The Longer life wafer tray for MOCVD
-AlN ceramics (FAN090) by solid phase sintering-

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Introduction

GaN-base epitaxial wafer had been developing since the 1990s, and it is one of the promising for white-LED application market. On the other hand, it costs more that GaN-base epitaxial process than GaAs-base epitaxial process. The reasons of the rising costs are as below.

1)In GaN epitaxial process, the V/Ⅲ ratio is 10times or more than the GaAs-epi. So NH3 gas(V-group) consumption is much and the disposal cost is high.

2) The growth temperature is around 1100℃,that is over 500℃ higher than GaAs-base epitaxial process, so that brings the rising cost for maintenance and consumable parts. Furthermore, it needs over 1300℃ in AlN-base epitaxial wafer for UV-LED or GaN-power device which is developing these days.

3) In GaAs base MOCVD, relatively inexpensive carbon parts can be used, but for GaN base MOCVD, SiC coated carbon parts should be used because it is operated in high temperature and a plenty of NH3 gas flow above.

4)The thickness of SiC coat is so thin(around several hundred micron) that the physical strength of these coat is weak. Once, the coated SiC would be peeled or cracked , the inner graphite material would be reacted with NH3. That means these parts are broken. It is a serious problem that the life time of SiC coated graphite parts (ex. wafer tray) is only 1-2 months in mass production.

In this paper, we report that AlN ceramics can be used at high temperature in NH3 atmosphere and has longer life time than SiC coated graphite. AlN ceramics will contribute the cost reduction of GaN-base epitaxial wafer and also white-LED.

Experiment

At first we started to check the physical properties of every kind of materials. Our focus points are ; 1)usable in high temperature, 2)no reaction with NH3 gas and 3)low cost. Considering the thermal property —coefficient of thermal expansion, conductivity— ,we paid attention to SiC-bulk and AlN ceramics at first. About the thermal expansion, in case of using Sapphire(7ppm/℃) substrate, that of AlN is 4.5ppm/℃ and is nearer than that of SiC-bulk(3.7ppm/℃). (Table 1) Concerning thermal conductivity, SiC-bulk is superior than AlN at room temperature, but over 1000℃ (using on MOCVD), the both are almost the same. (Fig.1) At cost issue, SiC-bulk is 3 times higher than AlN ceramics. (Table 1) Furthermore,UV-LED of AlGaN is developing by many researchers in these days. It needs higher temperature around 1300℃ to make high quality epitaxial layer of AlGaN. AlN ceramics can be used in such high temperature. Considering the above, we decided to develop AlN ceramics for wafer tray of MOCVD.

The conventional AlN ceramics materials are mixed with 3~5% of Y2O3 powder as a sintering aid. The principle of sintering AlN is as follows. At first Y2O3 react with impurity Al2O3 on surface of AlN powder (raw material) and form Y-Al-O-N compounds. Y-Al-O-N liquid promotes particle rearrangement and densification in sintering temperature(~1900℃). However Y2O3 should be avoided because it might be also impurities for semiconductor process. To realize “Y2O3 free sintering”, we can not use liquid phase sintering like conventional AlN ceramics. Therefore, we paid attention to oxygen that is dissolved in AlN as Al-N-O and tried to sinter AlN ceramics by solid phase sintering.(Fig.2) The micro-texture is shown in Fig.3.

The larger size of grain can be seen in the right photo. It shows that the grain had grown well in high temperature. Some property of FAN230(containing Y2O3 as sintering aid) and FAN090 are shown in Table2. FAN090 contain no Yttrium. To check the durability, we put FAN090(30×30×10mm size sample) into an electric furnace at 1,100℃ with frowing NH3 gas. After over 1000 hours, neither weight change nor appearance change can be seen.

Result

We succeeded in development of AlN ceramics (FAN090) which does not contain any sintering aid. FAN090 is suitable for semiconductor process for its purity, thermal property and longer life time than SiC coated carbon. Some of our customers reported that it is over 5000 hrs and also their production yield was better by using FAN090

Table 1 Comparison materials properties

	Thermal Expansion (ppm/℃)	Thermal Conductivity (W/m/K)@RT	Thermal Conductivity (W/m/K) @1000℃	Cost
Si	4.1	140		
Saphire	7	40		
SiC	3.7	270	50	6
C	5	100	49	1
AlN	4.5	230	48	2

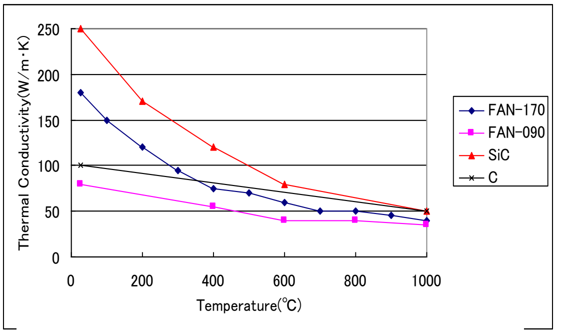

Fig.1 Thermal conductivity depend on temperature

Table 2 Comparison AlN conventional vs. developping

	Materials	FURUKAWA AlN	
Features	Unit	FAN-230	FAN-090
Thermal Conductivity	W/m·K(RT)	230	90
Heat radiation	(100℃)	0.93	0.93
Thermal Expansion Coefficient	10^{-6}/℃ (RT～400℃)	4.5	4.5
Volume Resistively	Ω·cm(RT)	$>10^{13}$	$>10^{13}$
Dielectric Strength	kV/mm(RT)	15	15
Dielectric Constant	(1MHz)	8.8	8.8
Dielectric Loss	10^{-4} (1MHz)	5	5
Bending Strength	MPa	350	300
Dencity	g/cm^3	3.3	3.2
Y	%	3.4	0
O	%	1.7	0.6

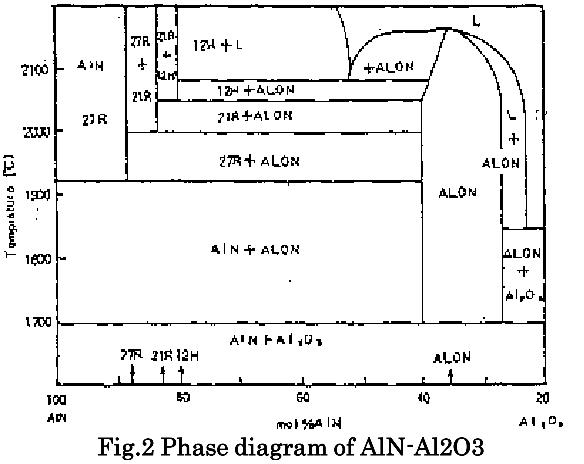

Fig.2 Phase diagram of AlN-Al2O3

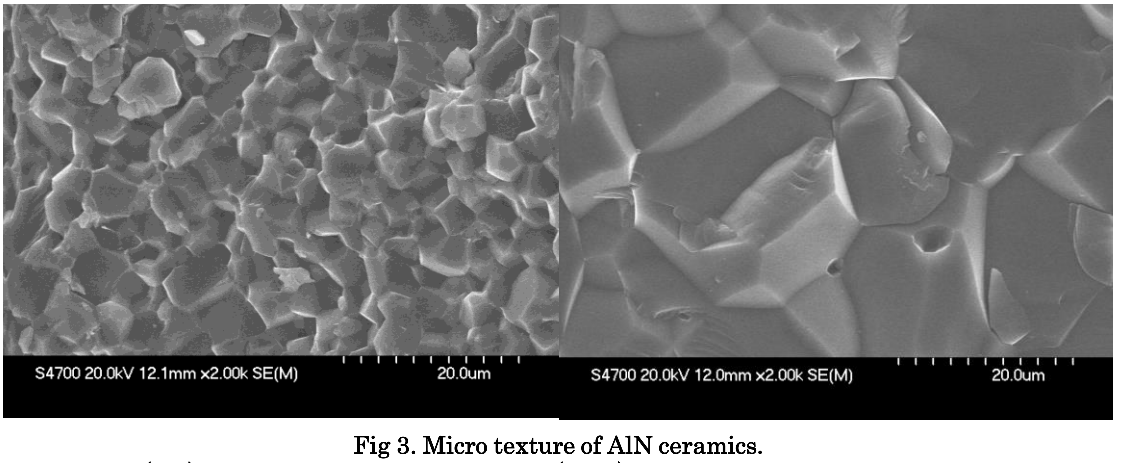

Fig 3. Micro texture of AlN ceramics.
(left) with sintering aid—Y2O3 (right)FAN090—solid phase sintering

Reference

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