

## Description of Additional Supplementary Files

File Name: Supplementary Movie 1

Description: An in situ TEM movie showing the reaction of the MgO nanocrystals with excited CO<sub>2</sub> under electron beam. The movie was recorded at 5 frames/second and played at 50× speed. Snapshots of this movie are shown in Figure 2.

File Name: Supplementary Movie 2

Description: Real-time record of heating and e-beam irradiation effects on the reaction of  $\text{MgO} + \text{CO}_2 \rightarrow \text{MgCO}_3$ . This movie unambiguously illustrates that it is the e-beam ionization rather than its heating effect that activates this reaction. The movie was recorded at 5 frames/second and played at 50× speed. Snapshots of this movie are shown in Figure S2.

File Name: Supplementary Movie 3

Description: In situ TEM movie shows the reaction process of the brushy corrosion products (pre-existing on surface) with excited CO<sub>2</sub>. The movie was recorded at 5 frames/second, and played at 50× speed. Snapshots of this movie are shown in Figure 4 a,b,c.