

Formation and characterization of γ -Al₂O₃ films produced by oxidation of β -NiAl(110)

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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 -Al₂O₃ 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 -Al₂O₃ stabilize the Pt nanoparticles. These simulations are conducted on ideal single crystal γ -Al₂O₃, whereas commercial γ -Al₂O₃ 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 -Al₂O₃ thin film forms on single crystal β -NiAl by oxidation [3], Fig.1b.In this research, NiAl alloys are used to grow ultrathin γ -Al₂O₃ 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 °C, respectively. The selected area electron diffraction pattern (SAED) confirmed that the oxide is γ -Al₂O₃, not another phase of alumina (e.g. theta, delta, alpha). The XRD results confirm that epitaxial (111) γ -Al₂O₃ 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 -Al₂O₃ 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 -Al₂O₃ surface to examine the interface of Pt/ γ -Al₂O₃ by cross-sectional TEM methods.

References:

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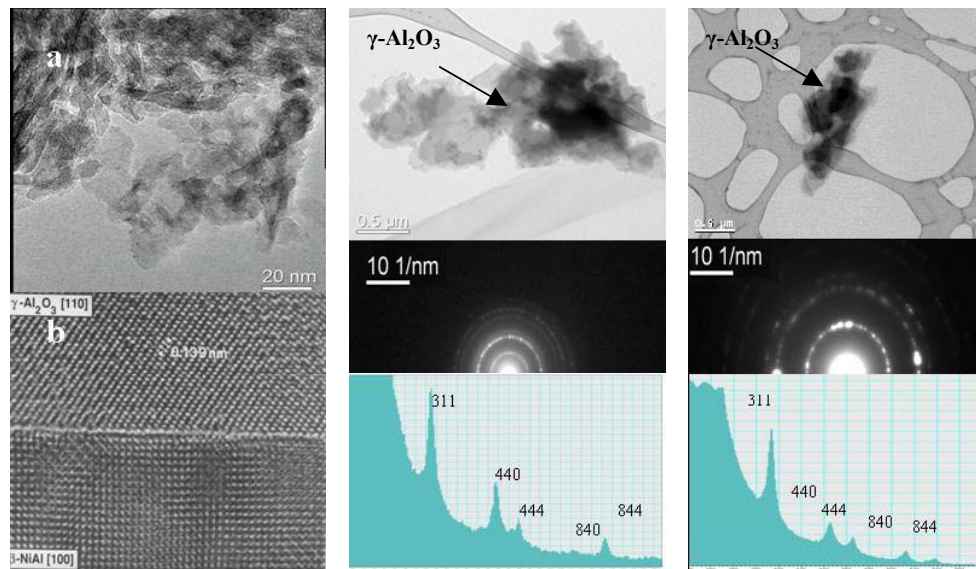


Fig.1 TEM images: a. commercial γ -Al₂O₃. polycrystalline b. γ -Al₂O₃(110) epitaxial growth on NiAl(100) [3]

Fig 2 TEM images of 950°C 1hrs oxidation confirm γ -Al₂O₃ structure

Fig 3 TEM images of 850°C 1hrs oxidation confirm γ -Al₂O₃ structure

Fig.4 XRD of 950°C 1hour oxidation, epitaxial (111) γ -Al₂O₃ is found on (110) NiAl

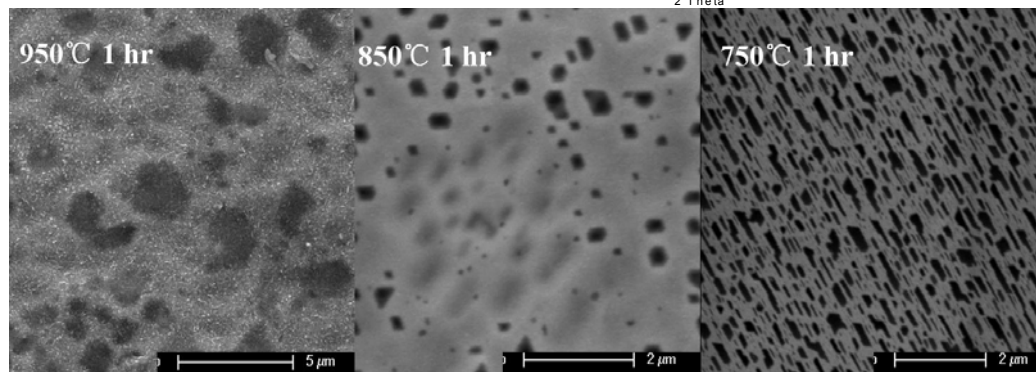
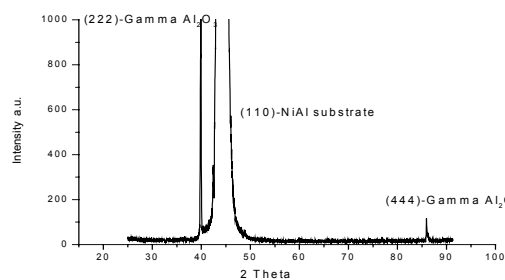


Fig.5 SEM images of γ -Al₂O₃ on NiAl surface oxidized at 750,850,950°C for 1hour