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Investigation of Al/CuO multilayered thermite ignition and combustion

Influence of the heating surface area, bilayer number, and layering

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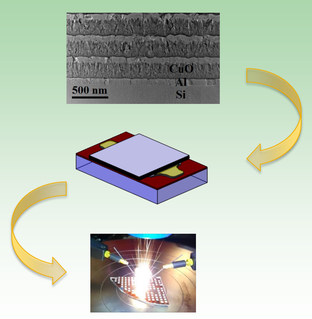
Al/CuO multilayered thermite

Stack of Aluminum and Copper oxide nanolayers

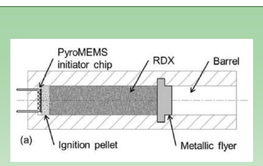
High heat of reaction

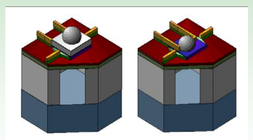
Self-sustained combustion reaction



Applications:

- Impact ignition of high explosives
- Drug injector
- Safe arm and fire device
- Microthruster





Goal:

In this work, we evaluated the influence of the heating conditions and nanothermite layering on the nanothermites ignition characteristics (ignition time, spark intensity, combustion velocity).

Some of the information in this poster is described in A. Nicollet et al. 'Investigation of Al/CuO multilayered thermite ignition': JAP DOI: 10.1063/1.4974288.

Electro-pyrotechnic initiators fabrication

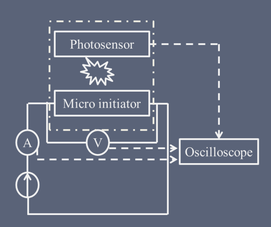
Adhesive transfer tape and Kapton laminations

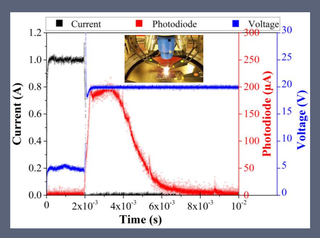
Evaporation and patterning of the micro-heater

Sputter deposition of Al/CuO nanothermites and patterning

Characterizations

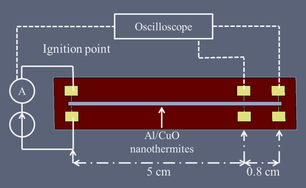
Ignition experiment





- **Ignition time**
- **Maximum** of the photodiode signal → Visible light intensity (sparks)
- **Integral** of the photodiode signal → Heat of reaction

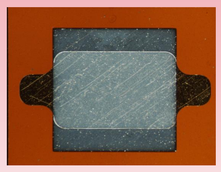
Combustion experiment



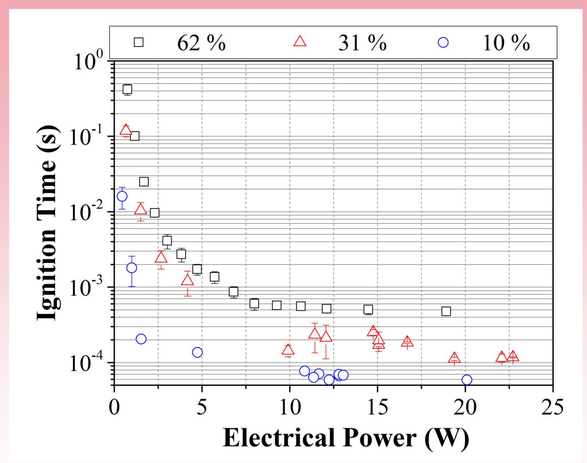
- **Combustion velocity**

Influence of the heating surface area

3 heating surface areas



62%, **31%** and **10%** of the nanothermite surface area

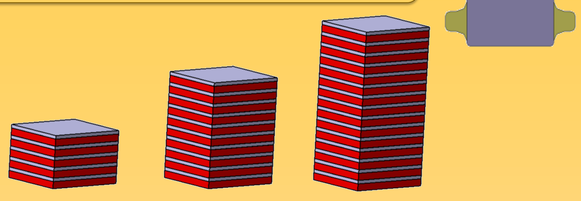


- Ignition time ↘ with ↗ electrical power
- Minimum ignition time ↘ with ↘ heating surface area
- Fire/No fire condition ↘ by 41% when heating area divided by 4
- No change in the nanothermites reaction energy with electrical power and heating surface area because nanothermites volume is kept constant

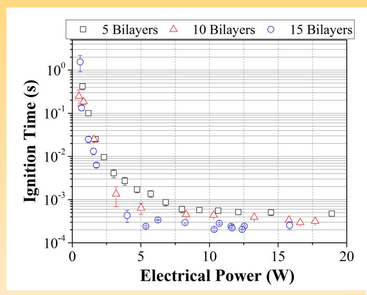
Ignition time is reduced by 87 % with the heating surface area divided by 4.

Influence of the bilayer number

5 , 10 or 15 bilayers of Al/CuO (200/100 nm)

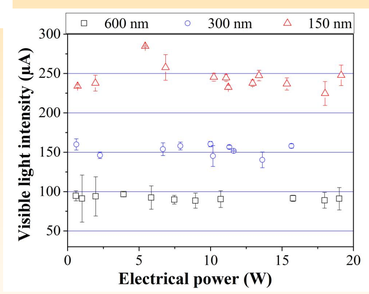


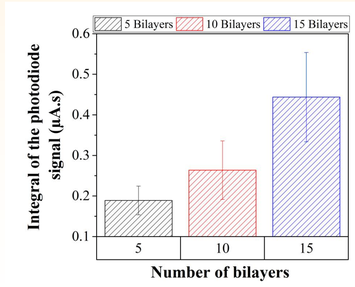
× 5 × 10 × 15



- Ignition time ↘ when bilayer number ↗
- Fire/No fire condition ↘ when bilayer number ↗

- Visible light intensity ↗ when bilayer number ↗
- Integral of the photodiode signal ↗ when bilayer number ↗

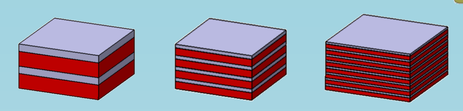




When bilayer number is tripled, ignition time is reduced by 96 % and the heat of reaction (integral of the photodiode signal) is multiplied by 2.35.

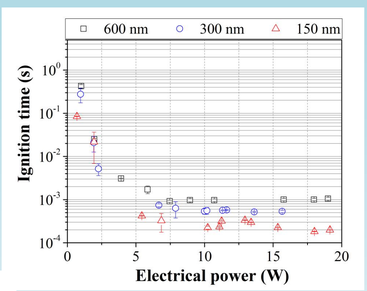
Influence of the bilayer thickness

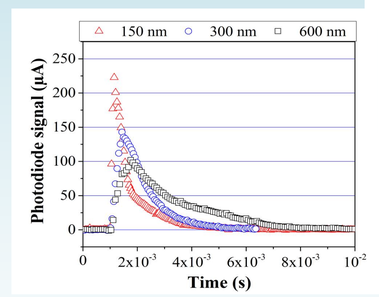
Total thickness 1.2 µm 5 Bilayers



600 nm × 2 **300 nm × 4** **150 nm × 8**

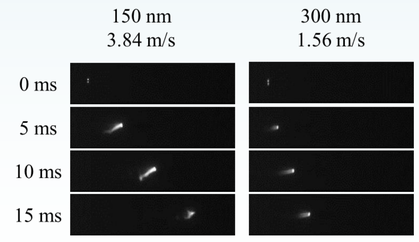
- Ignition time ↘ when bilayer thickness ↘
- Fire/No fire condition↘ when bilayer thickness ↘





- Visible light intensity ↗ when bilayer thickness ↘ but this does not affect the integral of the photodiode signal

Ignition time is reduced by 81 % when bilayer thickness is divided by 4.
Combustion speed multiplied by 2.46 when bilayer thickness is divided by 2.



Conclusions

- Large influence of the heating surface on the ignition time.
- Number of bilayers influences ignition time and nanothermite reaction.
- Increasing the bilayer spacing increases the ignition delay since it decreases the reactivity of the nanothermites.

Aknowledgements

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