Opto-Electronic Advances

Supplementary information

September 2023, Vol. 6, No. 9

DOI: 10.29026/oea.2023.220201

Deep-ultraviolet photonics for the disinfection of SARS-CoV-2 and its variants (Delta and Omicron) in the cryogenic environment

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Supplementary information for this paper is available at https://doi.org/10.29026/oea.2023.220201

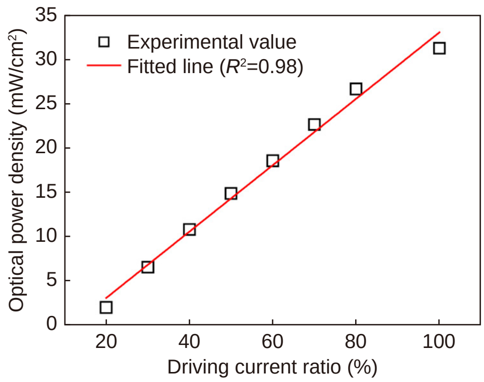

Fig. S1 | The current ratio (the total current value was 3 Amperes) dependent power density of the DUV light source, which was measured at the center of the irradiation area and 4.5 cm away from the DUV LED arrays.

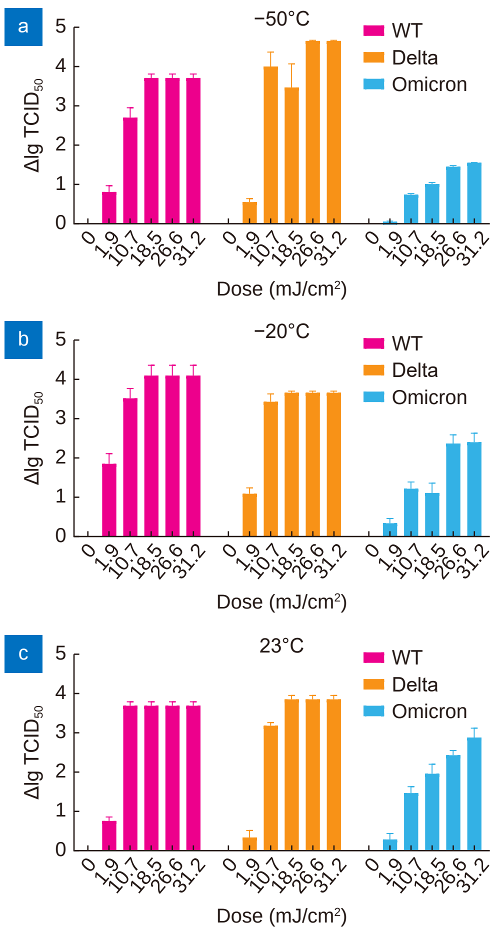

Fig. S2 | The reduction of $TCID_{50}$ (averaged values ± standard error) on SARS-CoV-2 and its variants at different temperatures. (**a**) −50 °C. (**b**) −20 °C. (**c**) 23 °C.

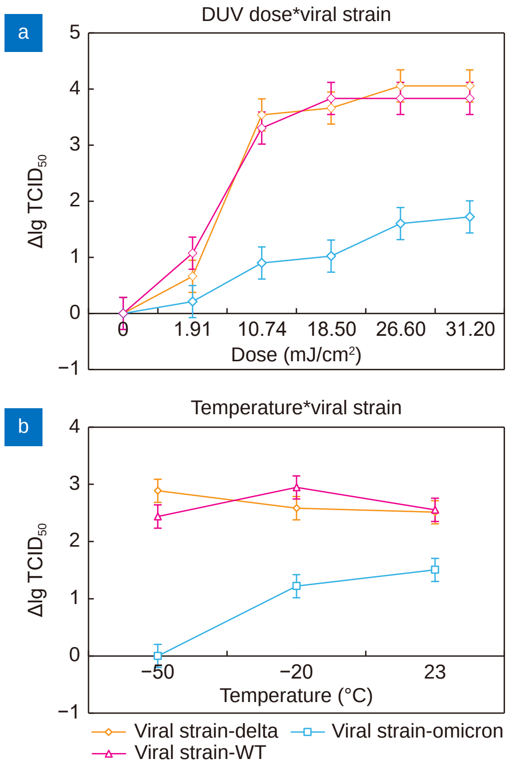

Fig. S3 | The reduction of TCID$_{50}$ (averaged values ± standard error) on SARS-CoV-2. (**a**) DUV dose*Viral strain, where data of different temperatures were averaged. (**b**) Temperature*Viral strain, where data of different DUV doses were averaged.

Table S1 | Physicochemical property of S protein of SARS-CoV-2 WT and Omicron[1].

Viral strain	Published by	State	RCSB PDB ID [2]	PDB DOI [2]	Number of amino acids	Isoelectric point	Extinction coefficient at 280 nm (1 mg/ml) [3]	Extinction coefficient at 280 nm (1 mg/ml) [4]
WT	Cell (2020) 181: 281	Open	6VYB	10.2210/pdb6VYB/pdb	1281	6.04	0.982	0.968
	DOI: 10.1016/j.cell.2020.02.058	Close	6VXX	10.2210/pdb6VXX/pdb	1281	6.09	0.982	0.968
Omicron	Nat Commun (2022) 13: 1214-1214	Open	7TGX	10.2210/pdb7TGX/pdb	1234	6.37	1.003	0.990
	DOI: 10.1038/s41467-022-28882-9	Close	7TGY	10.2210/pdb7TGY/pdb	1234	6.37	1.003	0.990

[1] Calculated by the ExPASy – ProtParam tool (https://web.expasy.org/protparam/).

[2] https://www.rcsb.org/.

[3] Assuming all pairs of cysteine residues form cystines.

[4] Assuming all cysteine residues are reduced.

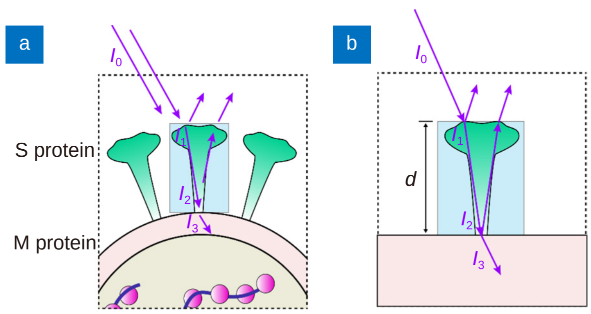

Fig. S4 | (**a**) Illustration of the light transport on the surface of SARS-CoV-2 virion and (**b**) The simplified light transport model for analysis.

Note: In view of the light absorption and scattering/reflecting effect of the S protein, the light transport model can be simplified as in Figure S4b. Assuming that the initial light intensity (irradiated on the surface of S protein) was I_0 and the extinction coefficient of S protein was k. For normal incidence from the air, the reflected light part (R) could be expressed as[5]:

$$R = \frac{(n-1)^2 + k^2}{(n+1)^2 + k^2} \,, \tag{S1}$$

where n is the real part of the complex refractive index. Thus, the transmitted part of the light (I_1) can be expressed as:

$$I_1 = I_0(1-R) = I_0\frac{(n+1)^2 - (n-1)^2}{(n+1)^2 + k^2} = I_0\frac{4n}{(n+1)^2 + k^2} \,, \tag{S2}$$

According to the thin-film optics theory, the light passes through the S protein to reach the M protein could be calculated by: $I_3 = I_0(1-R)^2\exp(-2\omega dk/c)$, where ω is the angular frequency of light, d is the equivalent thickness of S protein, and c is the speed of light in vacuum. Therefore, the k played an important modulation role in the incident of light getting into the virus, and a larger k would lead to a reduction in the actual received dose of viral RNA chains.

[5] Stenzel, O. Optical Coatings. (Springer Berlin, Heidelberg, 2014).