Fig. S1 shows the evolution of friction coefficient as a function of sliding time for MoS$_2$/DLC multilayer coatings against steel ball without SLD condition. As shown in Fig. S1, the friction coefficients decreased first and increased afterward with bilayer period. And the MoS$_2$/DLC-4L coating with the lowest value of 0.02 can be selected as the optimum coating.

**Fig. S1** Variation in friction coefficients of MoS$_2$/DLC multilayer coatings sliding against steel ball as a function of the sliding time under the applied load of 7 N in high vacuum without SLD.

Fig. S2 shows the wear rates of MoS$_2$/DLC-4L coating under different applied loads without SLD. As shown in Fig. S2, the wear rates increased gradually with the increasing of applied load.

**Fig. S2** Wear rates of MoS$_2$/DLC-4L coating sliding against steel ball without SLD under different applied load in high vacuum.