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The Main Preparation Methods of Gan Films

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Abstract: *Wide band-gap semiconductor materials have many properties such as the big forbidden band width, high thermal conductivity, high dielectric strength, low dielectric constant, high electron velocity (saturated speed). In numerous wide band-gap materials, GaN and group III nitrides are noticeable. This is the third generation of new type of semiconductor material appeared after the second generation of semiconductor materials such as GaAs, InP, which can be widely used in high temperature electronics, power electronics, and high frequency, resistance to radiation and other fields. HVPE (hydride vapor phase epitaxy) is a kind of atmospheric pressure chemical vapor deposition technique. Its growth speed is fast, which can reach more than 100 um/h. Its manufacturing cost is low. The equipment process is relatively simple. It is the most effective way to grow thick film GaN and GaN crystal blocks. In this dissertation, we research the factors influencing on growing 4 inch GaN on sapphire substrate by vertical HVPE. We firstly design the reactor cavity structure of HVPE by using computer, then simulate and optimize the distance between substrate and the gas inlet. At last, the gravity and gas parameters influencing on the deposition of GaN is also discussed.*

Keywords: *HVPE; GaN; simulation; gravity; gas parameters*

I. Thin Film Epitaxial Technology

The contents of each section may be provided to understand easily about the paper. Although people for the growth of single crystal materials GaN body a lot of positive exploration, but because of GaN grows in the high temperature nitrogen dissociation pressure is very high, it is difficult to get a large size GaN body single crystal materials, so only in other heterogeneous epitaxial growth on the substrate.Suitable for GaN film epitaxial growth technology mainly include: hydride vapor phase epitaxy (HVPE), molecular beam epitaxy (MBE), metal organic chemical vapor deposition (MOCVD), chemical beam epitaxy (CBE), two step growth and lateral epitaxial growth, etc.

II. Hydride Gas Phase Epitaxial (HVPE)

HVPE is a common pressure chemical vapor deposition technique, which is the first to use this growing technique to produce GaN single crystal films. In 1967 Maruska and Tietjen made the first use of the technique on the sapphire substrate to produce large swaths of the GaN epitaxy, which led to a systematic study of GaN materials. Because HVPE method has a high growth rate, it is usually 50 to 200 MMS per hour for the preparation of the single crystal substrate of the GaN body. This GaC1 as source of grain growth technology, NH3 as N source, at about 1000 ℃ on the sapphire substrate can quickly grow good quality GaN thin-film, dislocation density can fall below 107 cm - 2.This is comparable to the quality of the current monocrystalline materials (109cm-2).The drawback of HVPE is that it is difficult to control the precise growth of the membrane, and the reaction gas is corrosive to the equipment, which affects the further improvement of the purity of the GaN materials. Until 1980, HVPE was widely used as a means of growing GaN. However, GaN, who grew up with the HVPE method, had a very high concentration of the base, so that he could not engage in the research of the p-type GaN, and was gradually replaced by the MOCVD. In recent years, the emergence of LED technology and the need for thick film self-supporting GaN substrate have brought the HVPE technology back on the radar.However, the homogeneity of the GaN films grown by HVPE has yet to be improved, and it is difficult to grow In the alloys of either In or Al.

III. Molecular Beam Epitaxy (MBE)

MBE prepared GaN began in 1975, MBE is with one or more heat in ultra high vacuum molecular or atomic beam to heat the substrate, through a series of physical and chemical processes, on the surface according to certain growth direction of GaN films. A prominent feature of MBE is the ability to grow atomically smooth mutated interfaces. Due to accurately control the material composition and doping, MBE has now become extremely versatile film preparation technology, not only can be used to grow the semiconductor thin film, but also can be used for metal and dielectric thin film growth. There are two branches of this production technique: the GSMBE and the metal-organic molecular beam epitaxy (MOMBE).The first method is to use the molecular beam of Ga directly as a source of III, as an N source for NH3, and to react on the substrate surface to produce nitride. This method can be used to achieve GaN growth at lower temperature. However, at low temperature, the cracking rate of NH3 is low, and the reaction rate of the group III metal is slow, the movement of the product molecules is poor, and the crystal quality is not high. In order to improve the quality of crystal, people studied in RF (Radio Frequency, the RF) or plasma assisted enhancement technique inspire N2 as N sources, and obtained more satisfactory results. The second method USES Ga's metallic organic matter as the source of III, which is produced by plasma or ion source, as N source, and produces nitride on the substrate surface. This method can be used to achieve GaN growth at lower temperature. Moreover, this method solves the problem of the low cracking rate of NH3 at low temperature, and is expected to obtain good crystal quality. The advantage of this approach is growth process can be characterized, low growth temperature, can accurately control the film thickness, particularly suitable for quantum well, ultra-thin layer structure of the material such as superlattices. The disadvantages are the complexity of the equipment, the large investment, the slow growth rate, the high surface defect density and the poor economic performance. It is not possible to meet the requirements of mass production for the extended layer, such as LEDs, which require thicker devices, such as LEDs. And when using a plasma assisted method, take measures to avoid the damage of high energy ions to the film.

IV. Metallic Organic Gas Phase Epitaxial (MOCVD)

MOCVD technique is Manasevit H first proposed in 1968, also known as metal organic vapor phase epitaxy (MOVPE), it is the metal organic compounds and gas with hydrogen hydride after switch network into the reaction chamber heating substrate, through thermal decomposition reaction and the final on the growth of epitaxial layer technology. The technology is now being used almost exclusively in gallium nitride. Is a common process of trimethyl Ga, trimethyl Al, trimethyl In as Ⅲ clan source, on the substrate reaction with NH3, while the temperature of the substrate is heated to above 1000 ℃.Using low temperature (550 ℃) on preexistence A12O3 substrate growth AIN or GaN buffer layer, then grow under high temperature (1050 ℃) GaN epitaxial layers. The main reaction occurs when MOCVD grows GaN: Ga (CH3) 3 + NH3, GaN. Its growth process involves the complex processes of gas phase and solid surface reaction kinetics, fluid dynamics and mass transport and their intermixing. MOCVD growth is at atmospheric pressure or low pressure, hydrogen carry metal organic source through stagnation gas layer on the surface of the substrate when some or all of the decomposed into atoms, III in the crystal lattice of the substrate surface movement to the right position, and captured in the substrate surface has been pyrolysis V atoms, thus forming groups III -v compound, or alloy. At normal temperatures, the MOCVD growth rate is determined primarily by the rate of diffusion of the metal-organic molecules of the III group of metal molecules through the stagnant layer (boundary layer).In general, in order to get better quality of the epitaxial layer growth conditions to choose in the growth rate of diffusion controlled area, that is to say epitaxial growth is in thermodynamic equilibrium conditions. MOCVD equipment is supplied by the source system (III or II family of metal organic compounds, V or VI hydride and doping source), gas transport and traffic control system, reaction chamber and the substrate rotation heating control system, exhaust gas treatment and security alarm system, etc. Its main advantage is suitable for the growth of elemental and compound thin film materials, especially the phosphide high vapor pressure, high Curie temperature (Tc) and superconducting oxide and metal film, etc.;In addition, the components and dopants of MOCVD used in the growth compound are gaseous sources, facilitating precise control and exchange of sources without exposing the system to the atmosphere. Combined with the growth rate than MBE and the temperature range of single epitaxial growth, less need to control the parameters etc, make the MOCVD technology for large area, multichip industrial scale production. Currently, the industrial production MOCVD equipment has been developed successfully and has been put into production. Weakness of MOCVD technique in addition to the source of metal organic (MO) and hydride is toxic to be doubly prevention, chemical pollution, the growth of the high temperature can make the material purity and compared with the MBE to interface quality. In addition, because of the thin film growth, general with two-dimensional nuclear shape and three-dimensional island growth is given priority to, the film quality is relatively poor, and metal organic matter decomposition is easy to produce the impurities such as carbon, hydrogen, making materials luminescence spectra appear noise band, namely yellow belt.In recent years, in order to make this kind of method to grow a better quality of semiconductor thin film, on the basis of MOCVD developed more buffer layer, high temperature buffer layer, shuangliu MOCVD technology, lateral epitaxial growth technology and the growth of two-step process.It is possible to predict that MOCVD technology will remain one of the main preparation methods for low-dimensional semiconductor materials for a long time to come.

V. Chemical Beam Epitaxy (CBE)

The chemical beam epitaxy (CBE) is a successful attempt to apply MOCVD sources to the MBE device, which combines the advantages of both MBE and MOCVD. And unlike the MBE and MOCVD, III organic metal compounds is not the source of gas before contact with the substrate but acquired in the thermal decomposition of substrate, the compound beam of the gas source as atomic beam in the MBE under low pressure direct injection to react with V elements on the substrate. As a result of the MBE operation mode makes the original MOCVD viscous flow into molecular flow, thus ensuring the uniformity of composition and thickness, film quality is significantly higher than the MOCVD film. In addition, this approach can still be maintained as high as the MOCVD technology. In order to further improve the CBE extension rate, similar to improved MBE, V compounds also by electron spin resonance excitation into plasma, thereby to improve the ability to react .

VI. The Two-Step Growth Method

Because the lattice mismatch of GaN and sapphire is too large, the two-step growth process must be adopted in order to obtain the good GaN outer layer of the crystal. That first at low temperature (500 ~ 600 ℃) grows very thin layer of GaN or AlN buffer layer (buffer layer), to adjust the temperature to higher temperature GaN growth.Akasaki first grew with AlN as a buffer layer with high quality GaN crystals. Then Nakamuara found that GaN as a buffer can get higher quality GaN crystals.

VII. Lateral Growth (ELO/ELOG

The ELO/ELOG can further reduce the dislocation density and improve the quality of the crystals in GaN's epitaxial layer. First, deposit a polycrystalline SiO2 on the sapphire substrate and then use lithography and etching techniques to form sapphire Windows and SiO2 bars. During the subsequent growth of MOCVD, GaN first grew on the sapphire window and then grew laterally on the SiO2 strip. The experimental results showed that the dislocation density of GaN on the SiO2 bar was several orders of magnitude greater than that of the sapphire window. The ELO technology has been applied to blu-ray LDs and has received satisfactory results.

VIII. This Article Summary

This chapter of GaN film epitaxial growth technology, mainly include: hydride vapor phase epitaxy (HVPE), molecular beam epitaxy (MBE), metal organic chemical vapor deposition (MOCVD), chemical beam epitaxy (CBE), two step growth and lateral epitaxial growth. In addition to the above preparation method for a semiconductor film epitaxial growth of other methods and sol gel method, hydrothermal method, laser assisted deposition method and dangling epitaxial growth method, etc. Anyhow, GaN as a kind of important compound semiconductor material, in the field of optoelectronics, semiconductor devices, magnetic materials have very important application prospect in the future study of its preparation methods will also become an important topic.

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