Laser-Induced Graphene/*h*-BN Laminated Structure to Enhance the Self-Lubricating Property of Si_3N_4 Composite Ceramic

Wei Li [1], Jinzhi Dong [1], Dalong Xu [1], Yifan Dong [1], Sikandar Iqbal [2], Jingwei Li [3], Ting Luo [1,*] and Bingqiang Cao [4,*]

[1] School of Mechanical and Automotive Engineering, Qilu University of Technology (Shandong Academy of Sciences), Jinan 250353, China.

[2] School of Materials Science and Engineering, Zhejiang University, Hangzhou 310027, China

[3] Analysis and Testing Center, University of Electronic Science and Technology of China, Chengdu 611731, China.

[4] School of Material Science and Engineering, University of Jinan, Jinan 250022, China

* Correspondence: tingluo_mae@qlu.edu.cn (T.L.); mse_caobq@ujn.edu.cn (B.C.)

Table S1 The main raw materials and main parameters of Si_3N_4/L-rGO/*h*-BN ceramic composite

Materials	grain size	purity %	Density g/cm3
α-Si_3N_4	500 nm	99.9	3.18
L-rGO/*h*-BN	～100 nm	99.9	/
Al_2O_3	400 nm	99.9	3.5
Y_2O_3	50 nm	99.9	5

Table S2 List of heating rate and holding time in sintering process

Number	Initial temperature （℃）	End temperature （℃）	Heating rate （℃·min^{-1}）	Heating time/holding time （min）
1	570	600	30	1
2	600	1300	100	7
3	1300	1450	50	3
4	1450	1600	30	5
5	1600	1600	0	5
6	1600	1650	25	2
7	1650	1650	0	10

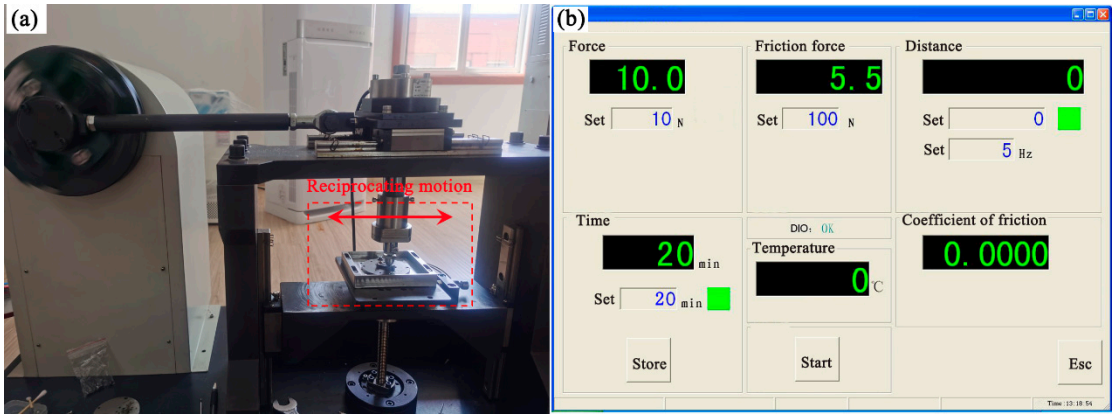

Figure S1 Experimental equipment and parameters of ball-on-disc reciprocating friction: (a) experimental equipment and (b) Experimental parameters

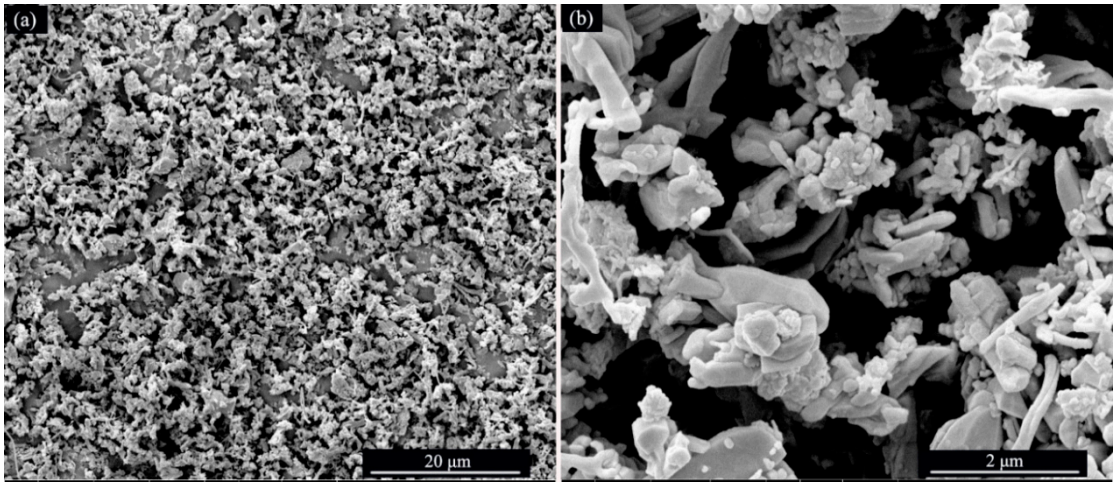

Figure S2 SEM image of α-Si_3N_4 raw material: (a) low power and (b) High magnification

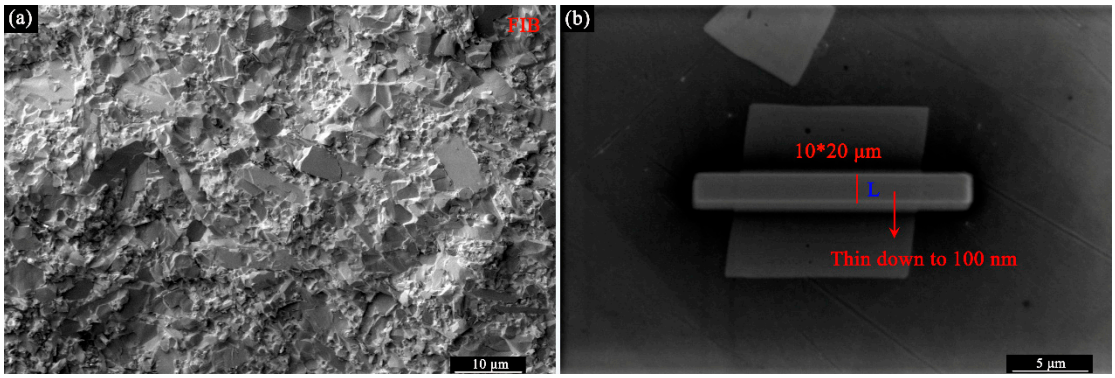

Figure S3 FIB thinning process of Si_3N_4/L-rGO/*h*-BN ceramic composite at 0.75wt % added concentration: (a) Si_3N_4/L-rGO/*h*-BN cross-section STEM images and (b) flaky sample after FIB thinning

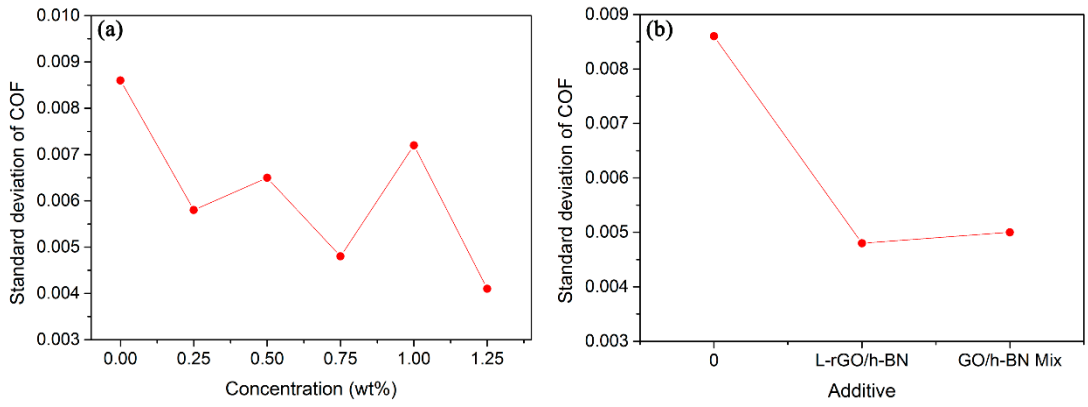

Figure S4 Standard deviation of COF: (a) Different addition concentrations and (b) Different additives at 0.75 wt%

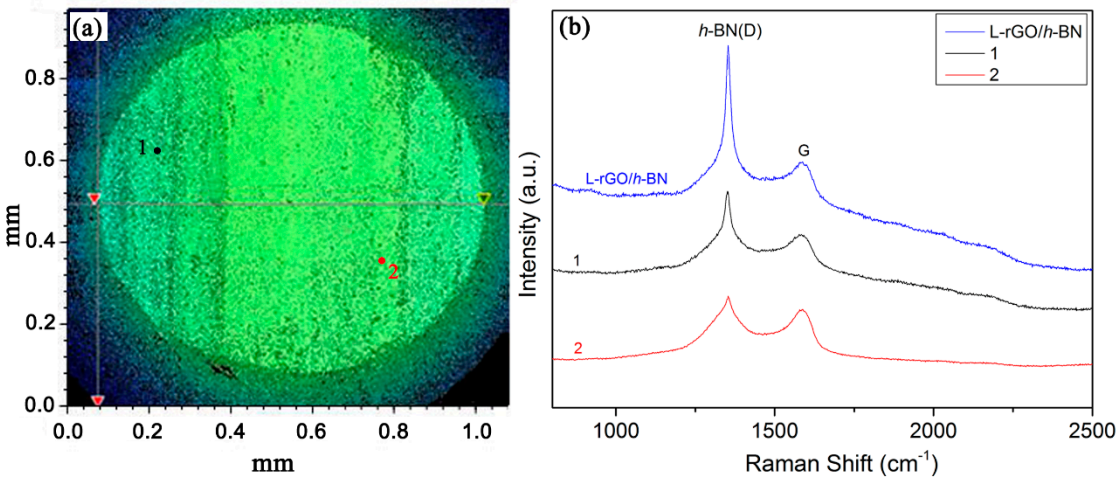

Figure S5 Raman spectra of wear surface on Si_3N_4 ball: (a) Wear morphology of Si_3N_4 ball after friction experiment with 0.75 wt% L-rGO/*h*-BN and (b) Raman spectra of Points 1, 2 in Figure S5 (a) and L-rGO/*h*-BN.