STRUCTURAL PROPERTIES OF III-NITRIDES RECEIVED BY UV STIMULATED TECHNOLOGY

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Abstract. In terms of structural studies, X-ray diffraction (XRD) studies are discussed in this paper. Based on the experimental results, X-ray diffraction graphs of III nitrides obtained with and without UV irradiation are shown and is evaluated the role of UV stimulation in magnetron sputtering technology.

Key words: 2θ degree, intensity, FWHM.

1. Introduction

The presented paper discusses the structural analysis of III nitrides (GaN, AlN, InN). These nitrides are obtained by reactive magnetron sputtering technology stimulated by ultraviolet radiation [1,2,3]. This technology has been the leading technology for many decades to obtain thin metallic, semiconductor and dielectric films. With this technology, it is possible to obtain not only individual elements, but also their compounds. Such compounds are represented by wide-bandgap semiconductors gallium nitride (GaN), aluminum nitride (AlN) and indium nitride (InN). For this purpose, magnetron sputtering takes place in the presence of the reagent gas whose chemical compound we want to obtain. In our case, such a reagent gas is nitrogen (N2). An important factor in obtaining clean and high quality materials along with technological processes is the use of clean precursor materials. These materials include the material to be sputtered from the magnetron, in our case gallium, aluminum and indium, and the purity of the reagent gas. The purity of the metals used in the experiments was 99.95%, and in the case of the reagent gas nitrogen - 99.9999%.

Novelty and innovation in the technology of obtaining III-nitrides is the use of ultraviolet (UV) radiation [4,5,6] directly in the process of obtaining nitrides. UV radiation (365 nm wavelength) falls directly on the surface on which the nitrides are grown. Its intense absorption by the deposited first monoatomic layers helps to change the mutual arrangement of atoms and by this way prevents the formation of defects, since the formation and growth of the crystal in any crystallographic direction depends on the structure of the first monoatomic layers. Since III-nitrides are obtained on sapphire plates, it becomes even more important in the technology to eliminate defects at the boundary separating the two environments. Because it is known that in relation to sapphire, III nitrides have a large lattice mismatch. Therefore, introducing an additional stimulating component and reducing defects is a priority in these studies.

2. Experiment

To obtain III nitrides, reactive magnetron sputtering technology is used, which is performed on a „УВН-2М-1'' vacuum unit. This device is equipped with a two-stage vacuum system - a mechanical pump and a turbomolecular pump. By their action, the vacuum system can obtain a vacuum of $1 \cdot 10^{-6}$ torr. Vacuum measuring instruments and mass spectrometer (RGA 200) for residual gas analysis are attached to the vacuum chamber (Fig. 1).

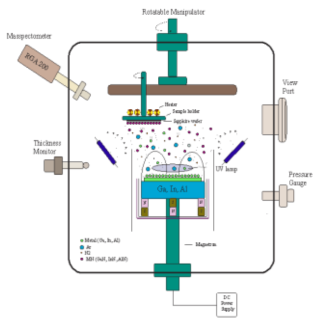


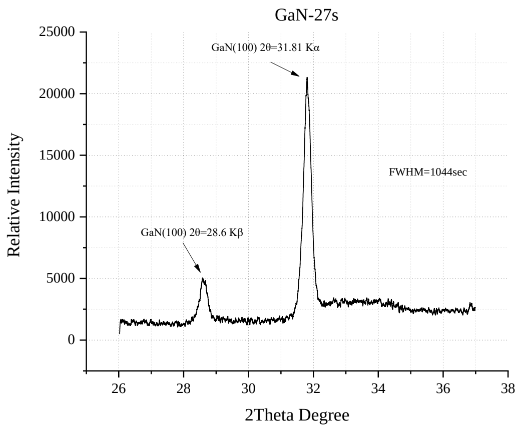
Fig.1 magnetron sputtering system

3. Results and disscutions

One of the important places in the research of III nitrides was determining the influence of UV radiation in the growth process of nitrides. As can be seen from Table 1, in the process of obtaining gallium nitride, UV stimulation accelerates the process and the deposition rate in the case of

GaN-37s and GaN-38s increases from 10.6 nm/min to 12.3 nm/min, while GaN-39s and GaN-40s increases from 17.2 Nm/min to 18.5 Nm/min. In the first case, the stimulation result is 16%, and in the second case is about 7%. The relatively low (7%) stimulation result is due to temperature and deposition current differences. In the case of a 16% increase, the average temperature is 650^0C and the deposition current is 100 mA, and in the second case the average temperature is 70^0C and the deposition current is 150 mA.

It is clear from the data that the structural parameters of GaN-38s are better (2θ=32.08; FWHM=828 sec) than those of GaN-27s. Also, the thickness of the sample obtained with UV (1511 nm) exceeds the thickness of GaN-27s (1272 nm). Which means that UV stimulation increases the deposition rate, and in the case of these two samples, the rate increased from 10.6 nm/min to 12.3 nm/min. Below are the X-ray graphs of GaN-27s and GaN-38s (Fig.2 and Fig.3).



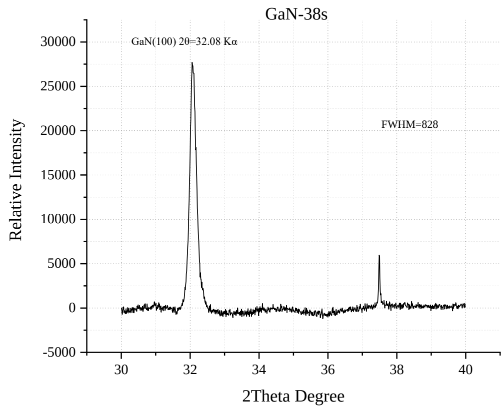
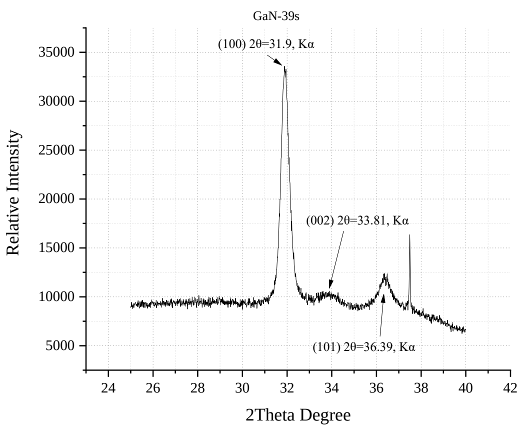


Fig.2 GaN XRD pattern for specimen GaN-27s **Fig.3 GaN XRD pattern for specimen GaN-38s**

Let's compare GaN-39s and GaN-40s samples obtained at low temperature. GaN-39s obtained without UV and GaN-40s obtained with UV. Thay have all other parameters the same. The same result is recorded here as in the case of the previous two samples. The structural parameters are better for the sample obtained by technological processes with UV, than for the sample obtained without UV. Here too, UV radiation stimulates the technological process and increases the deposition speed from 17.2 nm/min to 18.5 nm/min. It should be noted that the effect of UV stimulation in the case of these two samples is less pronounced than the previous two samples, both in terms of structure and deposition rate increase. which is mainly due to the low temperatures of growing GaN films.



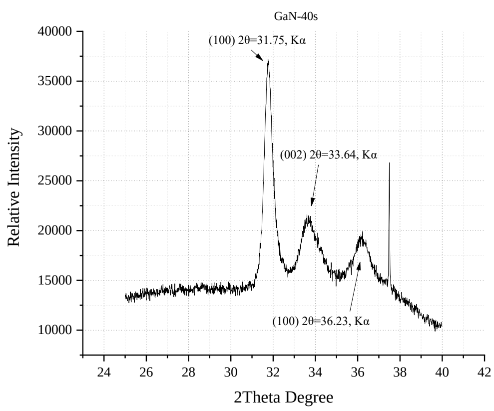


Fig.4 GaN XRD pattern for specimen GaN-39s **Fig.5 GaN XRD pattern for specimen GaN-40s**

4. Conclusion

Research outcomes have shown that stimulation with UV irradiation increases the deposition rate by up to 16%, and most importantly, the results of these studies show that UV exposure improves the structural properties of the deposited material. This was well demonstrated in the case of gallium nitride, when samples obtained at the same temperature, performed better those irradiated with UV rays.

Thus, multifaceted studies have shown that the properties of gallium nitride can be improved using technical and technological innovations. In particular, the inclusion of UV stimulation in reactive magnetron sputtering technology improves the properties of gallium nitride. For other III nitrides materials - aluminum nitride and indium nitride, the improvement of their parameters was not affected by UV exposure.

Acknowledgement:

The work is implemented under the #YS-21-488 project of Shota Rustaveli National Science Foundation of Georgia.

References:

[1] Kushitashvili Z., Bibilashvili A. Mechanism of Processes Stimulated by Ultraviolet Radiation. 6th World Multidisciplinary Earth Sciences Symposium, IOP Conf. Series: Earth and Environmental Science **609** (2020) 012051, doi:10.1088/1755-1315/609/1/012051

[2] Kushitashvili Z., Bibilashvili A., Biyikli N. Properties of Hafnium Oxide Received by Ultra Violet Stimulated Plasma Anodizing. IEEE Transactions on Device and Materials Reliability, Vol. 17, Issue: 4, pp. 667 – 671, December, 2017. DOI: 10.1109/TDMR.2017.2751078

[3] Bibilashvili A., Kushitashvili Z., Skhiladze G. Electrical, Optical and Structural Properties of Titanium Dioxide Dielectric Films Formed by DC Magnetron Sputtering. Nano Studies 2014, Vol. 9, pp.111-114, Decmber, 2014.

[4] Bibilashvili A., Kushitashvili Z. Low Temperature Oxidation of GaAs by UV Stimulated Plasma Anodizing. IOP Conf. Series: Earth and Environmental Science 44 (2016) 032002. DOI: 10.1088/1755-1315/44/3/032002

[5] Bibilashvili A., Kushitashvili Z. C-V Measurement of HfO2 Dielectric Layer Received by UV Stimulated Plasma Anodizing. IOP Conf. Series: Earth and Environmental Science 44 (2016) 052008. DOI: 10.1088/1755-1315/44/5/052008

[6] Kushitashvili Z., Bibilashvili A., Borisenko V. C-V Characterization and Electric Parameters of ZrO2 Received by UV Stimulated Plasma Anodizing. IOP Conf. Series: Earth and Environmental Science. 2019