doi: 10.1017/S1431927609095853
Microsc Microanal 15(Suppl 2), 2009

Formation and characterization of γ- Al_2O_3 films produced by oxidation of β–NiAl(110)

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Keyword: Catalyst support, oxidation, NiAl, γ-Al_2O_3

Pt nanoparticles dispersed on γ-alumina is one of the most widely used heterogeneous catalysis systems used in commercial chemical and energy industries, including petroleum refining[1]and, hence, has been investigated extensively as a model catalyst system to elucidate structure-catalytic activity and selectivity relationships.

Our specific research interest is to understand γ-Al_2O_3 support affects on the structure and chemistry of the Pt catalyst. Several recent researchers reported that the support determines the structure of the metal catalysts, including size, uniformity and 3-dimensional morphology. For example, recent theoretical simulations revealed that defects in the γ-Al_2O_3 stabilize the Pt nanoparticles. These simulations are conducted on ideal single crystal γ-Al_2O_3, whereas commercial γ-Al_2O_3 is polycrystalline, irregular in shape, and contains impurities (Fig. 1). In order to directly link experiments with theory necessitates the creation of a well-defined, single crystal gamma alumina film. Oxide terraces can be obtained and used as support for metal clusters in model catalytic systems[2]. Previous investigators demonstrated that epitaxial γ-Al_2O_3 thin film forms on single crystal β–NiAl by oxidation [3], Fig.1b.In this research, NiAl alloys are used to grow ultrathin γ-Al_2O_3 layers under well-controlled oxidation conditions. Morphology becomes flatter but more discontinuous during temperature decreasing. Here, we present our results of the oxidation of β–NiAl(110) as a function of oxidation temperature (750-950°C), time and air flow. The oxide films were characterized by transmission electron microscopy (TEM), scanning electron microscopy (SEM), atomic force microscopy (AFM) and X-ray diffraction (XRD). Plan-view TEM samples were prepared by scratching the oxide off of the surface and placed onto a holey C grid. Fig. 2 and 3 are the TEM results after NiAl was oxidized for 1 hr at 950 and 850 □, respectively. The selected area electron diffraction pattern (SAED) confirmed that the oxide is γ- Al_2O_3, not another phase of alumina (e.g. theta, delta, alpha). The XRD results confirm that epitaxial (111) γ-Al_2O_3 plane grows on (110)NiAl substrates (Fig.4). The surface morphology of the oxide films has been examined by SEM (Fig.5). With decreasing temperature, the morphology of the γ- Al_2O_3 film has become flatter but more discontinuous. The transformation kinetics is accelerated with higher air flowrate. A peculiar ridge network morphology is created which is believed to be a vestige of high diffusivity paths of oxides growth.

We will deposit Pt particles directly onto γ- Al_2O_3 surface to examine the interface of Pt/γ- Al_2O_3 by cross-sectional TEM methods.

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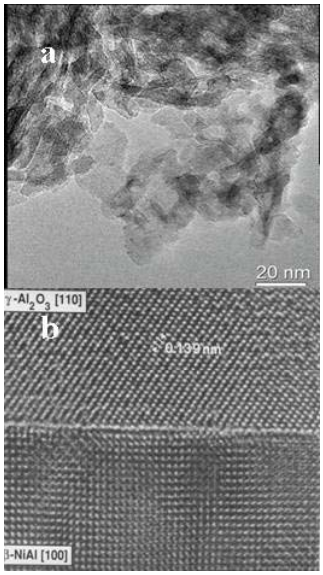


Fig.1 TEM images: a. commercial γ-Al_2O_3. polycrystalline b. γ-Al_2O_3(110) epitaxial growth on NiAl(100) [3]

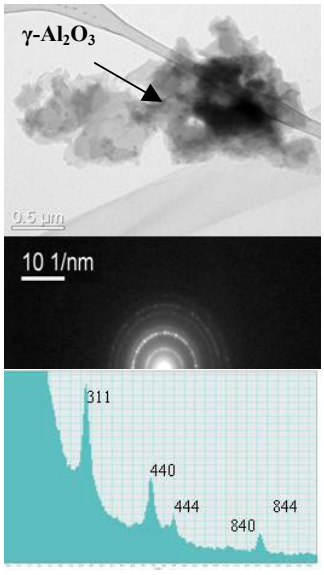


Fig 2 TEM images of 950□ 1hrs oxidation confirm γ-Al_2O_3 structure

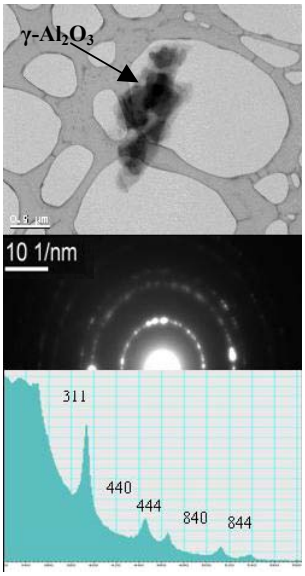
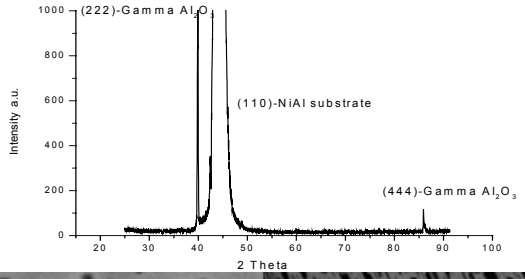


Fig 3 TEM images of 850□ 1hrs oxidation confirm γ-Al_2O_3 structure

Fig.4 XRD of 950□ 1hour oxidation, eptaxial (111) γ- Al_2O_3 is found on (110) NiAl



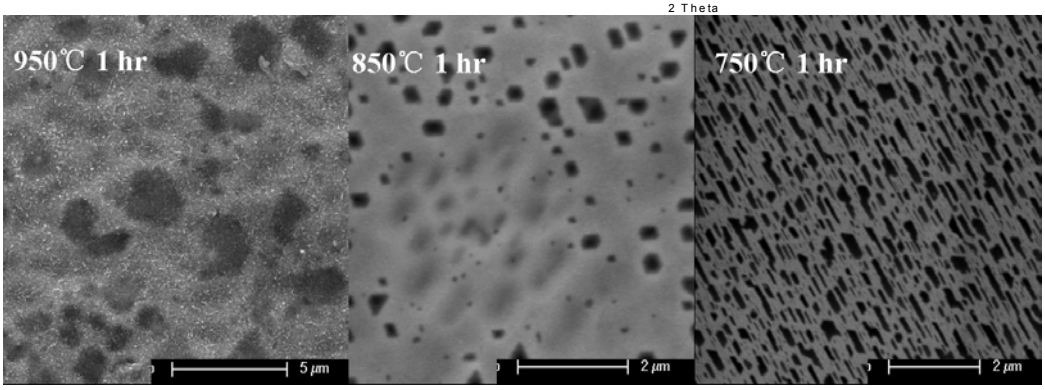


Fig.5 SEM images of γ-Al_2O_3 on NiAl surface oxidized at 750,850,950°C for 1hour

http://dx.doi.org/10.1017/S1431927609095853