Supporting Information

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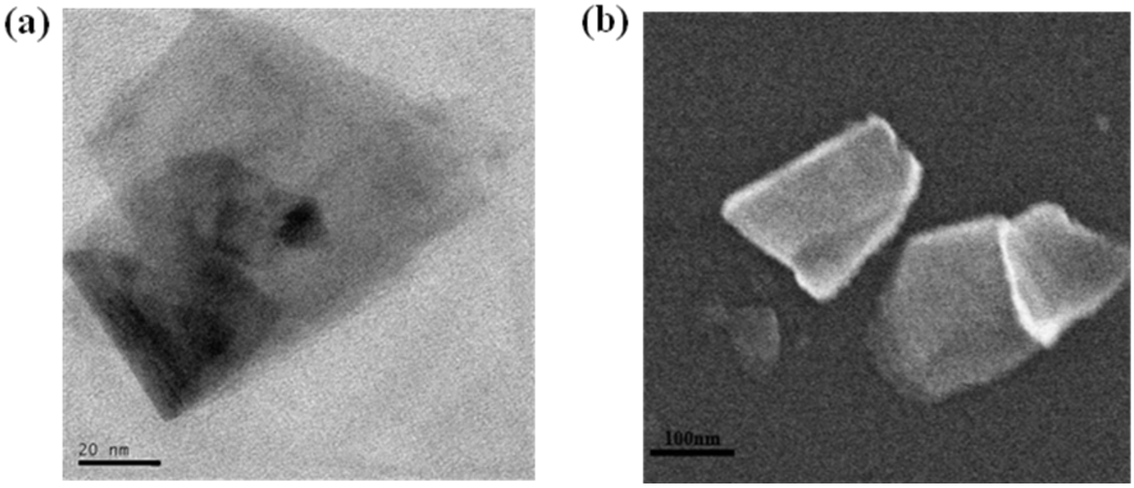

Figure S1. (a) TEM and (b) SEM images of the as-prepared mono/few layer WS_2 nanosheets with different magnification.

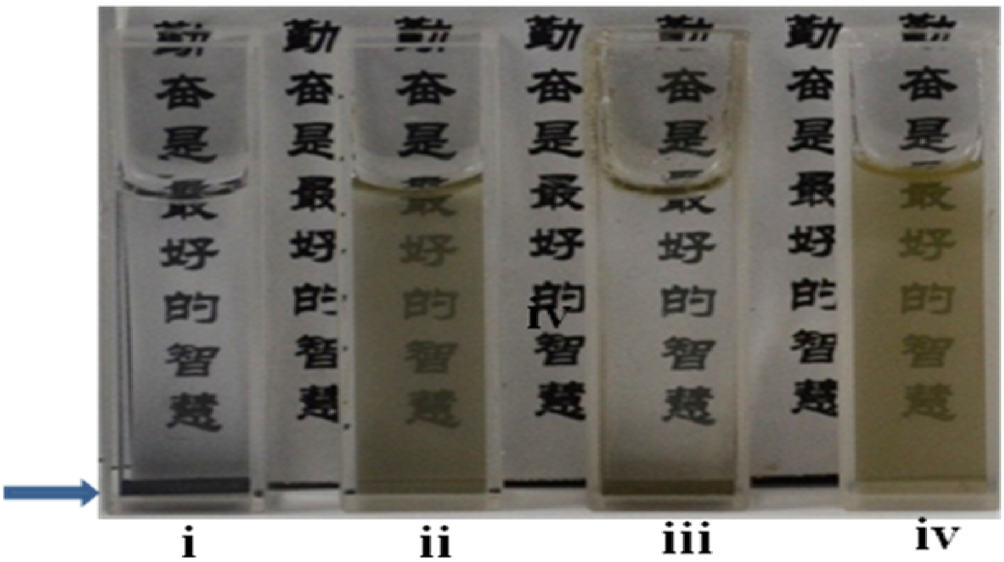

Figure S2. Photographs of WS_2 bulk dispersed in DI water (**i**), WS_2 nanosheets dispersed in DI water (**ii**), WS_2 nanosheets dispersed in PBS solution (**iii**) and BSA-WS_2 dispersed in PBS solution (**iv**).

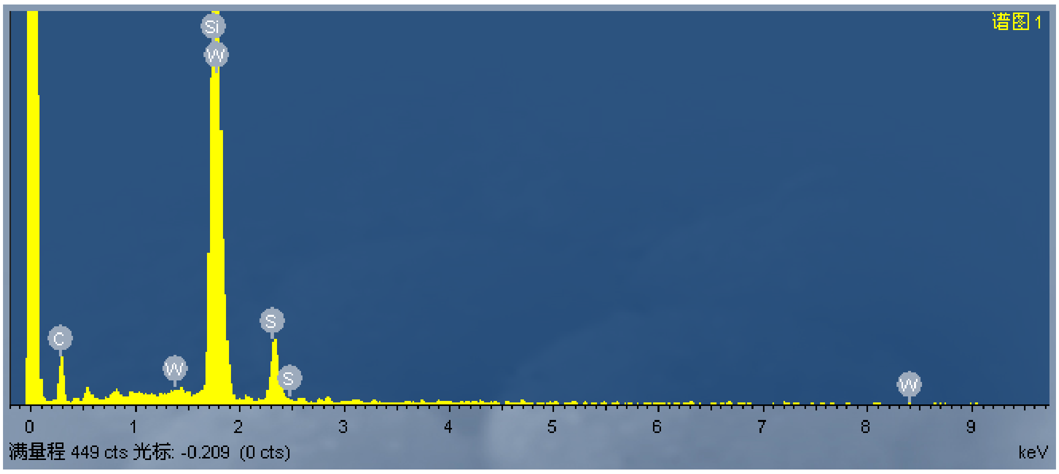

Figure S3. The energy-dispersive X-ray (EDS) spectra of the mono and few layer WS_2 nanosheets..

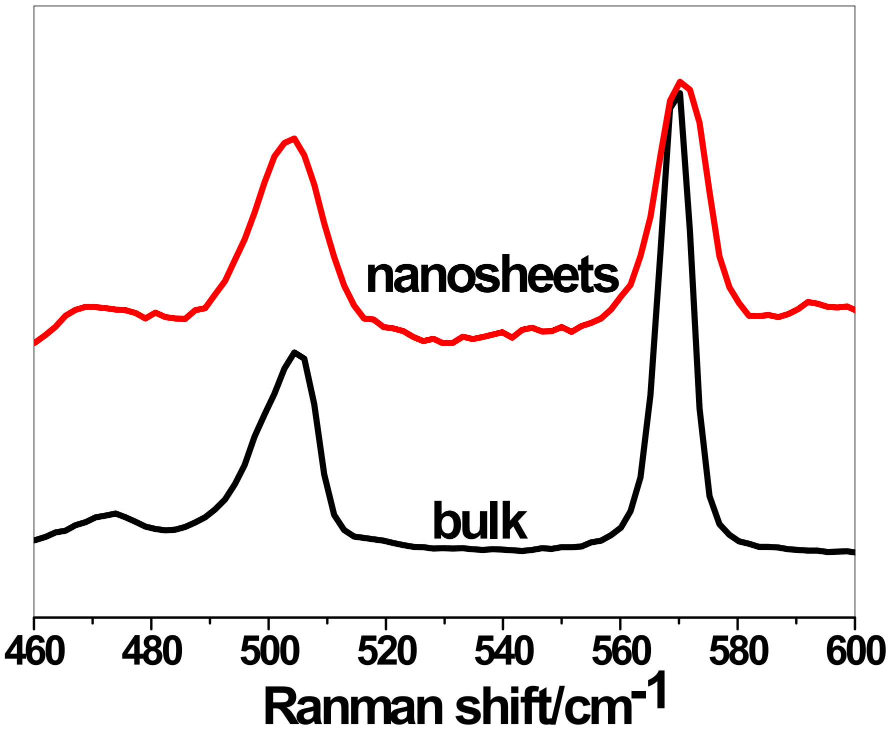

Figure S4. Raman spectra of the commercial WS_2 and obtained WS_2 nanosheets.

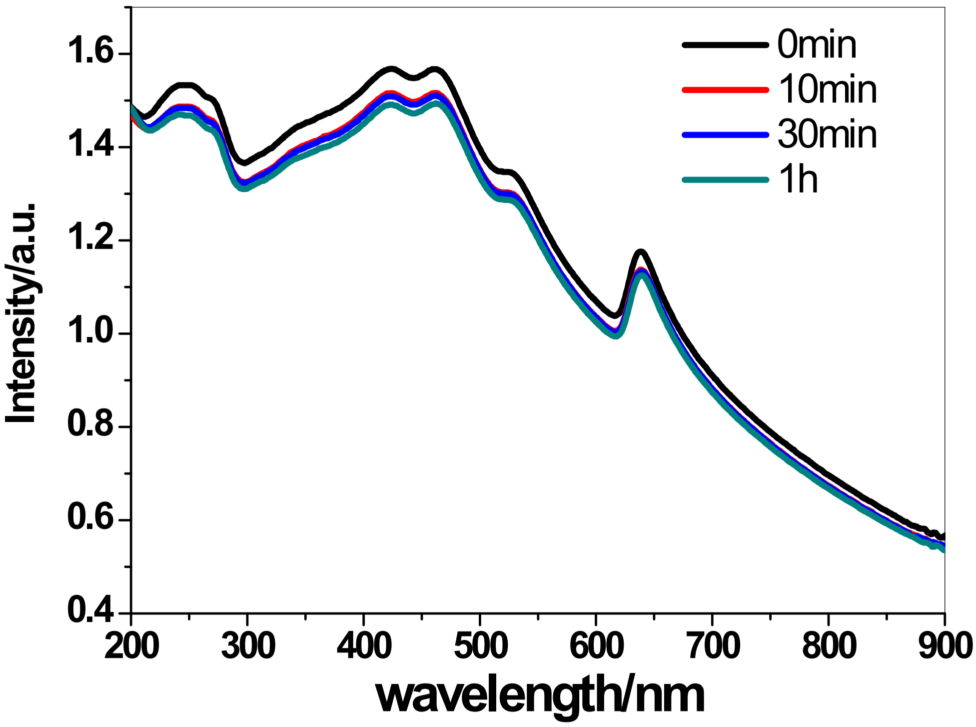

Figure S5. Photothermal stability test of the mono and few layer WS_2 nanosheets under 808-nm laser ($1W/cm^2$) irradiation for different times, which show evidently photothermal stability when exposed to the 808-nm laser even for 1 h.

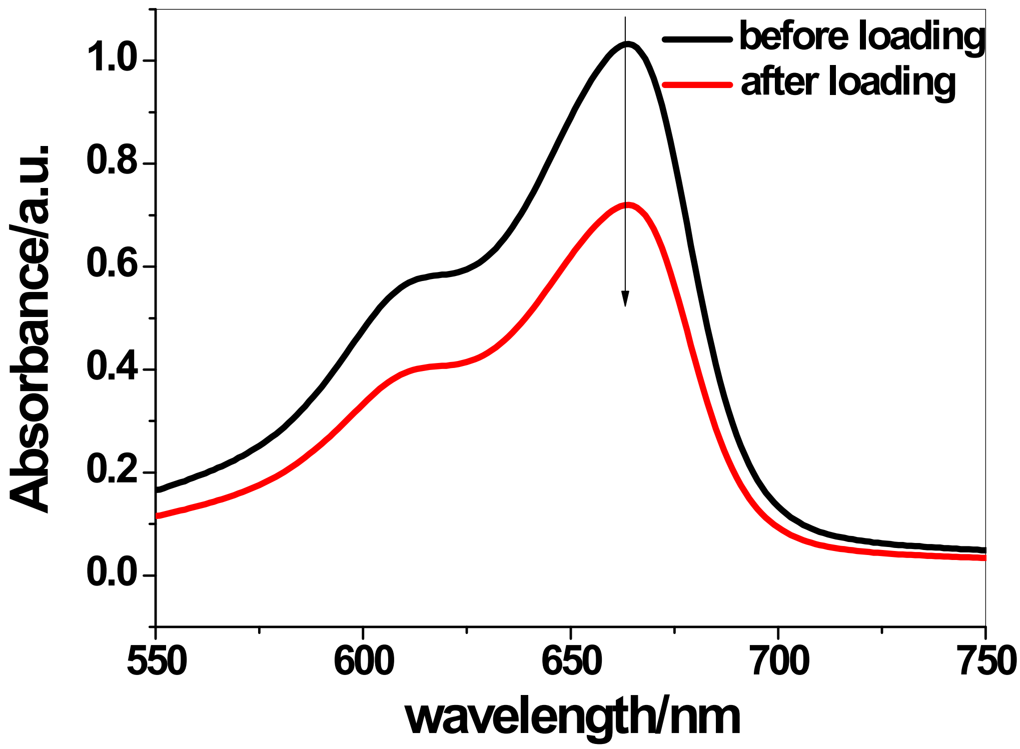

Figure S6. UV-Vis absorption spectra of MB before and after loaded on the mono and few layer WS_2 nanosheets.

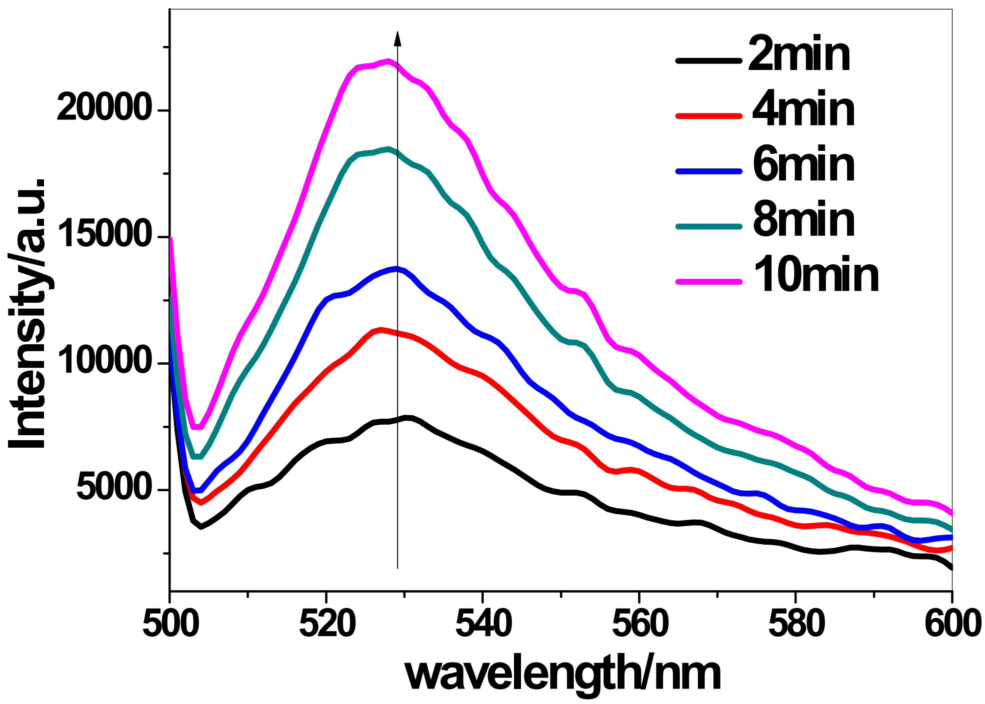

Figure S7. Fluorescence emission spectra of BSA-WS_2@MB in SOSG solution with the increase of the laser irradiation time.

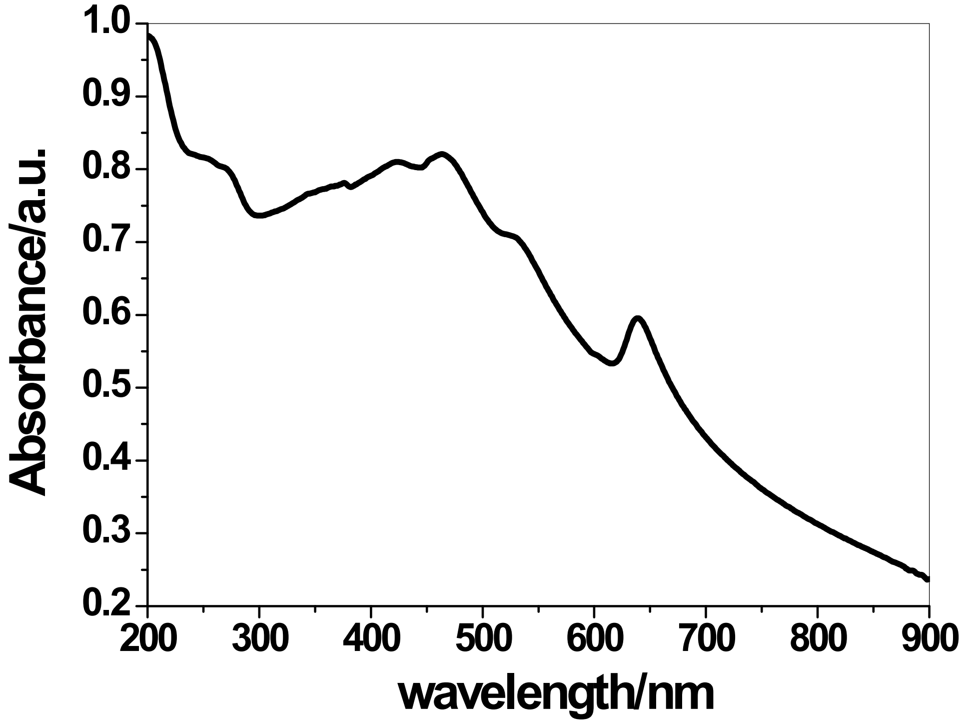

Figure S8. UV-Vis absorption spectra of WS_2 at the concentration of 50 μg/ mL.

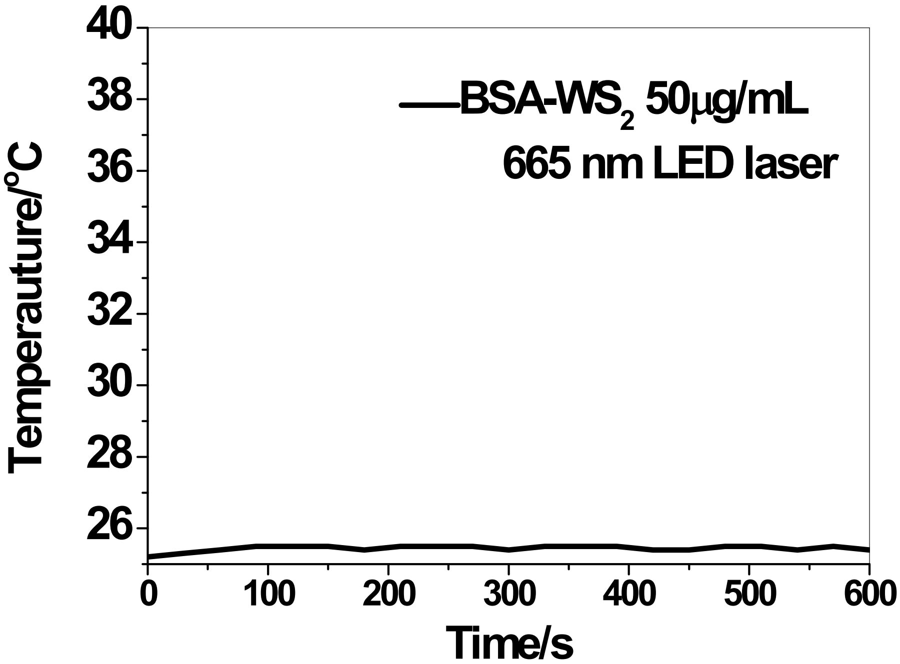

Figure S9. The temperature evaluation of WS_2 nanosheets solution (50ug/mL) as a functional of irradiation time (0-10 min) of 665nm LED (50mW/cm^2).

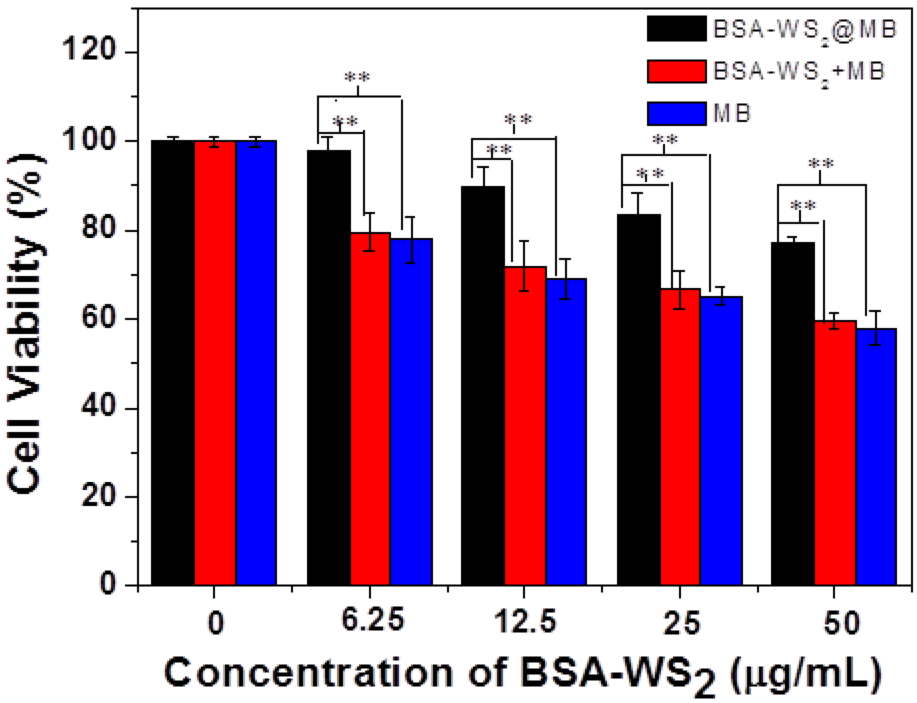

Figure S10. Cell viability of HeLa cells incubated with BSA-WS_2@MB, BSA-WS_2+MB and free MB irradiated by the 665 nm LED (0.05W/cm^2, 5 min).

Figure S11. Calculation of photothermal conversion efficiency.

Based on Roper's report, the total energy balance for the system can be expressed by Eq.1:

$$\frac{\sum_{i} m_i C_{p,i} dT}{dt} = Q_{NC} + Q_{Dis} - Q_{Surr} \quad (1)$$

Where C_p and m are heat capacity and the mass of water, respectively, T is the solution of temperature, Q_{NC} is the energy inputted by the mono and few layer WS_2 nanosheet, Q_{Dis} is the baseline energy inputted by the sample cell, and the Q_{Surr} is the heat conduction away from the system surface by air.

The laser-induced source term of Q_{NC} represents heat dissipated by electron-phonon relaxation of the plasmons on the WS2 nanosheet surface under the irradiation of 808 nm laser:

$$Q_{NC}=I\,(1-10^{-A808})\,\eta \quad (2)$$

Where I is incident laser power, η is the conversion efficiency, and A_{808} is the absorbance of the mono and few layer WS_2 nanosheets at wavelength of 808 nm. In addition, the term of Q_{Dis} presents heat dissipated from light absorbed by the sample cell itself , and it was measured using adquartz cuvette cell containing pure water without the mono and few layer WS_2 nanosheets. Furthermore, Q_{Surr} is linear with temperature for the outgoing thermal energy, as given by Eq 3:

$$Q_{Surr} = hs\,(T - T_{surr}) \quad (3)$$

Where h is heat transfer coefficient, S is the surface area of the container, and T_{Surr} is the ambient temperature of the surroundings.

Once the laser power is defined, the heat input (Q_{NC}+Q_{Dis}) will be finite. Since the Q_{Surr} is increased with the increase of the temperature according to the Eq3, the system temperature will rise to a maximum when the heat input is equal to heat output:

$$Q_{NC}+Q_{Dis}= Q_{Surr\text{-}Max}= hs\ (T_{Max}- T_{surr}) \quad (4)$$

As the sample cell reaches the equilibrium temperature, the $Q_{Surr\text{-}Max}$ is heat conduction away from the system surface by air, and T_{Max} is the equilibrium temperature. The 808 nm laser heat conversion efficiency (η) can be determined by substituting Eq 2 for Q_{NC} into Eq 4 and rearranging to get

$$\eta = \frac{\mathrm{hs(T-Tsurr)-Q_{Dis}}}{I\left(1-10^{-A808}\right)} \quad (5)$$

Where Q_{Dis} was measured to be 55.6 mW, the (T_{Max}- T_{surr}) was 18.435 ^{O}C according to figure 2c, I is 2 mW/cm^2, A_{808} is the absorbance (0.306) of the mono and few layer WS_2 nanosheets at 808 nm (Figure S7). Thus, In order to calculate η, the hS is needed to be known.

In order to calculate the hS, dimensionless driving force temperature, θ is introduced serving the maximum system temperature, T_{Max}

$$\theta = \frac{T - T_{surr}}{T_{Max} - T_{surr}} \quad (6)$$

And the τ_s

$$\tau_s = \frac{\sum_i m_i C_{p,i}}{hs} \quad (7)$$

Which is substituted into Eq1 and obtained the Eq8

$$\frac{d\theta}{dt} = \frac{1}{\tau_s}\left[\frac{Q_{NC} + Q_{Dis}}{hs\ (T_{Max} - T_{surr})} - \theta\right] \quad (8)$$

At the cooling stage of the aqueous dispersion of the mono and few layer WS_2 nanosheets, the light source was shut off, the $Q_{NC}+Q_{Dis}=0$, yielding the Eq. 9

$$d_t = -\tau_s \frac{d\theta}{\theta}$$

(9)

And then rearranging, giving the Eq. 10

$$t = -\tau_s \ln \theta$$

(10)

Therefore, time constant for heat transfer from the system is calculated to be 199.7891 s by applying the linear time data from the cooling period (after 780 s) *vs* negative natural logarithm of driving force temperature (figured 2d). In addition, the m is 1.0 g and the C is 4.2 J/g. Thus, according to Eq.7 the hs is deduced to be 18.435 mW/^{o}C, substituting 18.435 mW/^{o}C to Eq. 5, the 808 nm laser heat Conversion efficiency (η) of the mono and few layer WS_2 nanosheets can be calculated to be 32.83%.