The catalytic growth of GaN powders

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Synthesis of GaN powders employing catalysts are achieved by direct reaction of gallium and NH_3. The growth rate of GaN powders in the presence of Ni-mesh catalyst was much higher than that in the absence of the catalyst. Bigger grain size of GaN powders was synthesized in the catalytic growth reaction. It was considered that the Ni-mesh catalyst enhanced the decomposition of NH_3 gas into chemically active nitrogen atom as well as the formation of GaN nucleus on Ni surface.

The wide direct band gap of GaN are considered that the promise of short wavelength optical devices because of their exceptional optical and electrical properties[1, 2]. GaN films has been grown in MOCVD and MBE and efforts to find a proper substrate are continuously exerted because of big lattice mismatch and difference of thermal expension between epilayer and substrate[3-6]. GaN powders have been applied as a source of sublimation method. It has been considered that bulk crystal and nano size GaN are effective to the future optical applications. Especially nano size of GaN particles occurs quantum confinement effect to improve the luminescence of GaN[7,8].

GaN powders were grown by a direct reaction of liquid Ga and ammonia gas using catalysts. Bubbling method was adapted to induce the catalytic reaction. 50sccm NH_3(99.99%) was introduced into liquid Ga(8g) and Ni catalyst was filled in the reactor. At the first stage, the reactor was vacuumed and N_2, chemically inert against Ga, was slowly supplied to remove oxide impurities in the reactor and to regulate the reactor pressure at one atmosphere. After N_2 gas was supplied, H_2 gas was introduced into the reactor to activate the surface of Ni-catalyst, and temperature was elevated to 800℃. During increasing the temperature from 800℃ to the growth temperature, NH_3 was supplied into the reactor. The reaction time was dramatically decreased as the increase of the growth temperature. After the reaction, the temperature was slowly cooled down to room temperature. Ni catalyst and unreacted Ga were removed in the HCl solution and GaN powders was filled. The purified GaN powders were washed with distilled water and dried in the vacuum dry oven. To characterize the synthesized GaN powders, scanning electron microscopy (SEM), X-ray diffraction (XRD), Photoluminescence (PL), and Transmission electron microscopy (TEM) were employed to evaluate the crystal, optical and morphological properties of GaN powders. Mass spectroscopy were also used to analyze gas composition during the growth reaction of GaN powders.

Figure 1 shows the growth rate of GaN powders as a function of growth temperature in the presence and absence of Ni-mesh catalyst. The growth rate of GaN powders increases as the reaction temperature rises from 1000 to 1100℃ and the dependency of the growth rate on the growth temperature is much more significant in the presence of Ni catalyst. For 1100℃, the growth rate of GaN powders in the presence of Ni catalyst is almost 9 times higher than that in the absence of the catalyst. This result demonstrates that Ni-metal acts as an active catalyst for the growth of GaN powders. It is considered that the Ni-mesh catalyst enhances the decomposition of NH_3 gas into chemically active nitrogen species, but reduces the activation energy for the reaction of gallium with NH_3, resulting in the increase of the growth rate of GaN powders.

Figure 2 shows selected area diffraction patterns (SADPs) of the GaN powder grown using the Ni-mesh catalyst and scanning electron microscopy (SEM) images for GaN powders grown in the presence and absence of the Ni-mesh catalyst. The GaN powders were grown at 1000 ℃ and 1 atm with 50 sccm NH_3. The average grain size of GaN powders synthesized in the presence of the Ni-catalyst (5 - 8 μm) is larger than that in the absence of the catalyst (2 - 3 μm). It seems that the catalyst induces the increase of GaN particle size. This is because the catalyst is effectively used to generate chemically active nitrogen species that directly participate into the growth of GaN. It is considered that the increase of the GaN growth rate in the presence of the Ni-catalyst is mainly due to the increase of GaN powder grain size.

In this experiment, the growth rate of GaN powders rapidly increases in the presence of Ni-catalyst than in the absence of the catalyst. The reaction time is decreased in the catalytic reaction because of the active reactivity of ammonia species with Ga on the catalyst surface. Ni-mesh Catalyst used in the growth of GaN powder enhances the reaction rate and selectivity of the GaN powders because Ni-catalyst not only stimulates the decomposition of NH_3 gas, but also decreases the activation energy of the GaN powder growth

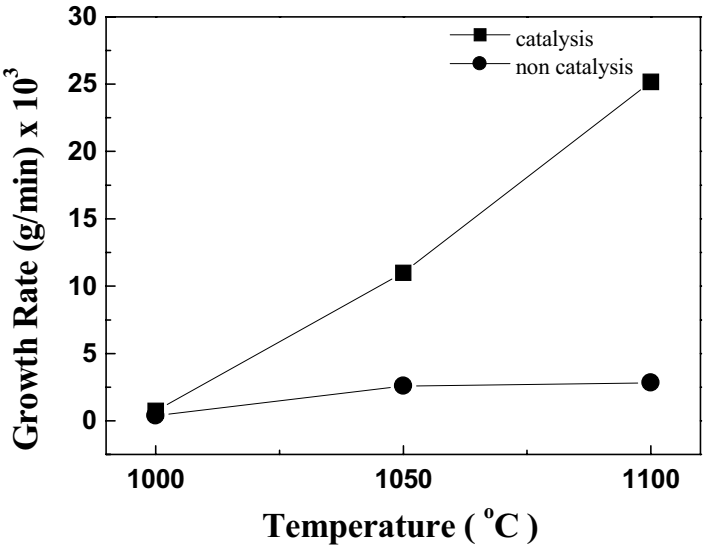
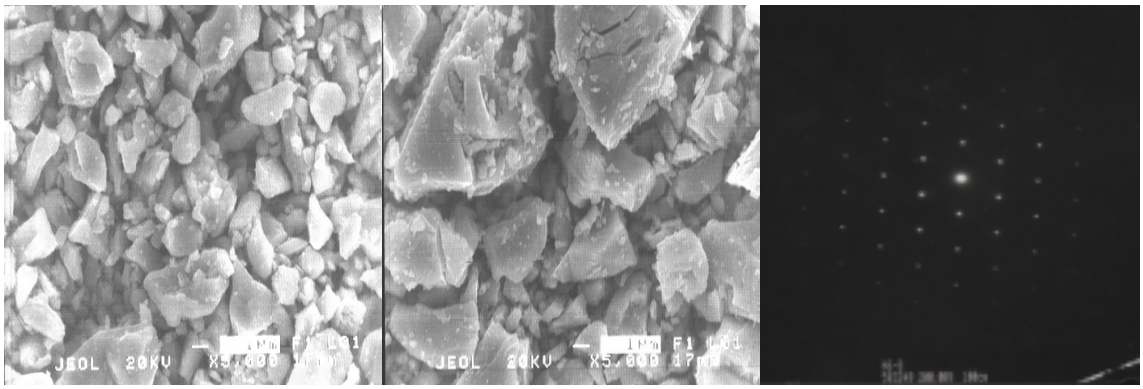


Figure 1. The growth rate of GaN powders as a function of growth temperature. (● : in the absence and ■ : in presence of Ni-mesh catalyst at 1atm with 50sccm NH_3.)



(a) (b) (c)

Figure 2. SEM images for GaN powders grown in (a) the absence and (b) presence of Ni-mesh catalyst at 1000℃ and 1atm with 50sccm NH_3 and Selected area diffraction patterns (SADPs) (c) of TEM

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