Combustion of Al-NiO Nanolaminate Thermites

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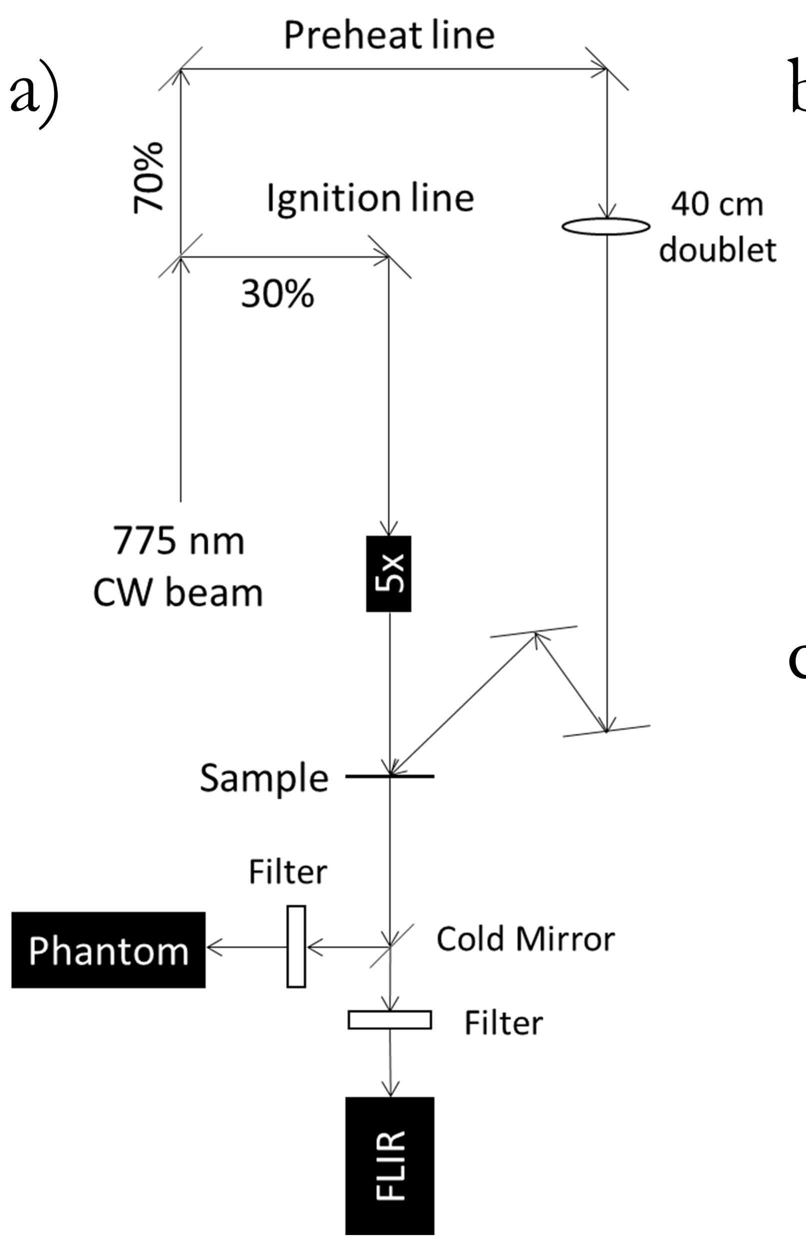
Motivation

Thermites are often produced through physical mixtures of nanopowders to achieve rapid propagation speeds. These physical mixtures often have significant issues with mixing and large amounts of the precursors being passivated. Physical vapor deposition (PVD) allows production of nanoscaled thermites without passivation layers that are perfectly mixed.

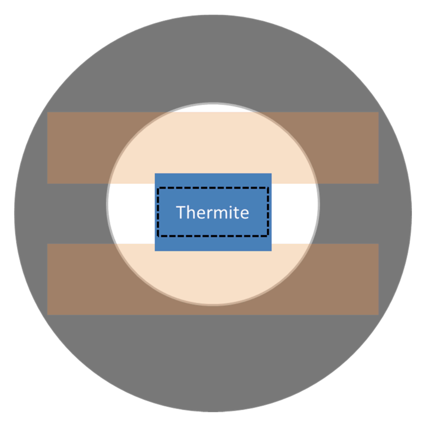
Experimental Methods

Samples were deposited on substrates from aluminum and nickel oxide targets using PVD. Films were deposited on NaCl and photoresist. Samples were recovered through dissolution of the substrates. NiO stoichiometry was verified through wave dispersive x-ray spectroscopy (WDS) on a Cameca SX100 Microprobe.

a)



b)



c)

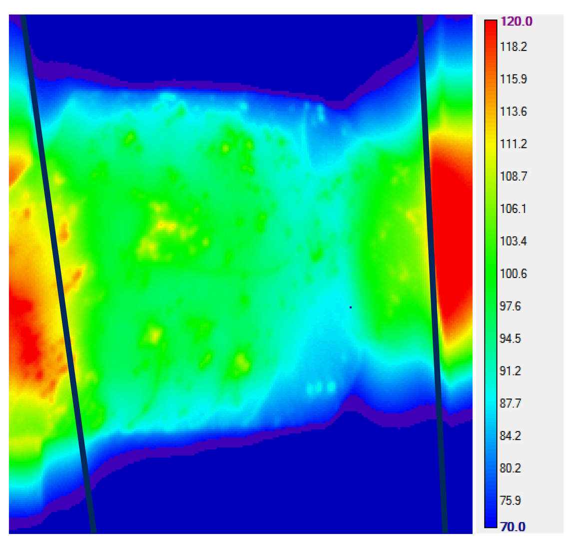


Figure 1. a) Laser line for preheating and ignition of freestanding foils. The initial beam is split into a preheat line and a shuttered ignition line. b) The sample is mounted between 2 pieces of kapton tape on a metal washer. c) A typical example of the preheated foil. The black lines indicate the edges of the kapton tape. Note that the variation across the heated area of the foil is approximately ±5°C.

Results and Discussion

Microstructural Characterization

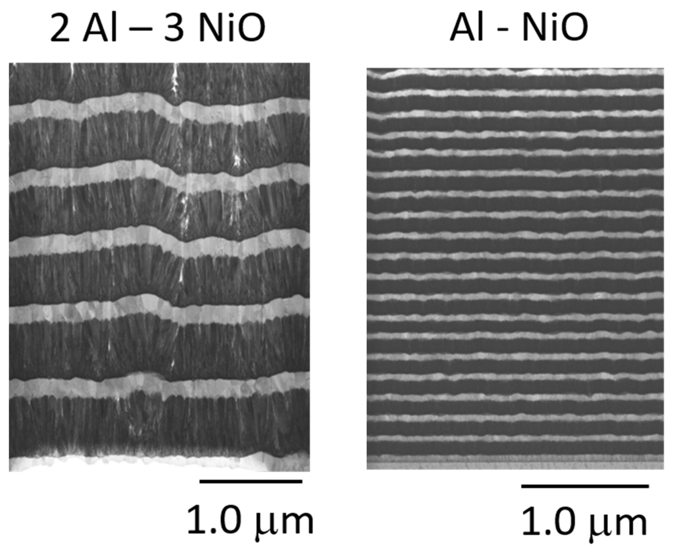


Figure 2. Scanning transmission electron micrographs of both stoichiometries deposited.

Table 1 WDS of deposited NiO.

	Atom Percent
Ni	50.834
O	49.098
Si	0.068

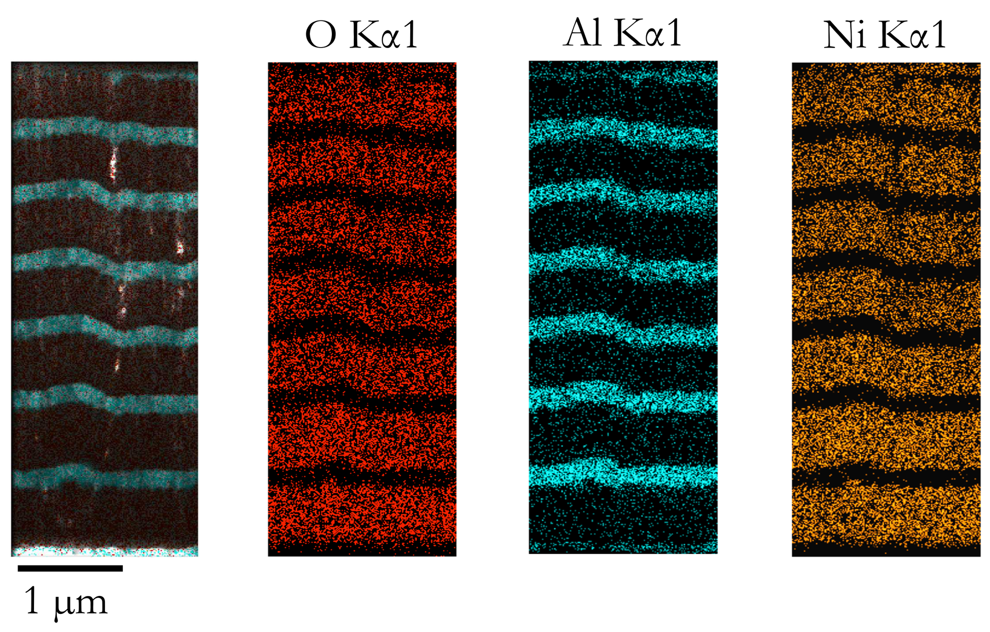


Figure 3. SEM-EDS of 2Al+3NiO nanolaminate.

Flame Speed Measurements

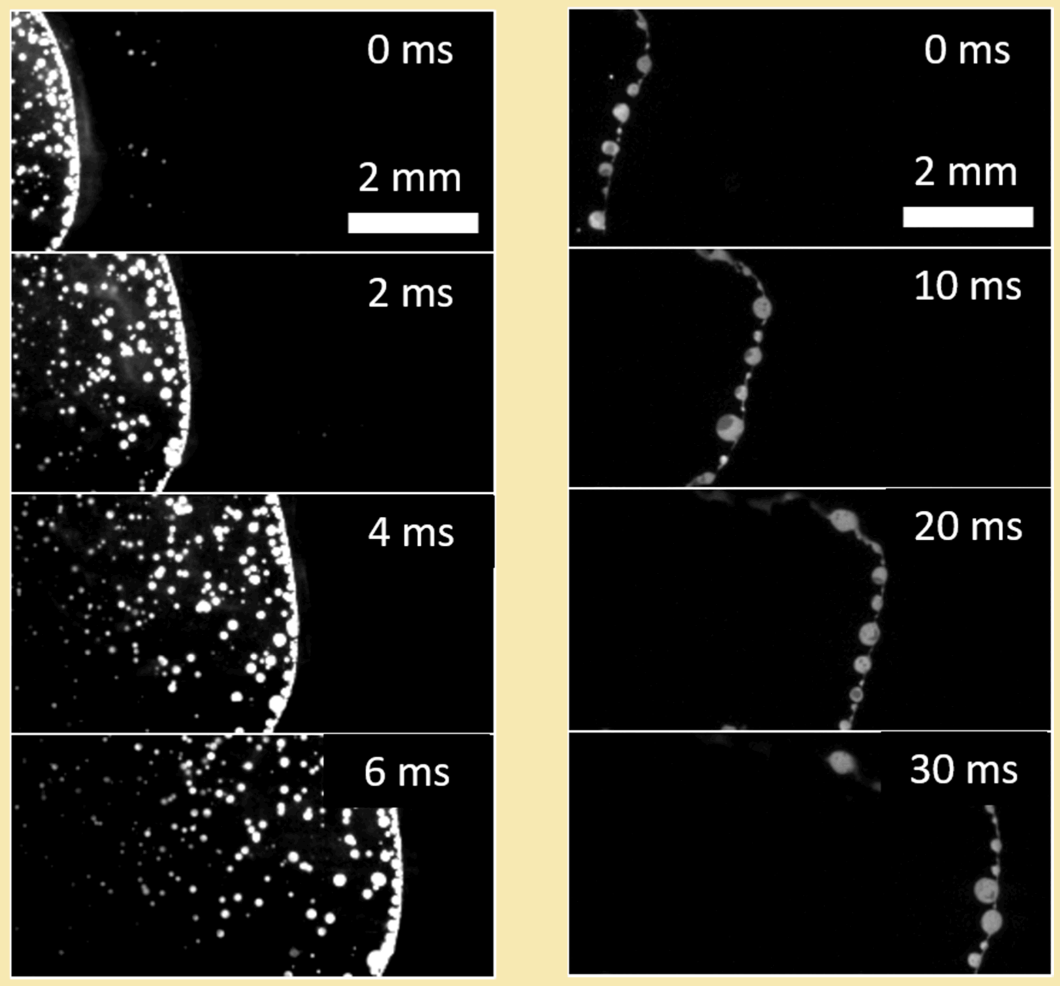


Figure 4. Typical flame speed measurements for freestanding laminates. Note the difference between the propagation of the 250 nm (left) and 500 nm (right) 2Al+3NiO. The propagation of the 800 nm Al+NiO system is qualitatively similar to the 250 nm 2Al+3NiO.

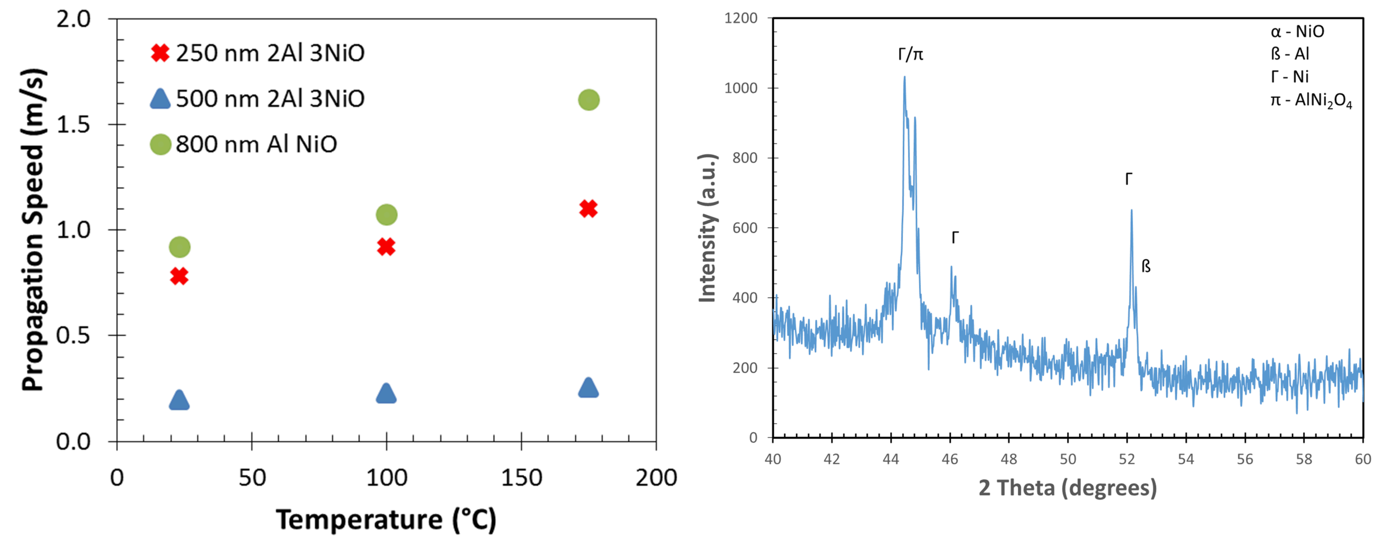


Figure 5. (Left) Plot of effect of preheat temperature on propagation speed as a function of laminate thickness and stoichiometry. (Right) X-ray diffraction results of material captured during combustion of 800 nm Al-NiO laminates.

Calorimetric Analysis

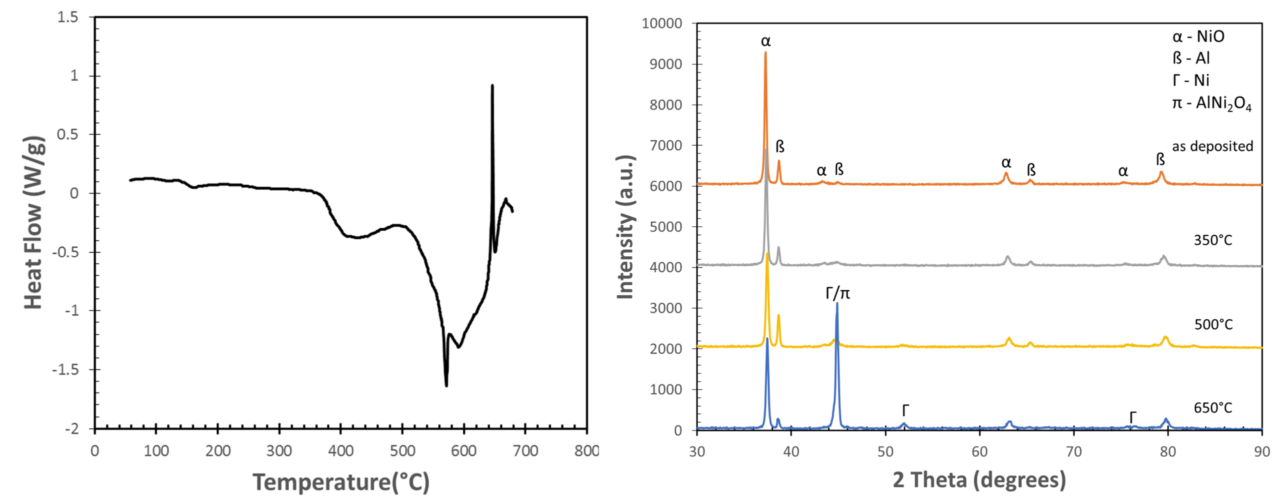


Figure 6. (Left) DSC of 500 nm 2Al+3NiO nanolaminate plotted with exotherm down. (Right) XRD of quenched DSC runs at key temperatures.

Conclusions

- Al-NiO thermite nanolaminates have been produced at 2 different stoichiometries.
- DSC quench experiments followed by XRD indicate that Al remains at 650°C.
- Measurements of propagation velocity vs. preheat temperature in free standing laminates show that the Al+NiO stoichiometry propagates more rapidly than 2Al+3NiO.

Acknowledgements

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