

Developing a high-energetic and fast-response ignitor by integrating reactive inks on semiconductor bridges

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Abstract

Due to the growing appetite for developing compatible miniaturized micropyrotechnics systems, the traditionally used electro-pyrotechnic initiators have been upgraded from a bridge wire to a semiconductor bridge (SCB) *via* microelectromechanical systems (MEMS) technology. As an innovative ignition device, SCB can generate heat and plasma upon an electrical input. With its superior properties in the ignition, such as rapid response, low energy input, and high degree of integration, SCB has been largely employed in various civilian and military applications. For the purpose of successful ignition, energetic nanothermites have been integrated into SCB (ESCB) based ignitors in order to enhance the energy output and flame size. Nanothermite reactions refer to a redox reaction between a physically mixed metal fuel and solid metal oxides and have been substantially studied due to their high energy densities, greater stabilities, and also high tunability in terms of particle size, composite composition, stoichiometry, and packing. Over the years, reactive multilayer films (RMF), mostly Al/CuO nanolaminates, have been integrated into microchip ignitors and achieved ignition in a time scale of μs with energy input as low as several watts. However, the fabrication process (mostly magnetron sputtering) of such RMFs suffers from drawbacks like low sample loading, long process time, delamination due to thermal shocks, etc, which limits the industrial application of ESCB. Thus, an alternative method is urgently needed to develop by withholding the advantages and discarding the disadvantages of RMF materials in ESCB-based ignitors. In the last decade, direct ink writing has gained much attention due to its facile manipulation, high adaptability, and scalability as well as tunability.

In this work, for the first time, we combined the direct ink writing technique and ECB chip to fabricate a novel ESCB ignitor that features good ignition performance but with much less cost in time and goods. Briefly, a $5\times 5\text{ mm}^2$ sized SCB-based ignition chip with gold contact pads and titanium resistance is fabricated using a series of photolithography/lift-off processes and magnetron sputtering. Then a 250 μm high peripheral container was fabricated on top of the chip by lamination and photolithography processes and is designed to controllably store the printed energetic materials. Moreover, the ignition behaviour of such an ignitor can be easily tuned by changing the fuel/oxidizer/binder constituents to apply in different scenarios.

Keywords: Ignitors, MEMS, direct ink writing, energetic materials, ignition

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