

Fabrication of micro-ignition sequence based on electronics safety and arming unit

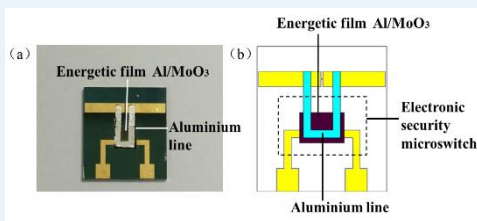
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Abstract

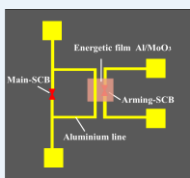
This paper describes an ignition circuit consisted of one micro igniter and one electronic security microswitch that could realize the intelligent function of micro-ignition sequence. The micro-ignition sequence, integrated with ignition circuit, chamber, nanothermite and B/KNO₃, was fabricated on the same silicon chip by mechanical engraving and classic micro mechanical systems (MEMS) technology including magnetron sputtering and plasma etching steps. In addition, the size of micro-ignition sequence was less than 0.15 cm³. The electronic security microswitch based on energetic film Al/MoO₃ can implement the function of circuit switch conversion under 1.5 A during 3 ms. The paper presents the design, fabrication and test of the micro-ignition sequence integrating of electronics safety and arming unit.

Design and preparation of initiator

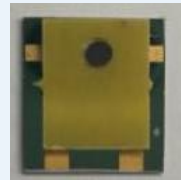


Ignition circuit layer: (a) photograph, (b) schematic diagram.

- An aluminium line is placed on top of the energetic film Al/MoO₃ deposited on the Arming-SCB on a silicon-based substrate.
- The Arming-SCB is a polysilicon resistance of 14 Ω with a polysilicon resistivity of 3.8 Ω/square.
- Al/MoO₃ is insulated from both aluminium line and Arming-SCB by depositing MoO₃ at the junction.



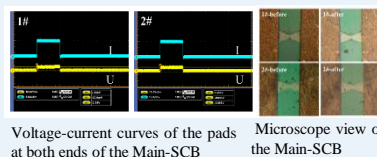
Layout of the ignition circuit layer



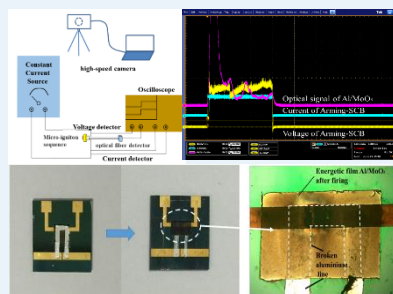
Micro-ignition sequence after assembly.

- Ignition circuit layer has a size of 9.5 mm × 8.7 mm × 0.5 mm.
- Al/MoO₃ has a shape of square (2 mm × 2 mm) and a thickness of 3 μm.
- Each bilayer is 20 nm and 30 nm thick for Al and MoO₃.
- Nanothermite is charged in a chamber with a diameter of 1 mm and a depth of 0.5 mm.
- B/KNO₃ pellet is a 1.5 mm diameter, 0.28 mm height cylindrical grain.

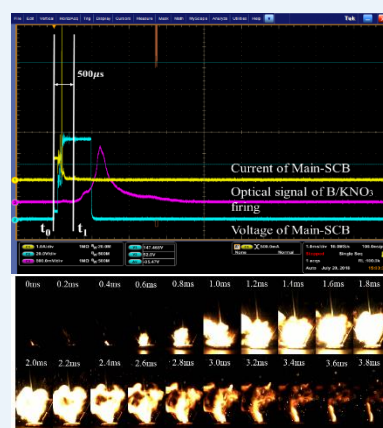
Validation of electronic arming operation



Voltage-current curves of the pads at both ends of the Main-SCB
Microscope view of the Main-SCB



Photograph of broken aluminium line after electronic disarming operation



High-speed photographic record of micro-ignition sequence firing at a constant current of 1 A for 1 ms after electronic disarming operation.

- ◆ Validate the short-circuit protection function of aluminium line Before receiving disarming instruction.
- ◆ After receiving the disarming instruction, the energetic film Al/MoO₃ can be successfully ignited at the constant current of 1.5 A for 3 ms.
- ◆ The Main-SCB enters the working state with the completion of the electronic disarming operation.
- ◆ Arming-SCB composite-SCB energetic film Al/MoO₃ igniter has a discharge voltage at 50% of 14.78 kV.
- ◆ Validate the availability of the micro-ignition sequence after electronic disarming operation.
- ◆ B/KNO₃ starts to fire during 0.4 ms-0.6 ms.

Conclusion

In combination with the development requirements of the new generation of smart and smart weapon ammunition technology, the electronic security microswitch was designed on silicon substrate to realize the electronic safety and arming unit function of the ignition sequence. Constant current of 1.5 A for 3 ms applied on Arming-SCB can ignite the energetic film Al/MoO₃ and realize the disarming function. The energetic film Al/MoO₃ is in close contact with the Arming-SCB and the aluminium line that improve the reliability of the electrical disarming operation. The electrostatic safety of the electronic security microswitch has been tested. The discharge voltage at 50% of Arming-SCB composite energetic film Al/MoO₃ is 14.78 kV.