

Morphology and reactivity of aluminum nanoflakes

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INTRODUCTION

Among energetic materials, aluminum powders have a prominent position due to their use as a component in propellant formulations, explosives and pyrotechnics [1]. The reactive and propulsive properties of the aluminum powders are linked to the exothermic reaction of aluminum with an oxidant. Powders with a high specific surface area (higher than $10\text{m}^2/\text{g}$) i.e. aluminum nanopowders have a higher reactivity than micronic powders. Aluminum nanopowders are currently manufactured either by vapor phase condensation or by liquid state chemistry and they all have a spherical morphology. Recently, we showed that particle morphology and grain nanostructuration influence the reactivity of aluminum nanopowders [2]. In this work, morphology and nanostructure were investigated by TEM and related to the powder reactivity. The powders are obtained by high energy ball milling. The influence of the milling parameters and additives on the morphology, structure and reactivity of the powder was also investigated.

RESULTATS

The reactivity of the aluminum powders is characterized by thermogravimetric (TG) analyses (Figure 1): reactive powders should present high mass increases M1 and M2 and low temperature T1. The influence of milling conditions on M1 and T1 was studied. The aluminum powders, obtained by high energy ball milling, show a flake like morphology. Depending on the milling conditions, the nanoflakes are highly dispersed in lateral size and thickness; the biggest ones have micronic lateral sizes (1-4 μm) and thickness less than 200 nm, and the smallest ones 100 nm lateral size and 30 nm in thickness. The nanoflakes contain several crystallites with an orientation relationship; a [110] texture was observed (Figure 2). They are surrounded by an amorphous layer of aluminum oxide, whose thickness seems to depend on the milling conditions. The amorphous layer thickness depends also on the crystallite size and on the underlying crystallographic planes [3] (Figure 3b). Small crystallites exhibit thicker amorphous layer at the edges than on basal planes, which could induce different oxidation rates and modify the shape of the first mass increase in TG analyses.

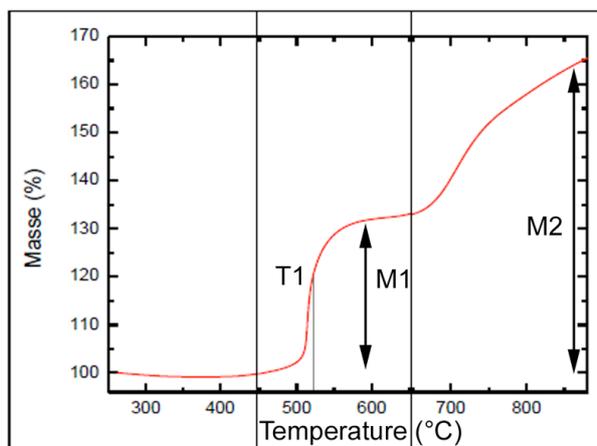


Figure 1. Mass variation with temperature of Aluminum nanoflakes

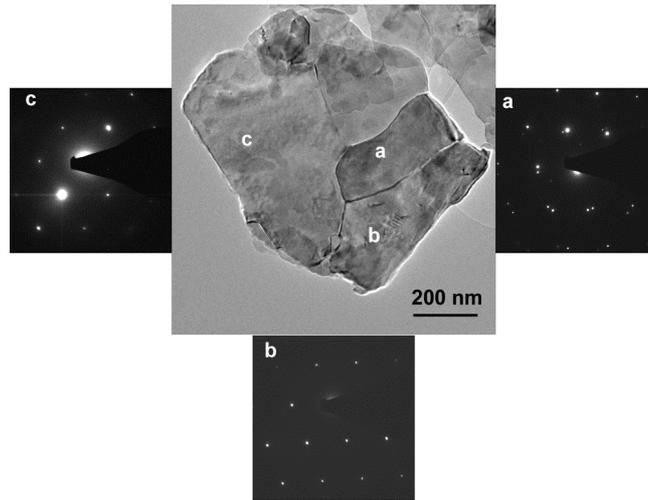


Figure 2. Aluminum nanoflake with grains all oriented [110]

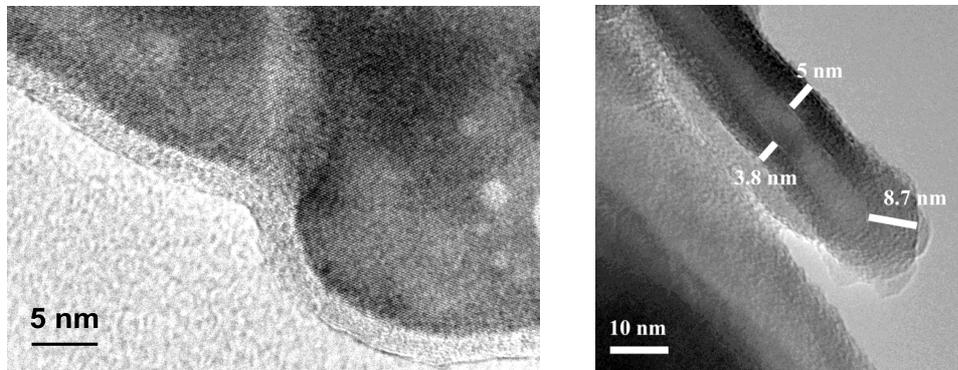


Figure 3. HREM image of [110] oriented aluminum grains, surrounded by an amorphous aluminum oxide layer with constant thickness of 2,5nm. Variation of the amorphous aluminum oxide layer thickness around one crystallite

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