Supporting Information

Integration of the 3DOM Al/Co_3O_4 nanothermites film with a semiconductor bridge to realize a high-output micro-energetic igniter

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1. Morphology images

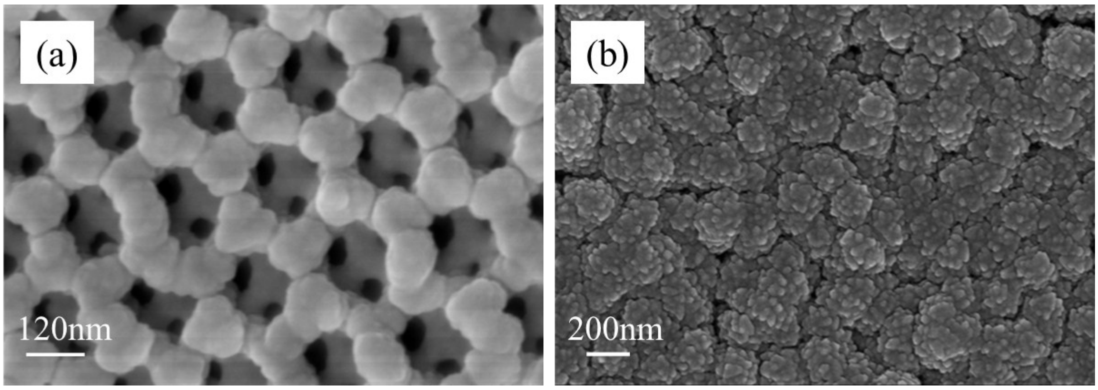

Fig. S1. The FE-SEM images of the Al/Co_3O_4 nanothermitesc film after (a) 10 min and (b) 30 min aluminization.

2. Comparisons for the sparks of the micro-energetic igniter at different voltages

The spark duration increases from 133.33 μs to 266.67 μs as the voltage increases in Fig. 9e-h. The spark height also increases with increasing voltage. It is only 3 mm in 30 V. However, the maximum spark goes out of the image frame in 50 V to be estimated about 8 mm in height. These phenomena are caused by two factors. First, the polysilicon ionization produces more plasma in a relatively high voltage (Fig. 9a-d). Second, more plasma should ignite more Al/Co_3O_4 nanothermites film to emit more energy.

3. Analyses for the voltage-current curves

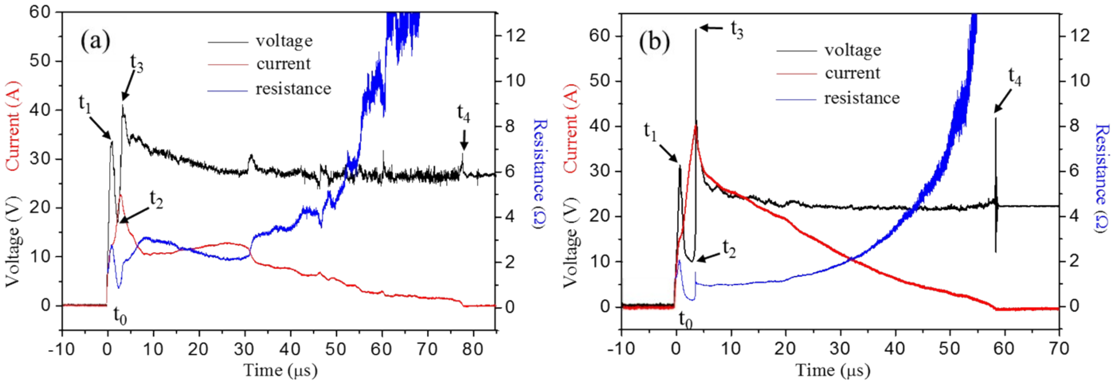

Fig. S2. The voltage-current curves of the (a) micro-energetic iginter and (b) SCB igniter stimulated in 47 μF/40 V.

The polysilicon bridge area begins to melt at first peak (t_1) of the voltage curve, so the resistance decreases rapidly. But then, the resistance immediately increases from t_2 to t_3 because the bridge area vaporizes to turn into a nonconductive polysilicon gas. The second peak is called ignition time (t_3) where the bridge area begins to generate the plasma. From t_3 to t_4, it is seen that the SCB igniter resistance increases exponentially to be defined as the late time discharge. The current, voltage and resistance of the micro-energetic igniter are of similar trends to these of the SCB igniter before t_3. They fluctuate to some extent after t_3, but the tendency for both igniters is quite similar. The unreacted Al and product Co from the thermite reaction are conductors, which irregularly splash in the process of the late time discharge, leading to the fluctuation of current, voltage and resistance. The splashing process also makes the fuel Al and Co_3O_4 particles react thoroughly. The oxidation of Al and Co in air would promote a spark intensity. According to the aforementioned discussion, it can be judged that the nanothermites film has no distinct effect on the change of the bridge area in the firing process. On the contrary, it can promote the spark intensity of the micro-energetic igniter.

4. Analyses of input energy curves

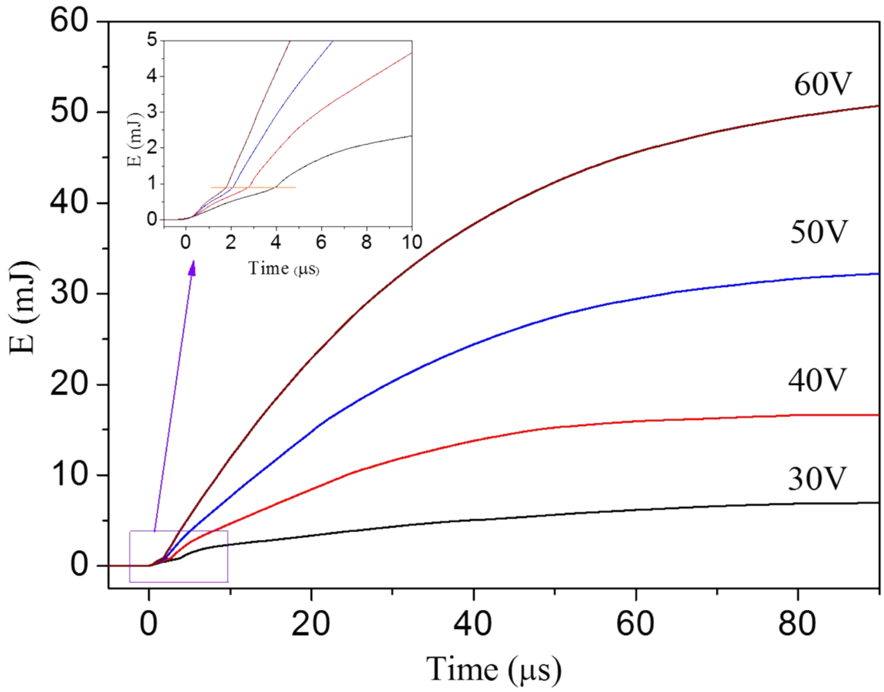

Fig. S3. The input energy curves along with the time at different voltages. The insert map is a magnified view at 0-10 μs.

The input energy curves along with the time at different voltages are obtained by the formula of $E = \int_0^t UIdt$. The capacitor discharge ends after 85 μs. According to the formula $Q = \frac{1}{2}CU^2$ (here Q is the storage energy of capacitor, C is a constant capacitance, U is a charging voltage), the capacitor stores more energy at a high charging voltage with more released energy per unit time. The resistance of the igniter has a mutation at the time of initiation, leading to a fluctuation of an input energy velocity. The ignition energy is fixed at different charging voltages which are judged by the fluctuations of curves (see the orange line). The ignition time decreases as the charging voltage increases.

5. DSC data

Table S1. The heat releases of the Al/Co_3O_4 nanothermites film at different aluminizing times.

	Aluminizing time (min)		
	10	20	30
Heat release before Al melts ($J\cdot g^{-1}$)	782.4	1325.9	337.6
Heat release after Al melts ($J\cdot g^{-1}$)	-	498.0	1056.2
Total heat release ($J\cdot g^{-1}$)	782.4	1740.4	1281.5
[a]Actual theoretical heat release ($J\cdot g^{-1}$)	3772.9	3548.9	1698.3
Energy release efficiency	20.7%	49.0%	75.5%

[a]Actual theoretical heat release is calculated based on the measured molar ratios of Al to Co_3O_4 in the EDS data.

6. Data of the ignition time and ignition energy

Table S2. The detailed information of the SCB igniter collected by a high-speed dignital storage oscilloscope in the capacitor discharge test.

Voltage (V)	ignition time t_3 (μs)	average ignition time (μs)	ignition energy E_3 (mJ)	average ignition energy (mJ)
30	4.88	4.47	0.87	0.91
	4.12		0.82	
	4.41		1.04	
40	3.23	3.34	1.08	1.14
	3.53		1.25	
	3.26		1.10	
50	2.39	2.53	1.08	1.16
	2.97		1.35	
	2.22		1.05	
60	2.50	2.26	1.40	1.28
	2.55		1.45	
	1.72		0.98	

Table S3. The detailed information of the micro-energetic igniter collected by a high-speed dignital storage oscilloscope in the capacitor discharge test.

voltage (V)	ignition time t_3 (μs)	average ignition time (μs)	ignition energy E_3 (mJ)	average ignition energy (mJ)
30	4.73	4.65	1.17	1.13
	4.92		1.24	
	4.31		0.99	
40	3.23	3.21	1.31	0.96
	3.25		0.80	
	3.15		0.76	
50	2.32	2.42	1.23	1.28
	2.61		1.51	
	2.33		1.11	
60	2.04	2.13	1.29	1.32
	2.17		1.39	
	2.19		1.29	