

Design, Fabrication and Testing of a Miniaturized end-of-life Ultimate Security Device Using Reactive Composites

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Security has become a vital part of electronic products and critical equipment such as military systems as not only they handle sensitive data in uncontrolled environments, but also they face intellectual protection issues or counterfeiting issues. Several electronic anti-tamper and anti-reverse engineering technologies do exist. Unfortunately, all current anti-tampering technologies, while being effective and in constant evolution to adapt to new complex topologies and progressing technologies, are susceptible to be cracked or bypassed leaving the system vulnerable. That is why, in sensitive hardware such as wearable medical devices or safety-critical components such as military systems, an ultimate action must be considered upon the detection of intrusion. Irreversibly destroying the component and its stored data is the most secure and cost-effective way to dispose of all types of end-of-life safety-critical components. This research develops and test a responsive transient device which acts as an add-on module that can be placed on any IC-circuit or memory cards, without requiring any specialized chip design, substrate type or encapsulation solution. This so-called ultimate safety-device (USD) can be actuated in a fraction of second to mechanically disintegrate any type of device containing sensible data upon the detection of intrusion into the system. The actuation mechanism is provided by a nanothermite based energetic film chosen as it is a source of reliable and “dormant” energy, exhibiting long shelf life (decades) and able to very quickly deliver gas and heat through a self-sustained redox reaction. Al/CuO nanothermites demonstrated their capabilities to provide high-energy density actuations to fracture silicon substrates [1] or disconnect circuitry [2] while being safe and stable until 250 °C [3]. Herein, we specifically designed and elaborated a printable thermite-based energetic composite featuring high-pressurization capability to produce an efficient mechanical actuation. [4] The ultimate safety-device concept uses multiple successive layers as represented on the schematic diagram of Fig. 1a. and is made of two main active parts: (1) the nanothermite based composite which is jetted into a 3D printed reservoir [5]. The mass of deposited nanothermite varies from 10 – 400 mg as a function of the required actuation. (2) The initiation circuitry integrating a pyroMEMS [6-9] to trigger the nanothermite composite combustion upon an electronic order (detection of intrusion). Because the pyroMEMS is manufactured using microelectronic manufacturing techniques, it can be easily interconnected with electronics, which enables controllability over the ignition process. We will present the thermite-based energetic composite synthesis and printing followed by the fabrication of each layers of the USD before detailing the assembly of one miniature (0.4 cm³) USD. A last part will be dedicated to the testing achieved on several mounted USD on SD memories cards which demonstrates the irreversible physical destruction of the silicon chip and thus all readable data of the memory. We will see that the reaction time and efficiency highly depend on the reactive material loading.

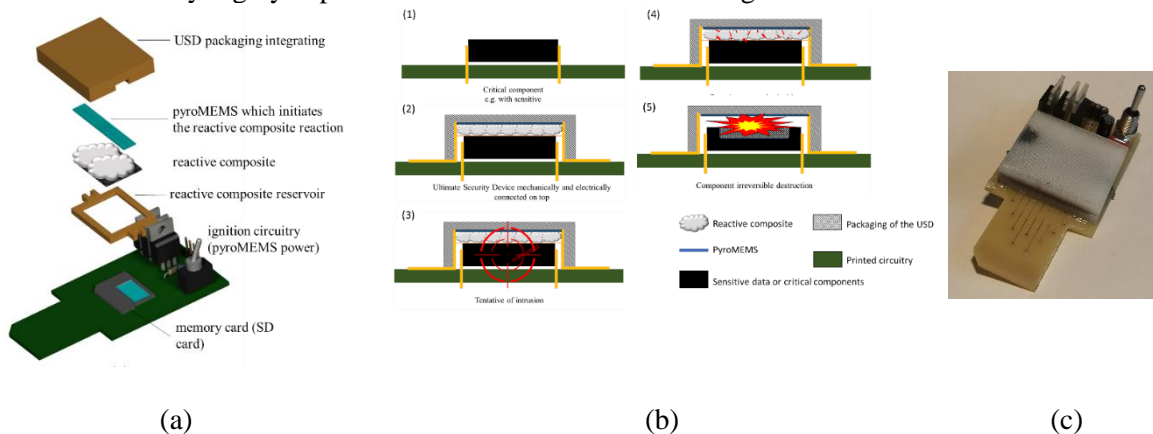


Figure 1. Conceptual illustration and photo of the USD operation principle. (a) Exploded view of the device, (b) Operating mechanism (c) photo of one assembled USD.

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