

Studying the titanium oxidation in reactive thin films via electron microscopy

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In this work [1], we put our focus on an in-depth understanding of the oxidation mechanism of titanium within a thermite system by employing a magnetron-sputtering technique to grow high purity and well-defined CuO/Ti reactive thin film (RMF), which features a very well-controlled interface (in thickness and structure) between the fuel and oxidizer. The multilayer system allows full contact between the different species compared to the particle system shows random contact, which is crucial to identify and rationalize the different mechanisms taking place during reaction. This provides an ideal model system to describe the TiO_x interfacial oxide growing quantitatively.

An RMF containing four nanolayers, CuO/Ti/CuO/Al, was prepared and annealed at 300 and 500 °C, respectively, and then studied using high-resolution electron microscopy, including HRTEM, EDX, and EELS to quantitatively describe structural and chemical evolution of the titanium oxidation process upon heating. Spectroscopy measurements show that Ti oxidation undergoes a two-step process: at 300 °C, Ti is first oxidized into TiO and further oxidized into crystalline TiO₂ at 500 °C, and no more Ti is detected as being oxidized in TiO completely. At a similar initiation temperature, the Ti-based sample supports more oxygen transport, thus a greater number of elementary exothermic reactions, causing greater heat per unit volume. In turn, this drives the system into the self-sustaining reaction mode where sufficient energy is present to activate mass transport across the continuously forming terminal oxide until the reaction is completed. This study confirms that Ti can be of great interest in the addition or replacing Al in nanothermites, for applications where it is desirable to lower the ignition temperature.

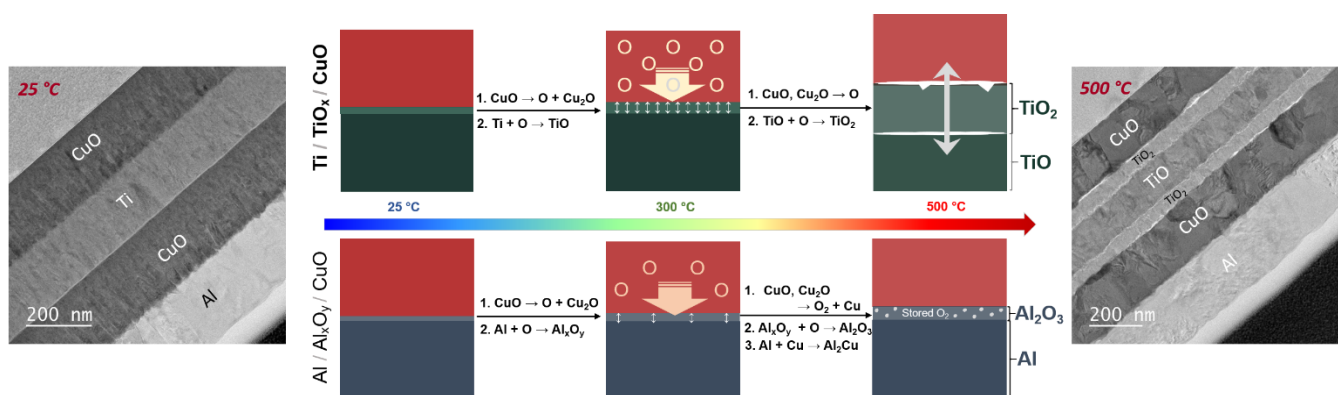


Figure 1. Schematic of the reaction mechanism of CuO/Ti compared with CuO/Al.

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References:

[1] T Wu, V Singh, B Julien, C Tenailleau, A Estève and C Rossi, Chemical Engineering Journal 453 (2023), 139922.