Supporting Information

Unleashing 2D MXene's Plasmonic Effect for Advanced Photonic Device Applications

Moonjeong Jang[a+], *Seoung Hyun Kim*[a+], *Shinho Kim*[b+], *Kwanbyung Chae*[a], *Sodam Choi*[a], *Hwi Heon Ha*[a], *Jungchul Song*[a], *Min Jun Bak*[a], *Su-Ho Cho*[a], *Eunji Kim*[a], *Wooseok Song*[c,d], *Hee Han*[a], *Min Seok Jang*[*b], *Chi Won Ahn*[*a], *Yonghee Lee*[*a]

a National Nano Fab Center (NNFC), Daejeon 34141, Republic of Korea

b School of Electrical Engineering Korea Advanced Institute of Science and Technology (KAIST) 291 Daehak-ro, Yuseong-gu, Daejeon 34141, Republic of Korea

c Thin Film Materials Research Center Korea Research Institute of Chemical Technology Daejeon 34114, Republic of Korea

d School of Electronic and Electrical Engineering, Sungkyunkwan University, Suwon 16149, Republic of Korea

* Corresponding authors: Min Seok Jang (jang.minseok@kaist.ac.kr), Chi Won Ahn (cwahn@nnfc.re.kr), Yonghee Lee (yhlee@nnfc.re.kr)

[+] Equally contributed.

Keywords MXenes, Surface-enhanced Raman scattering, Photodetectors, Plasmonics, Edge plasmons

Table S1. Summarized performance metrics for MXene-based photodetectors.

532 nm	Photoresponsivity (A/W)	Detectivity (cm·Hz$^{1/2}$/W)	EQE (%)
Flat	0.007	3.7×10^{8}	1.81
Trench	0.2	2.5×10^{7}	47.32
1064 nm	**Photoresponsivity (A/W)**	**Detectivity (cm·Hz$^{1/2}$/W)**	**EQE (%)**
Flat	0.02	9.8×10^{8}	4.8
Trench	0.41	5.1×10^{7}	48.7

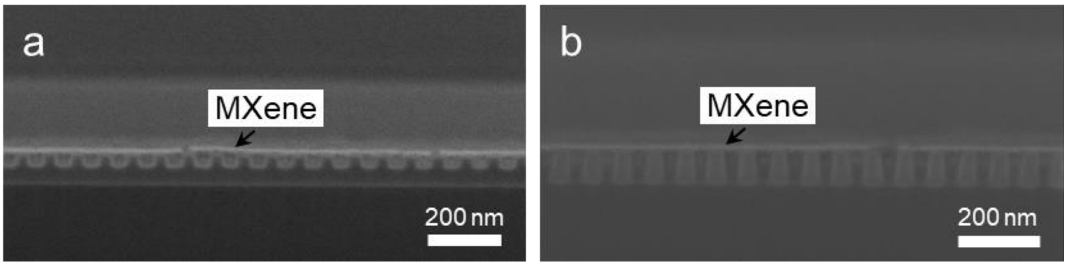

Figure S1. Cross-sectional SEM images of MXene-coated trench substrates with a line width of 40 nm and depths of (a) 50 nm and (b) 100 nm.

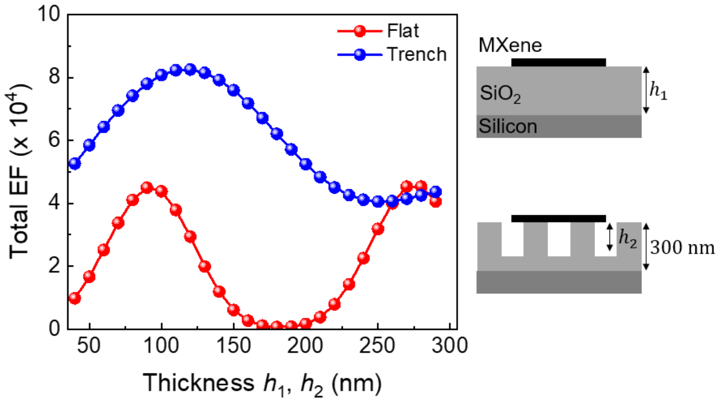

Figure S2. Enhancement factors in flat and trench structures for thicknesses h_1 and h_2.

To understand the underlying mechanism of the depth-dependent enhancement factor, we calculated the factor for both flat and trench structures at various thicknesses of h_1 and h_2. Figure S2 illustrates that the enhancement factor exhibits multiple resonance peaks at h_1 = 93 nm and 275 nm. The difference in thickness between adjacent peaks, 182 nm, corresponds to approximately half the wavelength in the SiO_x layer. This suggests that the variation in depth-dependent response arises from interference between the incident light from the front surface and the reflected light at the interface of SiO_x and Si. The difference in thickness between the maximum and minimum EF in the trench structure is slightly larger than that of the flat structure because the effective permittivity of the trench is lower than that of SiO_x.

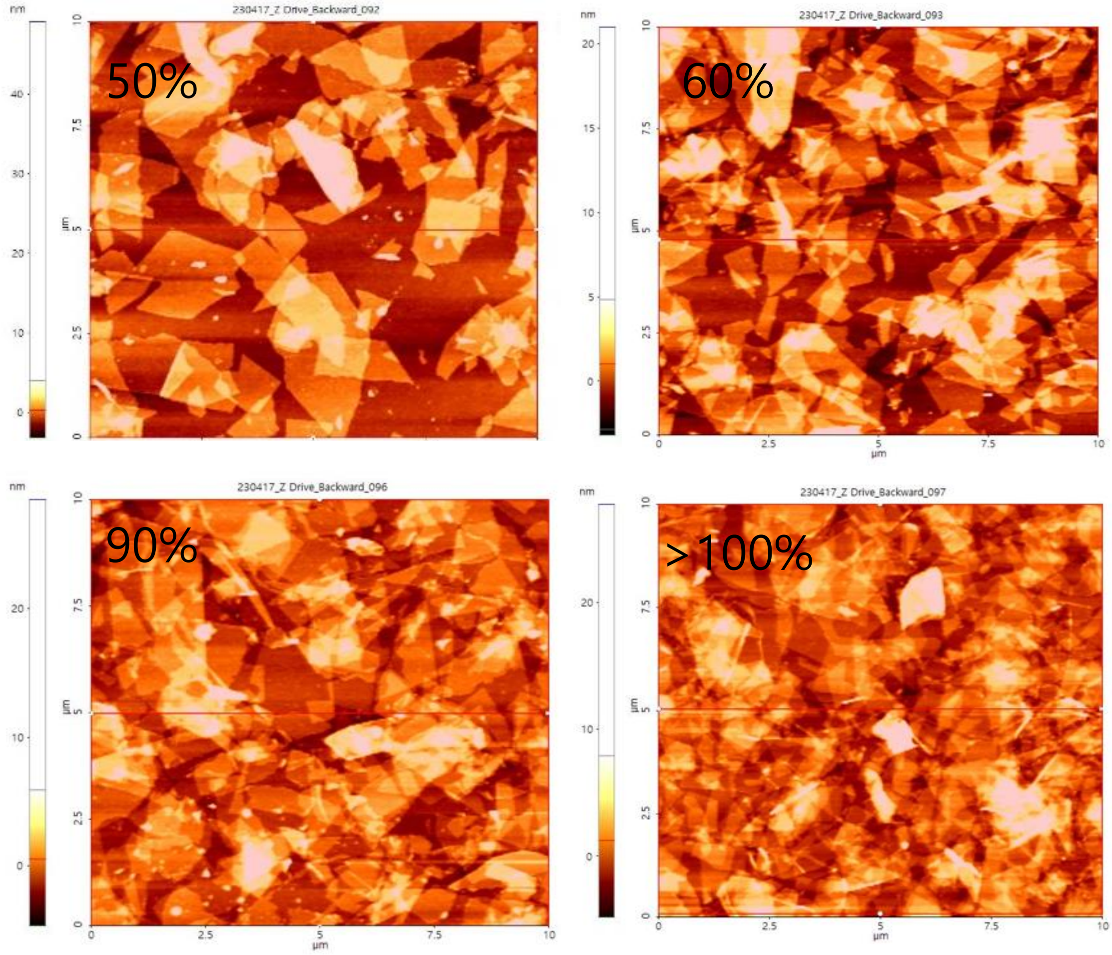

Figure S3. AFM images at MXene coverage of 50%, 60%, 90%, and >100%.

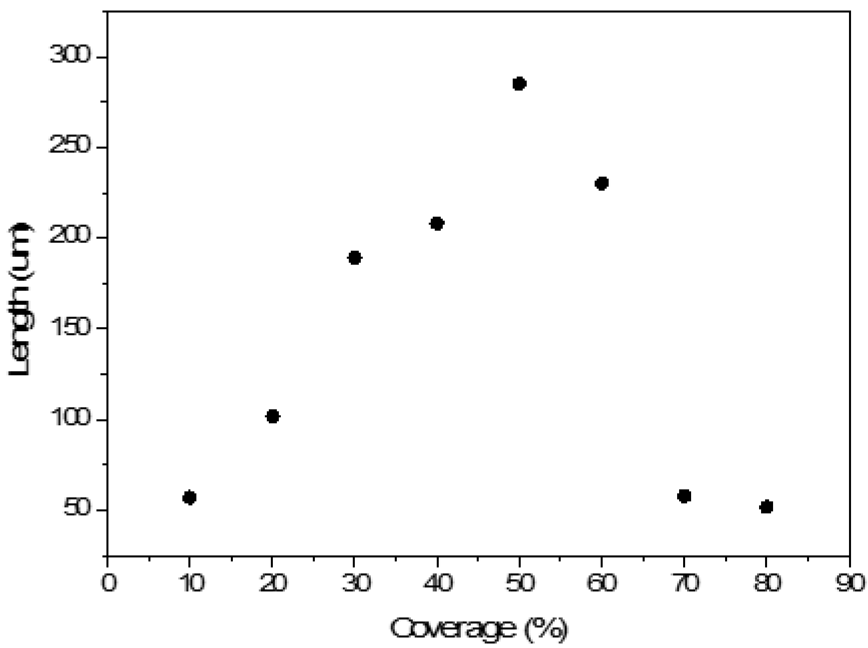

Figure S4. Edge length of MXene coverage ranging from 10% to 80%.

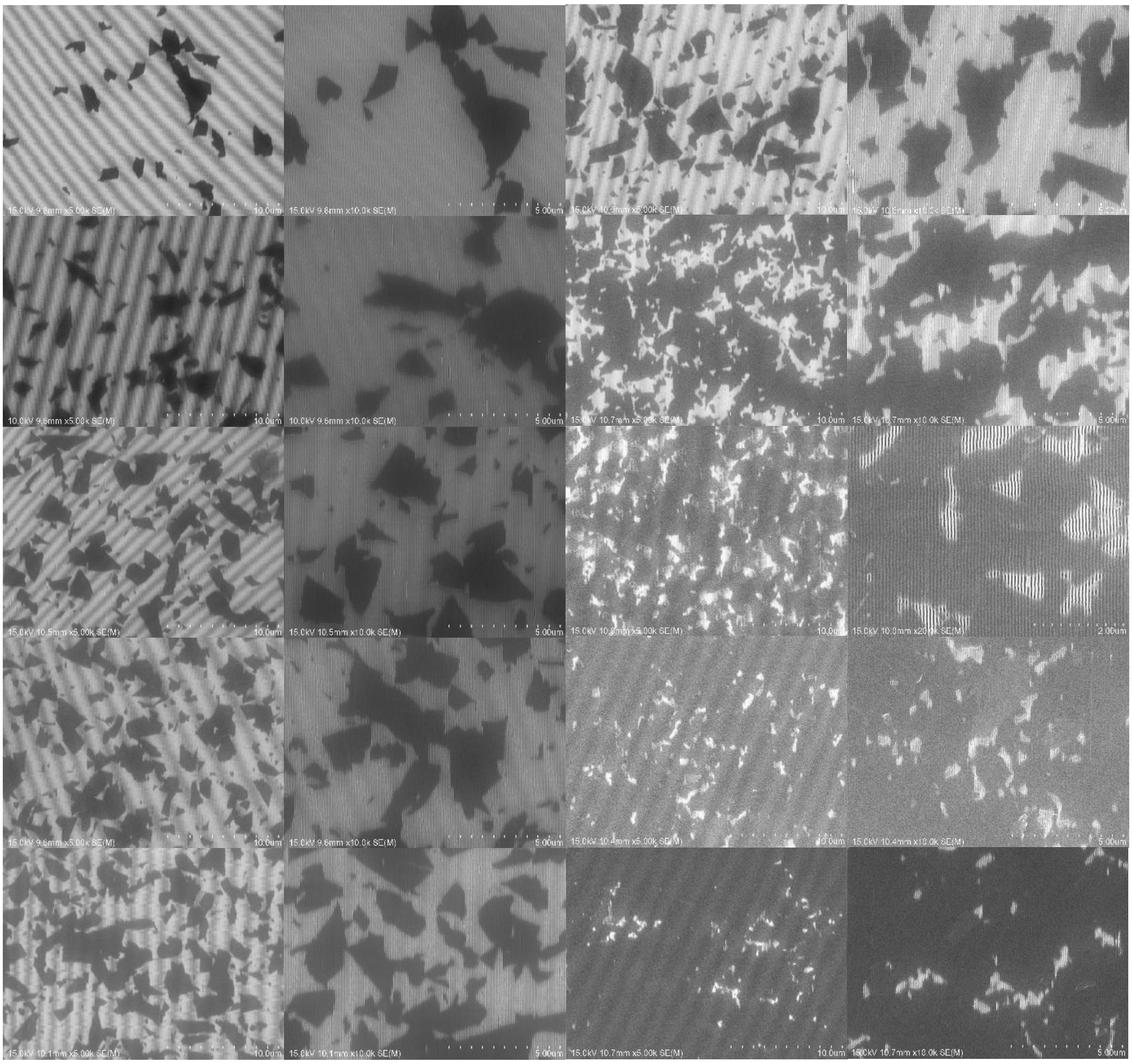

Figure S5. SEM images of trench substrate coated with MXene at various coverage levels.

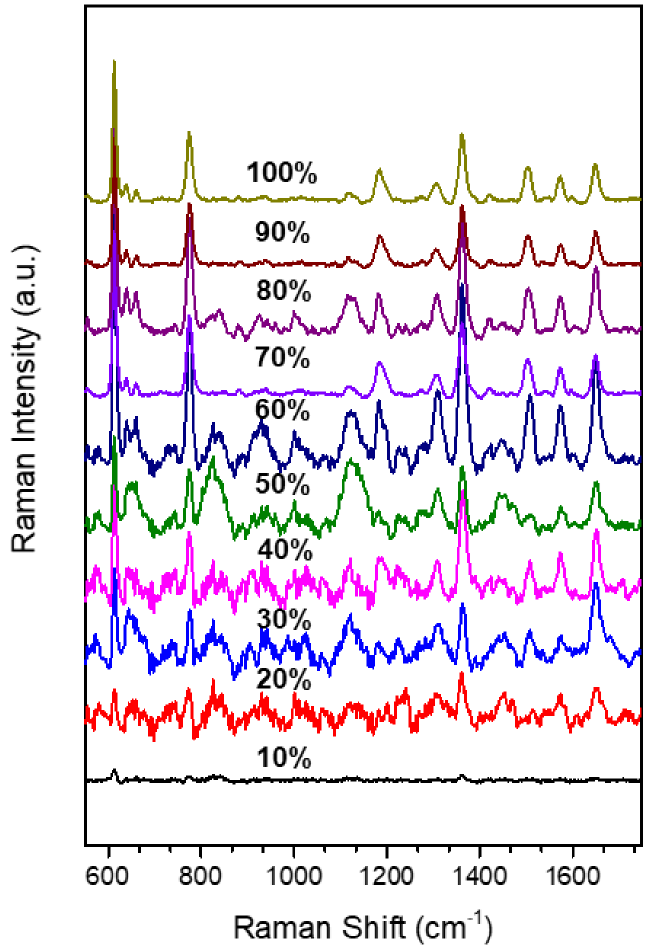

Figure S6. Raman shift resulting from coverage applied to trench mold.

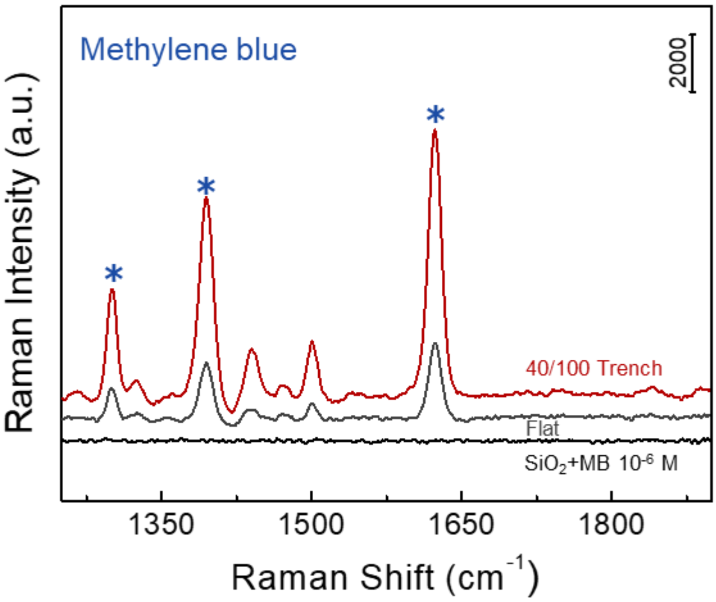

Figure S7. Comparative Raman spectra of 10^{-6} M MB adsorbed on Si/SiO_2 and MXene with flat Si/SiO_2 and Si/SiO_2 trench substrates.

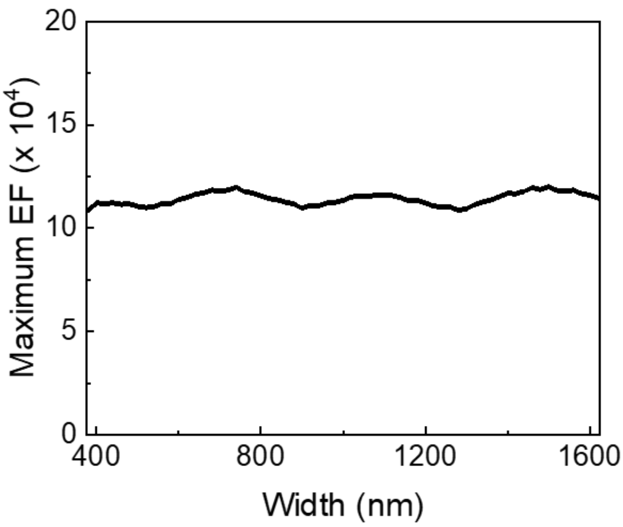

Figure S8. The maximum enhancement factor of MXene flake as a function of flake width. The thickness of the trench structure is assumed to be 100 nm.

Figure S9. EDS image after applying R6G on the coated MXene substrate.

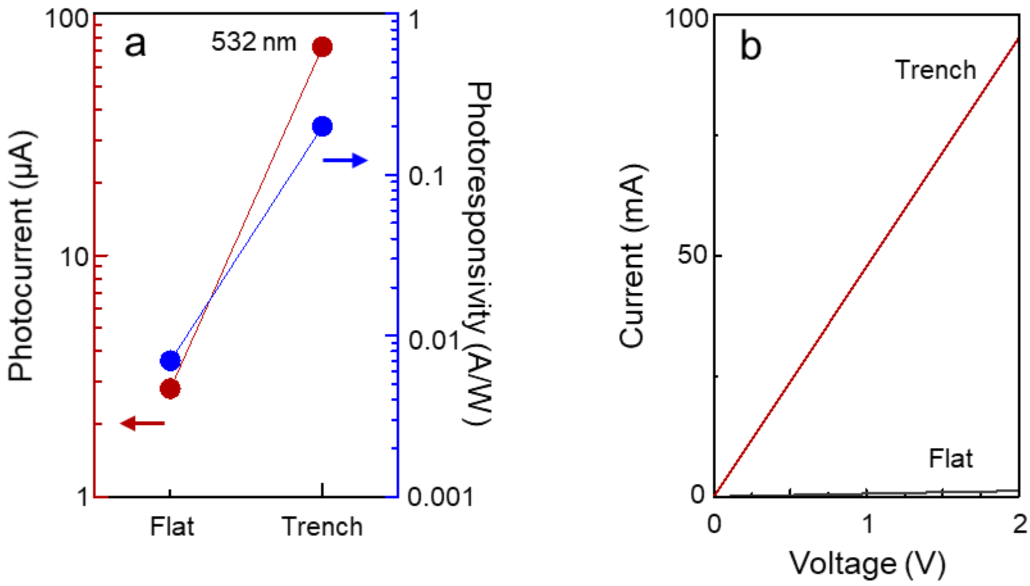

Figure S10. (a) Plots of photocurrents and photoresponsivities of the MXene photodetectors under laser irradiation (532 nm) with flat Si/SiO_2 and Si/SiO_2 trench substrates. (b) Current voltage characteristic curves of the MXene devices.

Table S2. Compared performance metrics for MXene-based photodetectors

Materials	Wavelength (nm)	Response time (s)	Photoresponsivity (A/W)	Detectivity (Jones)	Ref.
$Ti_3C_2T_X$	1064	0.000207	0.41	5.1×10^7	This work
$Ti_3C_2T_X$	Solar light	-	3×10^{-5}	-	[1]
Mo_2CT_X	660	-	9.0	5×10^{11}	[2]
Nb_2C	405	2.95	0.46	-	[3]

References

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