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# A micro initiator realized by integrating $KNO_3$@CNTs nanoenergetic materials with a Cu microbridge

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## HIGHLIGHTS

- CNTs with the oxidant $KNO_3$ filled in its cavity can form a new class of nEMs.
- EPD was the proper method to manipulate the CNTs composite energetic materials.
- The $KNO_3$@CNTs nEMs were used in the micro initiator to improve the performance.
- A temperature measurement system was applied to test the electrical explosion temperature distribution.

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## ABSTRACT

A micro initiator was developed by integrating $KNO_3$@CNTs nanoenergetic materials with a Cu thin-film microbridge realized onto a glass substrate. It was fabricated by magnetron sputtering with Cu and subsequent electrophoretic deposition with $KNO_3$@CNTs nanoenergetic materials, which were prepared by wet chemical method, embedding $KNO_3$ in carbon nanotubes (CNTs). The samples were characterized by TEM, XRD, TG/DSC and SEM, respectively. The electrical explosion performances of the micro initiator under capacitor discharge were investigated. The process of electrical explosion was observed by high-speed photography and the temperature distribution versus time was acquired by a temperature measurement system with double line of atomic emission spectroscopy. The results show that the hollow cavities of the CNTs were filled with crystalline $KNO_3$, and that the entire surface of the micro initiator was well distributed without large reunion. Compared with single-layer Cu thin-film microbridge, the micro initiator possessed more violent electrical explosion process, the electrical explosion duration was longer, and the peak temperature was higher, which indicate that chemical reactions of $KNO_3$@CNTs nanoenergetic materials were involved in the electrical explosion process of the micro initiator, accompanied by more heat release.



## 1. Introduction

An electropyrotechnic (or explosive) initiator that is activated by the application of electrical energy is used to initiate an explosive, burning, electrical or mechanical train [1]. Electropyrotechnic initiators have been applied to electroexplosive devices (EEDs) [2], micropropulsion systems for microsatellites [3–5], miniature Safe Arm and Fire (SAF) device used in missiles, rockets, and munitions [6], triggering the inflation of airbags in automobiles [7], and many other civil and military systems. The security and reliability of traditional electropyrotechnic initiators cannot withstand the electromagnetism conditions nowadays. The semiconductor bridge (SCB) is one new means for electropyrotechnic initiators among others. SCB devices are characterized by their low input energy, fast functioning, high security and reliability [8,9]. Although the performance is greatly improved, there are still some problems remaining such as not very good intimate contact between the SCB and the attached reactive materials, and smaller output energy compared with input energy [1].

Nanoenergetic materials (nEMs), due to increased surface to volume ratio of the reactants, can result in higher energy release in comparison with traditional materials. [10–20] . However, there's little research about the practical applications of nEMs. Carbon nanotubes (CNTs) can be regarded as being formed by the curling of graphene, and its interior is one-dimensional nanocavity which provides the ideal template for the structure and properties of materials in the nanoconfinement [21]. CNTs, as a flammable substance, with the oxidant filled in its cavity can form a new class of nEMs. The agglomeration of the nano oxidant can be effectively avoided. In addition, the heat exchange efficiency can be increased due to the well thermal conductivity of the CNTs. Many researchers

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