Temperature characteristics of the photosensitive structures metal-AlGaN developed by vacuum thermal deposition

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Abstract. Broadband ultraviolet photodiodes are developed on the basis of Au-AlGaN Schottky barrier and also the ultraselection ultraviolet photodiodes with a photosensitivity range width on a half-height of 5 nanometers. We studied temperature effect on spectral characteristics of photosensitive structures of Au-AlGaN.

1. Introduction
At present photodiodes are widely used in various fields of science and technology. The use of wide-area semiconductor materials allows developing photodiodes for the ultraviolet range of a spectrum. The most preferable way during the development of photodiodes of an ultraviolet spectral range is solid solutions of AlGaN [1]. The increase in a share of AlN in a solid solution of AlGaN displaces long-wave limit of photosensitivity to the area of short wavelengths [2, 3]. One of the most promising avenues is a development of the selective ultraviolet photodiodes [4]. On the basis of a Schottky barrier of Ag-AlGaN possible to develop the high-performance selective photodiode on a wavelength of 322 nm [5, 6]. In addition, possible to develop the selective photodiodes with the inverse illumination at other wavelengths [7]. The use of the effect of tunnel transition of charge carriers and the filtering semiconductor layers in structure allows implementing the selective photodiode with a photosensitivity range width on a half-height (FWHM) of 5–6 nm [8]. At such small FWHM change of temperature of the photodiode can significantly change photosensitivity range. Therefore the research of temperature characteristics of such ultraselective photodiodes is important.

2. Samples and technique of experiments
Semiconductor structures of AlGaN by method chloride-hydride epitaxy on substrates of sapphire [9]. The ohmic and straightening contacts were put with vacuum thermal deposition. Ohmic Ti/Al contact was double-layer. Ti was an underlayer for Al. Thickness of a layer of Ti was 15 nanometers. Thickness of a layer of Al was 35 nanometers. Because of an interaction of Al and Ti with refractory metals they were sprayed from tungsten boats. During dusting of metals the structure was warmed up to the temperature of 300 °C. Annealing was made for decrease of resistance of ohmic contacts that was described [10] earlier. Au contact forming a Schottky barrier with AlGaN was developed 20 nanometers thick. Au was sprayed from molybdenum boats. During dusting of Au the structure was warmed up to the temperature of 120 °C. The general appearance of structure is shown in the figure 1. The research of ranges of a photosensitivity was conducted in two ways: when irradiating through semidiaphanous contact of Au and when irradiating from sapphire.
Figure 1. Sample structure of AlGaN.

Monochromator was used for measurement ranges of the diffraction photosensitivity. The xenon lamp was used as a source of radiation. The samples were established on an express holder with a thermoelement. The thermal element allowed to change samples temperature with an accuracy of 1%.

3. The experiment results and discussion

On figure 2 shown photosensitivity ranges at the frontal flare of a sample from contact Au for different temperatures. At the frontal flare of a sample in a short-wave part of a range of a photosensitivity interband transitions are shown, a decrease of energy of photons the photosensitivity determined by an emission of electrons from contact Au is observed. The photosensitivity arises at the energy of incident photons larger, than barrier height of metal-semiconductor. The research of ranges of sensitivity at different temperatures showed that the different dependence of short-wave and long-wave edge of a photosensitivity on a temperature of a structure is observed. It is apparent that temperature effect on the position of the long-wave edge of a photosensitivity is bound to change of height of a barrier metal-semiconductor from temperature. At the same time, first of all, the short-wave edge is defined by the surface states on the interface metal-semiconductor.

Figure 2. Photosensitivity range with irradiating from contact Au for different temperatures.

The dependence of provision of a wavelength on the temperature at the level of a half of intensity of a photosensitivity for the left-hand and right borders of a range is represented in figure 3. Obviously, temperature more affects on a position of the long-wave edge of a photosensitivity, than short-wave. The range of a photosensitivity of structure moves to the long-wave area and broadens. Photosensitivity range width on a half-height increases from 31 nanometers at a temperature of –50 °C to 38 nanometers at a temperature of 150 °C. Such change of a range of a photosensitivity though has fundamental character, but it is necessary to recognize its influence on performance characteristics of broadband photodiodes slight.
Figure 3. The dependence of the left-hand and right limits of photosensitivity on temperature of broadband photodiodes.

Temperature effect on ranges of a photosensitivity of the selective photodiode is more appealing. In the figure 4 are presented photosensitivity ranges at an illumination of an exemplar from the transparent sapphire substrate for different temperatures. In this case, the photosensitivity is caused only by an emission of electrons from metal. The position of a short-wave edge of a range is defined by the size of a width of the forbidden region of the semiconductor acting as an optical filter in structure. The position of a long-wave edge of a range is defined by a value of the height of a barrier metal-semiconductor.

Figure 4. A photosensitivity range with irradiating from a sapphire substrate for different temperatures.

Obviously, a change of temperature can significantly shift a range of a photosensitivity of the selective photodiode. Dependence of provision of a wavelength on a temperature in a photosensitivity maximum, and at the level of 0.1 from a photosensitivity maximum for a long-wave and short-wave spectral range it is shown in figure 5. It was established that a change of temperature can shift a photosensitivity maximum from 356 nanometers at -50 °C on a wavelength of 370 nanometers at a temperature of 150 °C.
Figure 5. The dependence of the left-hand and right limits of photosensitivity on temperature with irradiating from a sapphire substrate for different temperatures.

Such change of provision of a maximum of a photosensitivity with FWHM of 5 nm is important for the selective photodetector since the spectral area of the photoresponse significantly changes. For example, in our case, the range of a photosensitivity can be both in the visible spectral region, and in ultraviolet.

4. Conclusion

Broadband ultraviolet photodiodes are developed on the basis of Au-AlGaN Schottky barrier with a long-wave limit of photosensitivity about 365 nanometers were created. The selective photodiodes with the inverse flare with FWHM of 5 nanometers with a photosensitivity maximum wavelength of 362 nanometers at a temperature of 26 °C.

Temperature effect on ranges of a photosensitivity of the developed broadband and selective photodiodes is investigated. It is established that for the broadband photodiode change of temperature has a slight influence. The temperature of the selective photodiode is important as significant changes in an area of its photosensitivity.

References

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