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Signal saturation in optical image sensors based on a non-ideal heterojunction

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The factors defining the dynamic range of an image sensor based on a non-ideal heterostructure have been studied (that range being about 10^5 for such devices). Two causes of the signal saturation are possible. The first one is the complete filling of trap centers in the space charge region while the second, the high field intensity at the hetero boundary (in this case, all carriers will cross the interface without recombination, thus, the recorded signal will also remain unchanged). The dependence of the heterojunction capacity on its illumination has been measured. It has been found that as the illumination intensity exceeds the value at which the signal saturation is observed, the photo capacity of the heterojunction continues to increase. Thus, the second signal saturation mechanism is realized.

Исследованы причины, определяющие динамический диапазон сенсора изображения на основе неидальной гетероструктуры (для такого прибора он составляет величину порядка 10^5). Возможны две причины насыщения сигнала. Это, во-первых, полное заполнение ловушечных центров в области пространственного заряда и, во-вторых, большая напряженность поля на гетерогранице (в этом случае все носители будут пересекать границу раздела без рекомбинации и регистрируемый сигнал также изменяться не будет). Проведены измерения зависимости емкости гетероперехода от его освещенности. Установлено, что при увеличении интенсивности освещенности выше значения, при котором наблюдалось насыщение сигнала, фотоемкость гетероперехода продолжала возрастать. Таким образом, реализуется второй механизм насыщения сигнала.

A non-ideal heterojunction is known to be usable as a converter of optical image into electric signal [1]. In this work, an optical image sensor was studied based on the CdS–Cu_2S non-ideal heterojunction [2]. The heterojunction was formed as follows. A CdS layer was deposited onto a glass substrate provided with a transparent tin dioxide conducting underlayer using pulverization of cadmium thiocarbamide and cadmium chloride. The subsequent annealing of the solid solution so obtained resulted in a polycrystalline film formation due to pyrolitic reaction:

$$CdCl_2 + CS(NH_2)_2 + 2H_2O \rightarrow$$
$$\rightarrow CdS\downarrow + 2NH_4Cl + CO_2\uparrow.$$

A copper chloride layer was deposited onto the obtained CdS layer using vacuum evaporation. At temperatures exceeding 200°C, the component diffusion took place accompanied by the chemical reaction of Cu^+ ion substitution for Cd^+ one in the solid phase:

$$CdS + 2CuCl \rightarrow CdCl_2 + Cu_2S.$$

Then, cadmium chloride was removed by washing the sample in distilled water. Such a converter is a strongly asymmetric heterojunction where the whole space charge region (SCR) is concentrated within the CdS having a higher resistance.

In this sensor, the signal is the short-circuit current generated in the narrow-band Cu_2S by the long-wavelength scanning probe. The current value is defined by the surface recombination rate of non-equilibrium carriers at the heteroboundary and by the electric field strength in the near-con-