Formation of Nano-Scale Aluminum Carbide Whiskers on Aluminum Foil

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Introduction

Interesting nano-scale whiskers, with approximately 25-35 nm in diameter, were developed on an aluminium foil annealed in atmosphere of hydrocarbon gas. The new products consist mainly of aluminium carbide including some oxygen, distributing all over the aluminium foil surface.

However, the basic study on the formation of the aluminum carbide whisker had been very limited so far. Therefore, this research was focused on the formation process of the aluminium carbide whiskers. Their applications were also discussed.

Experimental

99.3 mass% aluminum foil, with 50 μm thickness, was annealed at 823K for 25ks under hydrocarbon gas atmosphere.

In order to observe the distribution and structure of the whiskers, scanning electron microscope (SEM) and transmission electron microscope (TEM) with electron diffraction facility were employed. Especially, the specimen for TEM observation was prepared by the replica of the thermal oxide film, which had been stripped from the annealed foil. Electron energy loss spectroscopy (EELS) was used to obtain general information of the elements distributions along the whiskers.

Furthermore, in one attempt, carbon particles were fixed to the aluminium foil with aluminium carbide whiskers. Subsequently, the depth profile of selective elements in the surface layer was measured by secondary ion mass spectrometry (SIMS).

Results

Nano-scale whiskers formed on the aluminum foil annealed under hydrocarbon gas are shown Figures 1 and 2. Observations by SEM and TEM reveal that each of the whiskers grows on the related crystallized square core, which locate immediately beneath the thermal oxide film. Furthermore, electron diffraction patterns indicate that both the whisker and the core part consist mainly of crystallized aluminium carbide. According to the precise analysis by EELS, Al and C were detected, with a small amount of O element.

When an aluminum foil was annealed under hydrocarbon gas at relatively high temperature, aluminum carbide was formed as result of the chemical reaction between aluminum and carbon at the interface. The carbon would be generated from hydrocarbon gas by thermal decomposition and subsequently penetrates to the thermal oxide film.

The aluminum carbide whiskers are successfully applied to the advanced technology to fix carbon particles on the aluminum foil without any binder. Figure 3 shows secondary electron micrograph of the cross-section. The whiskers generated on the cores and aluminium substrate appear to bind the carbon particles strongly. SIMS analysis also identified the reduction of the thermal oxide film, due to heat treatment under reducing gas.

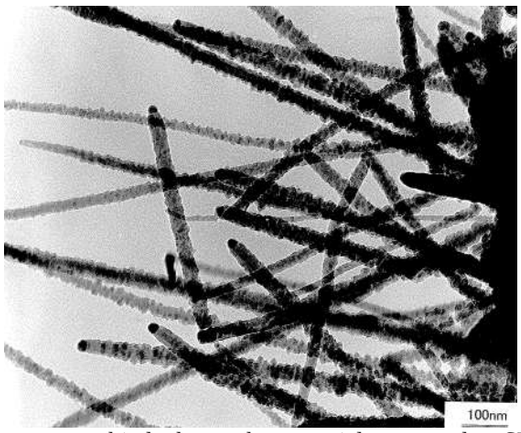

Fig.1 Transmission electron micrograph of the thermal oxide film stripped from the annealed foil.

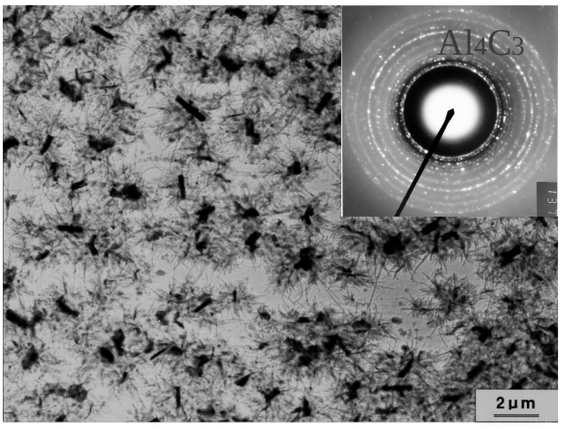

Fig.2 Transmission electron micrograph of the thermal oxide film stripped from the annealed foil with selected area electron diffraction pattern.

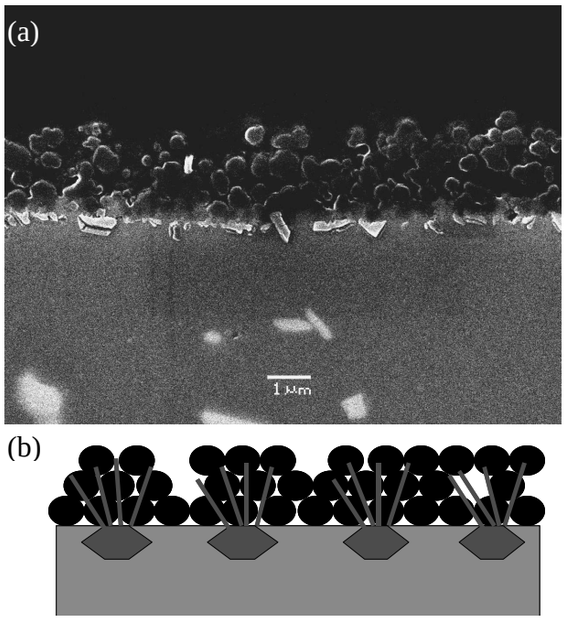

Fig.3 (a) Secondary electron micrograph of cross-section of carbon particles fixed on Al foil making use of aluminium carbide whisker.
(b) Schematic diagram of the carbon particles fixed on Al foil making use of aluminium carbide whisker.