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Optical FET Output Characteristics Research in Light-Activated Mode

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Abstract—This paper deals with researches of output characteristics of a field-controlled phototransistor with light excitation in a light-activated mode. Optical signal transformation mechanisms in a channel are determined, considering processes in a drain-gate junction. Criteria of base region effective modulation are specified. Obtained results can be used in design of new generation transistors.

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Photorecivers that receive optical signals of desired spectral band and sensitivity are widly used for optical electronic devices. They must provide signal transmission to following reception- transmission units. In this aspect field effect transistors (FET) with controlling *p-n*-junction in depletion mode application is of interest. An excitation of the transistor with deplection layer considers development of new optical reciver type, called light-activated transistor, that is, in fact, controled by light emission. In this case gate contact is not used as an active electrode. One of the problems of this struture application is absence of such planar structures compatibile with integrated circuit (IC). Another problem is lack of fabricating tecnology of FET with gate deplection layer channel. Schottky junction usage as a gate causes essential leakage currents [1]. So, the problem of optical FET development is urgent and it needs a solution.

The problem solution can be achieved mainly by development of optical transistor with deplection channel mode, caused by a draine-gate voltage, and optical signals are recived by drain and gate contacts [2]. This optical FET with *p-n* junction was illuminated by integrated visible light and obtained results are sufficient. Photocurrent values about 1 μA were obtained when the channel was illuminated by light with intensity up to 5000 lux [3]. For futher analysis of optical electronic devices it is of interest to consider not only cases of visible and infrared light (0.85, 1.3 and 1.5 μm illumination), but also case of low intensity light ilumination. For this purpose we research optical FET in light-activated mode to investigate its possible improvements for further development of the optical FET, with better parameters.

In this paper we present results of research of functional characteristics of gallium arsenide optic FET with controling *p-n* junction in light-activated mode.

Channel length of researched optical FET is 50 μm and its width is 0.32 μm. Channel area of *n*-GaAs, tin-doped up to concentration of $\sim 3\times10^{16}$ cm^{-3} is grown by means of liquid epitaxy on the top of intermediate epitxial *p*-GaAs layer with concentration of 3×10^{17} cm^{-3} and with thickness of 0.1 μm, which is grown on heavily p^{+}GaAs (2×10^{19} cm^{-3}) substrate. We selected such carrier concentration to provide channel effective overlap by bloking voltage, and it provides expansion of gate chanell space charge.

Reserched optical FET has typical drain volte-amper characteristics, shown in Fig. 1. If gate voltage is fixed, then drain voltage increase causes sublinear current dependence on voltage with great value of output resistance that provides high optical sensitivity of reserched optical FET [4, 5].

While blocking voltage increases from 0 to 1.6V, drain current decreases. Voltage increase causes increase of channel resistance, which means channel blocking by *p-n* junction space charge layer as it is shown in Fig. 1. This case corresponds to zero value of drain–source voltage, or to so-called process of channel blocking by means of voltage. So, channel resistance R_{ds} is a function of gate-source voltage [6]

$$R_{\mathrm{ds}} = R_0 / (1 - \{\mathrm{V}_{\mathrm{gs}} / V_{\mathrm{cut}}\}^{n}),$$