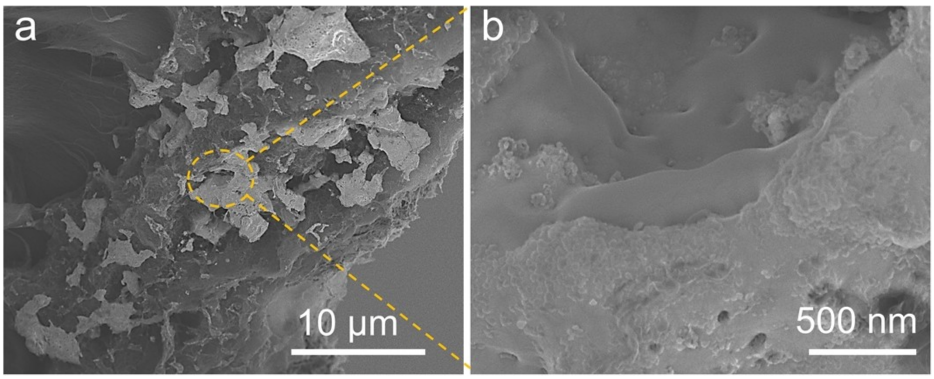

Fig. S1. (a) SEM image of the anchored CNTs film annealed at 900 °C after remove from the substrate (45° bottom view); (b) High-resolution SEM image of the region surrounded by the dashed yellow lines shown in (a).

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In order to investigate the anchoring result of the Ag nanoparticles after annealing at 900 °C, we removed the CNTs film from the substrate after annealing, and the SEM images were shown in Fig. S1. Fig. S1a is the SEM image of the anchored CNTs film after removing from the substrate (45° bottom view), we can see that a large number of melted and aggregated Ag lumps adhere to the bottom of the CNTs film, they are lifted from the substrate together. Fig. S1b is the high-resolution SEM image of the region surrounded by the dashed yellow lines shown in Fig. S1a, it can be clearly observed that partial Ag nanoparticles melted and aggregated to form a liquid state which have solidified.

S2. SEM images of the CNT film anchored at different temperatures

Fig. S2 shows the SEM images of the CNT films with SCP anchored at 850 °C, 900 °C, and 960 °C. When the samples were annealed at 960 °C, as shown in Fig. S2c and S2f, the excessively high temperature led to a large amount of Ag volatilization, which caused the SCP film coated on the substrate to be destroyed; thus, the anchoring strength was greatly reduced. Furthermore, when the annealing temperature was too low (850 °C), as shown in Fig. S2a and S2d, the Ag nanoparticles exist independently, and the anchoring processes cannot be achieved completely, Thus, the optimum annealing temperature was 900 °C in our experiment.

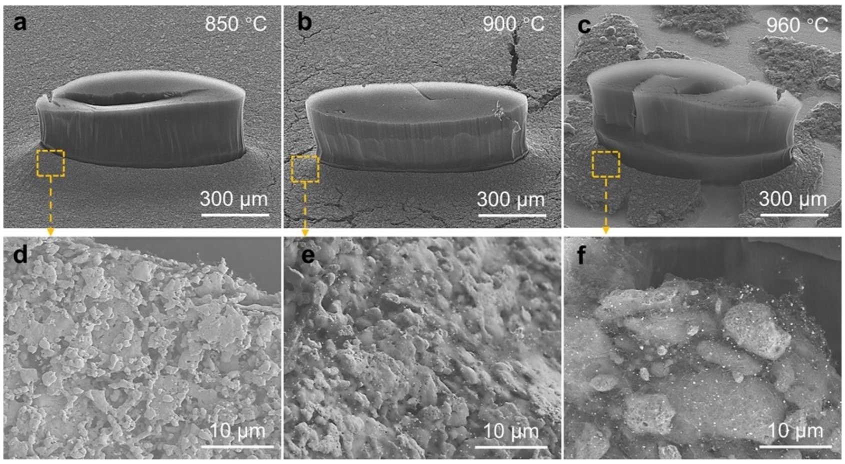

Fig. S2 SEM images of the CNT film annealed at different temperatures. (a), (b), and (c) SEM images of the CNT film annealed at 850 °C, 900 °C and 960 °C, respectively. (d), (e), and (f) Magnified view of the regions surrounded by the dashed yellow lines in (a), (b), and (c).

S3. Field emission stability of different CNT samples

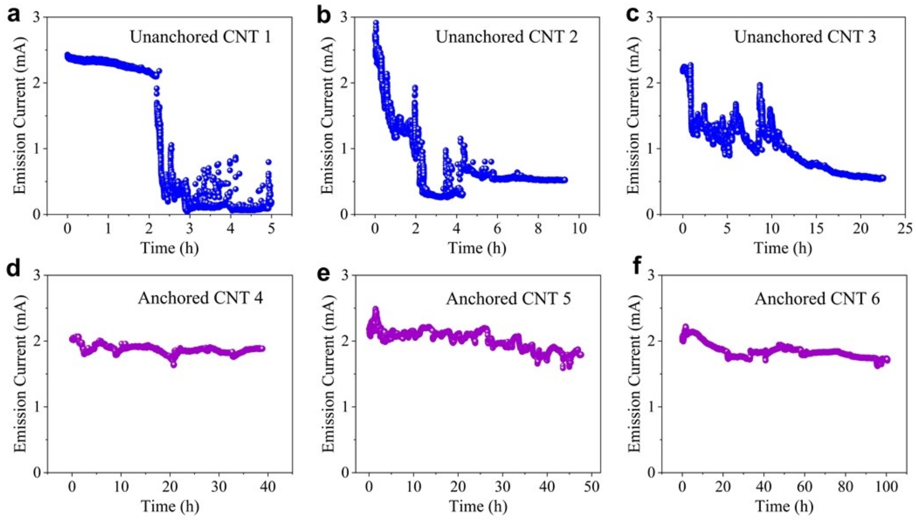

Fig. S3 Field emission stability of different CNT samples. (a), (b), and (c) Field emission stability of the unanchored CNT films 1, 2, and 3, respectively. (d), (e), and (f) Field emission stability of the anchored CNT films 4, 5, and 6, respectively.

The CNT samples were all prepared under the same conditions, so they have nearly the same characteristics, such as diameter, height, density, morphology and so on. The emission current of the unanchored CNT film decreased sharply from 2.5 to 0.5 mA in 2 h for both samples 1 and 2, while the same reduction occurred over 20 h for sample 3. By contrast, the anchored CNT film exhibited excellent current stability, and the current decreased only slightly after 50 h or even 100 h of testing. This proves that our mold-aligned transfer anchoring method is effective in improving the emission current stability and lifetime of CNTs.