Supplementary Information

Enhanced field emission performance of MXene-TiO_2 composite film

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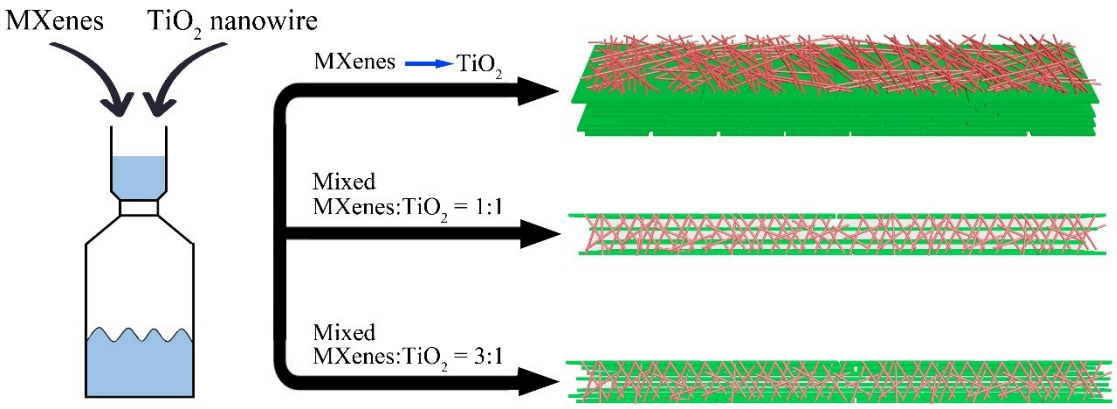

Figure S1. Schematic preparation representation of MXene-TiO_2 composites with different structure and content ratio of MXene to TiO_2.

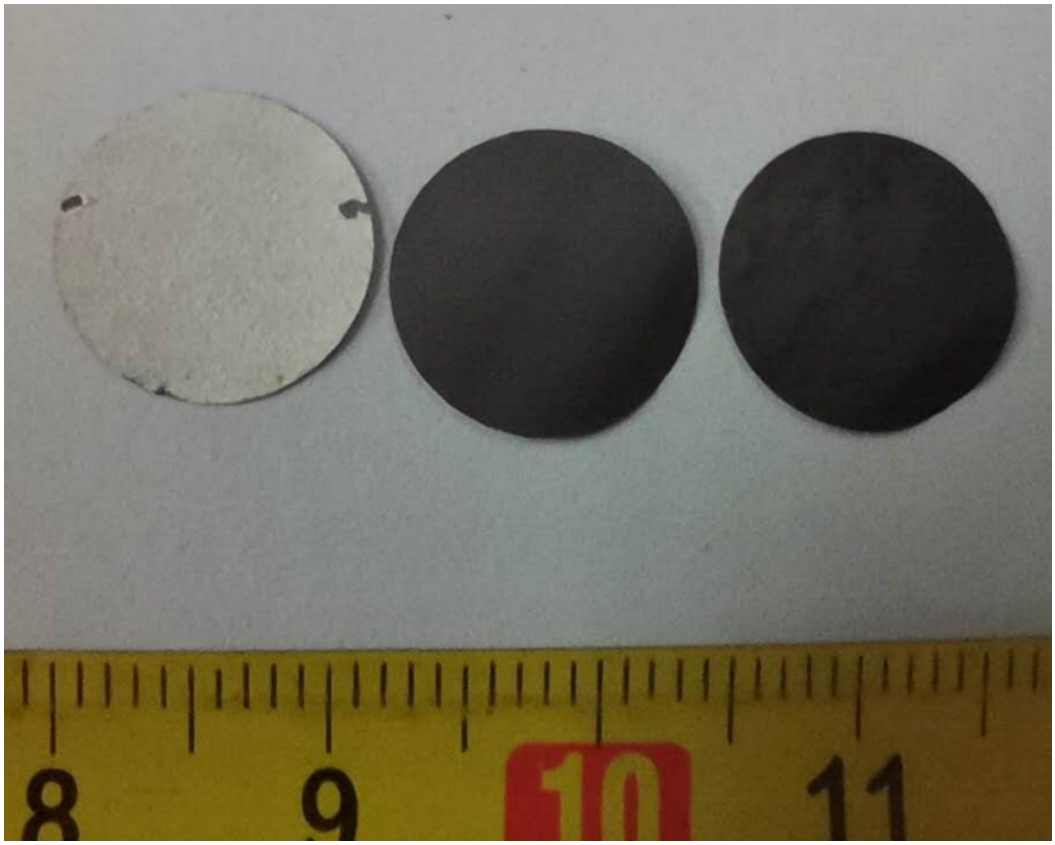

Figure S2. Digital image of MXene-TiO_2 composites with different structure and content ratio of MXene to TiO_2. From left to right in turn is MXene-TiO_2 (1:1 top), MXene-TiO_2 (3:1 mixed), and MXene-TiO_2 (1:1 mixed).

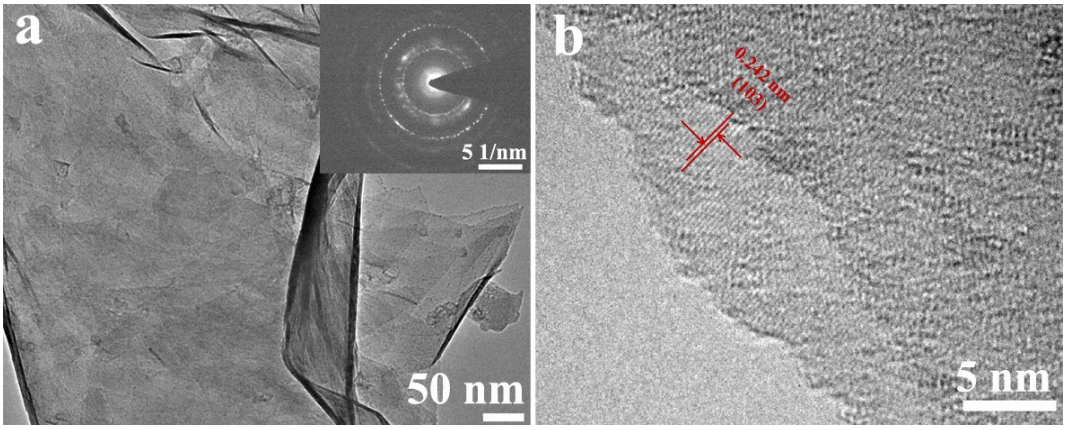

Figure S3. (a) TEM image and corresponding SAED pattern (inset) of MXene. (b) HRTEM image of MXene

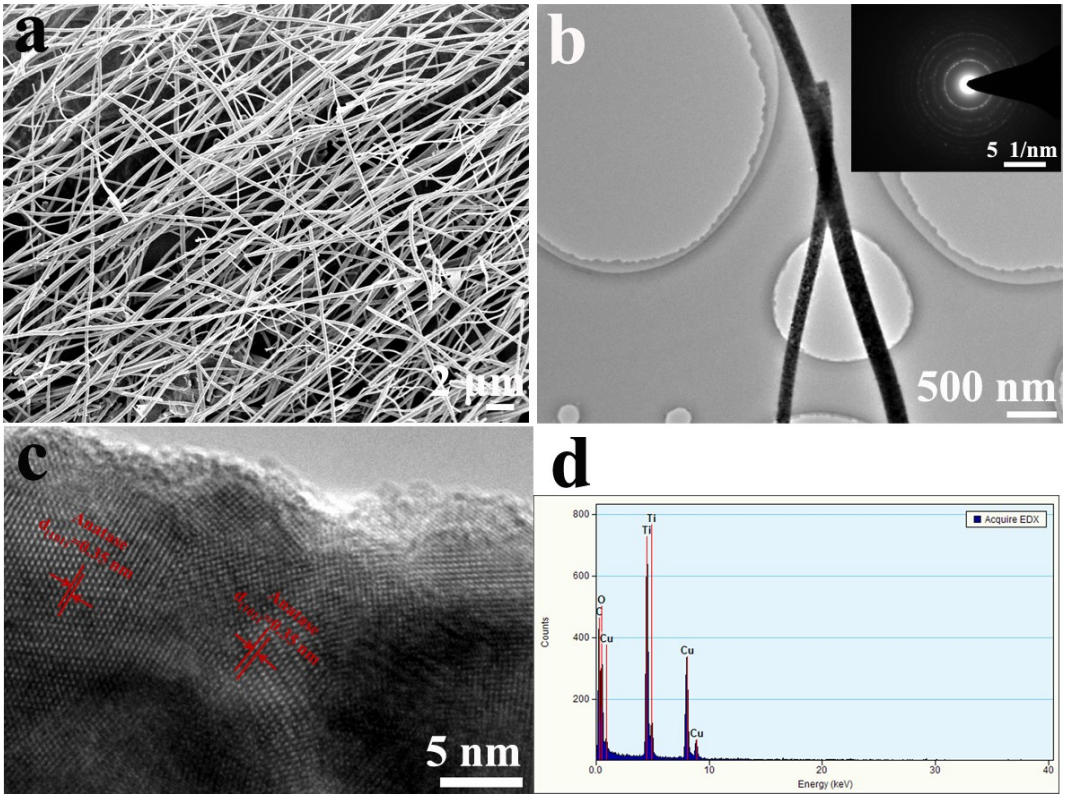

Figure S4. (a) SEM image of TiO_2 nanowires. (b) TEM image and corresponding SAED pattern (inset) of TiO_2 nanowires. (c) HRTEM image and (d) EDX spectrum of TiO_2 nanowires.

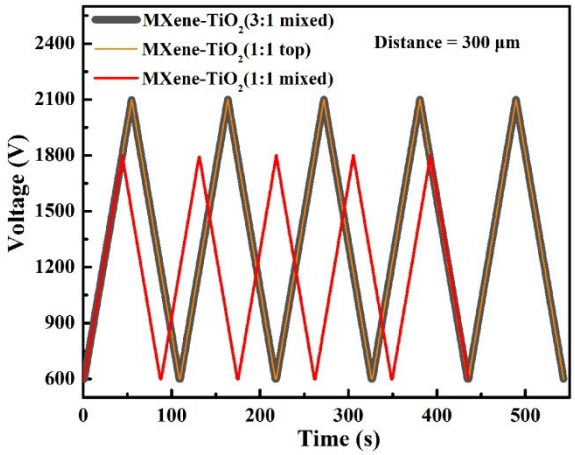

Figure S5. The curves of applied rised and falled voltages as the function of the time, the anode-cathode distance is 300 μm. The applied voltage across the MXene-TiO_2 (1:1 mixed) composite is lowest than the other two samples.

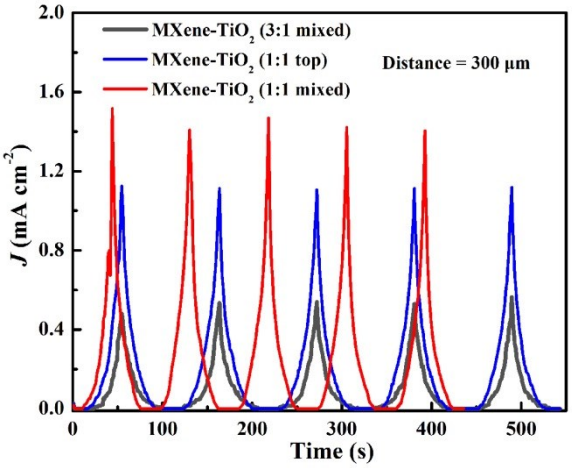

Figure S6. The curves of the current emission under the applied voltages showed in Figure S5, the anode-cathode distance is 300 μm. The MXene-TiO_2 (1:1 mixed) composite exhibits largest current emission density among the three samples.

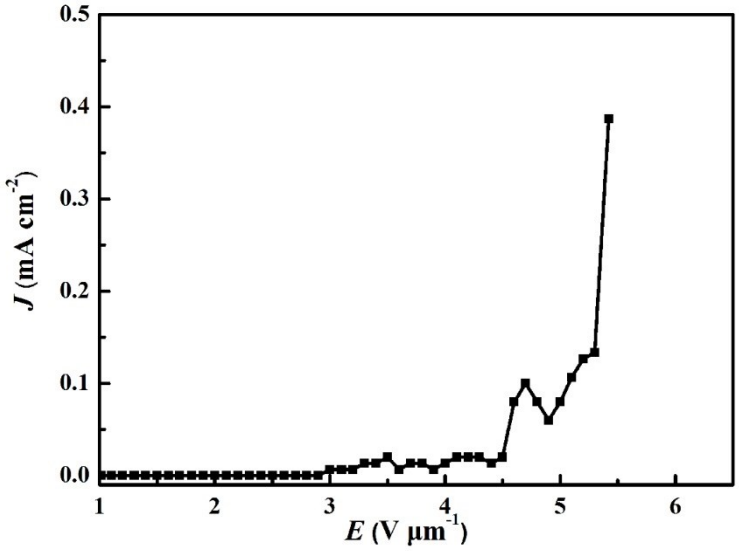

Figure S7. Field emission performance of the pure TiO_2 emitter.

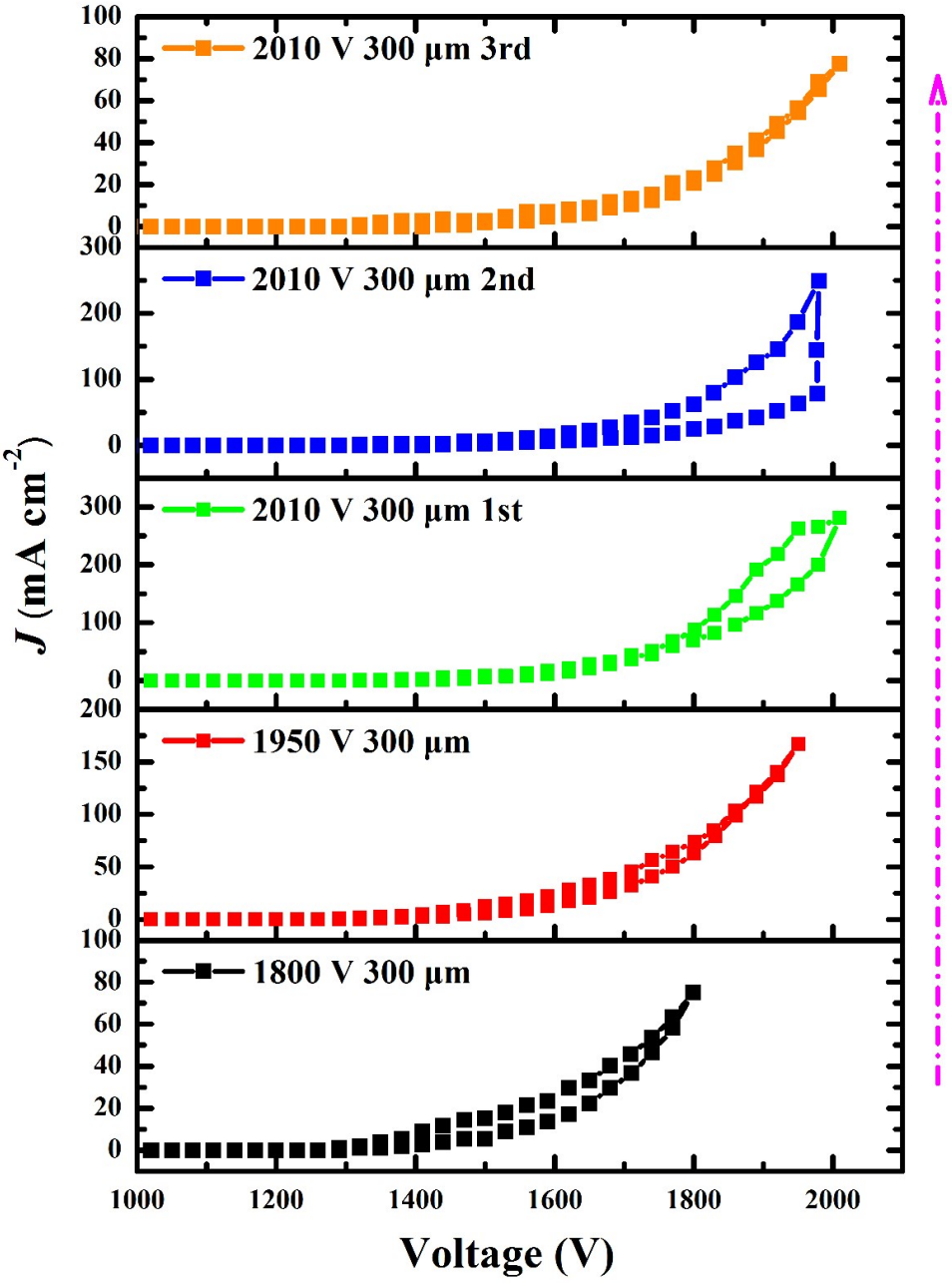

Figure S8. The curves of the current emission versus the applied voltages, the anode-cathode distance is 300 µm. It is trying to getting the highest current density from the cross-section of the MXene-TiO_2 (1:1 mixed) composite. During the testing, we have increased the voltages gradually in order to avoid the destroy of the emission sites.

Table S1. The comparation of the field emission performance reported previously for

MXene and TiO_2 cathodes.

Cathodes	**Turn-on fields**	**Maximum current density**	**Refs.**
Ti_3C_2 MXene	7.6 V μm^{-1} (0.1 mA cm^{-2}) (planar)	0.37 mA cm^{-2} (planar)	1
	/	59 mA cm^{-2} (cross-sectional)	
$Ti_3C_2T_x$ MXene	3.4 V μm^{-1} (0.1 mA cm^{-2})	0.20 mA cm^{-2}	2
Pristine TiO_2	12.49 V μm^{-1} (0.01 mA cm^{-2})	2 mA cm^{-2}	3
TiO_2 nanotubes	102.5 V μm^{-1} (0.1 mA cm^{-2})	0.30 mA cm^{-2}	4
TiO_2 nanotube	2.44 V μm^{-1} (0.01 mA cm^{-2})	3.3 mA cm^{-2}	5
MXene-TiO_2 composites	4.33 V μm^{-1} (0.1 mA cm^{-2})	1.52 mA cm^{-2} (planar)	**This work**
	/	289 mA cm^{-2} (cross-sectional)	

Notes and references

1 J. Chen, B. Yang, Y. D. Lim, W. Duan, Y. Zhao, B. K. Tay and X. Yan, *Nanotechnology*, 2020, **31**, 285701.

2 H. Wu, S. Shen, X. Xu, C. Qiao, X. Chen, J. Li, W. Li and W. Ou-Yang, *IEEE Trans Electron Devices*, 2020, **67**, 5138-5143.

3 W.-D. Zhu, C.-W. Wang, J.-B. Chen, Y. Li and J. Wang, *Appl. Surf. Sci.*, 2014, **301**, 525-529.

4 X. Xu, T. Zhai, M. Shao and J. Huang, *Phys. Chem. Chem. Phys.*, 2012, **14**, 16371-16376.

5 A.-Z. Liao, C.-W. Wang, J.-B. Chen, X.-Q. Zhang, Y. Li and J. Wang, *Mater. Res. Bull.*, 2015, **70**, 988-994.