Controlled oxidation of aluminum nano and micro particles: Modeling and validation.

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An experimental and theoretical analysis of the oxidation of aluminum micro and nanoparticles is presented.

The experimental methodology is based on Differential Scanning Calorimetry (DSC) and Thermo-Gravimetry (TG) measurements. The modeling of the oxidation is based on modified Cabrera-Mott model. For the initial thin layer appearing immediately after exposition to an oxidizing atmosphere, the Cabrera-Mott theory is used, while at later stages in the oxidation process diffusion-limited models of reaction are used. Porous media heat and mass transfer, both at the individual particle level and for an assemblage of particles, typically a fixed bed, are to be considered in order to better analyze both the TG-DSC laboratory analysis techniques.

While a single nanoparticle is already considered in the Cabrera-Mott and diffusion limited models such as the shrinking core or unreacted core model, an assemblage of particles presents multiple difficulties and can be treated in many ways. A possible avenue to treat the multi-particle system is, with an a priori knowledge of the particle size distribution, to calculate the overall oxidation of the particles through the sum of all particles. This method can be either used in a simplified way assuming that there is no interaction between the particles, or with relatively well-defined interactions (geometrical, bridging, etc...) and rapidly becomes (almost) computationally untractable.

A comparison between aged and non-aged, as well as between micron sized and nanometer sized particles is made, and compared with the predictions of the different models used. The results of the combined analysis are used to estimate and devise a strategy for efficient and safe passivation of aluminum nanopowders coming out from an industrial Inductively Coupled Plasma process.

Full results and references will be given in the full length paper.