POLY-Si SHORT WAVE PHOTODETECTORS

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Photoelectric properties of polycrystalline silicon films under influence of illumination were investigated. It was shown that polysilicon film with fine grain size may be use as short wave photodetectors due to the presence of shallow p-n junctions at their grain boundary.

During recent years an increasing interest is being towards high speed short wave photodetectors. It is known that sensitivity in this region of spectrum is obtained by the use of extremely shallow p-n junctions the formation of which presents some difficulties from the technological point view. For this reason the lightly doped poly-Si films are of interest due to the presence of deep traps at the grain boundaries which conditioned the formation of space charge regions the parameters of which could be controlled at a given concentration by changing the grain size [1]. Taking into account the grain size and the doping concentration level ratio in polycrystalline semiconductors the following cases can be realized. The grain conductivity type corresponds to that of impurity (high concentration, large grain size), either the depleted Shottky layers or the regions with opposite conductivity type are formed at the grain boundaries (average concentration and grain size). At last, at a low impurity level and a small grain size the space charge region can spread over the whole grain and condition is realized through intergrain spaces. The lightly doped space charge regions with small grain sizes can act as shallow p-n junctions at the grain boundaries of poly-Si films enabling their use as photodetectors and thus omitting the diffusion and ion doping steps.

In this paper the photon induced current properties of poly-Si films formed in the process of epitaxial growth of monocrystalline silicon films of n-type conductivity on the locally masked silicon substrates were investigated. The film thickness and the resistivity (ρ) was 6 μm and 0.2 Ω·cm respectively. The ohmic contacts to poly-Si were formed by vacuum deposition of Al on the previously formed n^+ regions.

The films with average grain sizes of 0.5 and 5 μm and linear sizes 200x20, 400x40 and 600x60 μm² were investigated. The measurements of poly-Si films under influence of illuminated showed that for both fine and large grain sized films the open circuit voltage U(I) was in proportion with film length. The short circuit current I(OS) didn't depend on the film's length and was defined by its width and the grain size within the film.

From the current voltage characteristics of the element with fine grain sized structure and area of $3.6 \cdot 10^{-2}$ mm² (Fig. 1) could be seen that the ratings of U(I) and I(OS) are 140 mV and 10 μA, respectively (curve 1) and the efficiency is the order of 5%. For the large grain sized films the corresponding ratings are 170 mV, 15 μA and 7 % (curve 2). It is known that after the electrical forming which consisted in forcing of current pulses (300 mA) through the film an effect of bystable switching could be observed in poly-Si films [2].

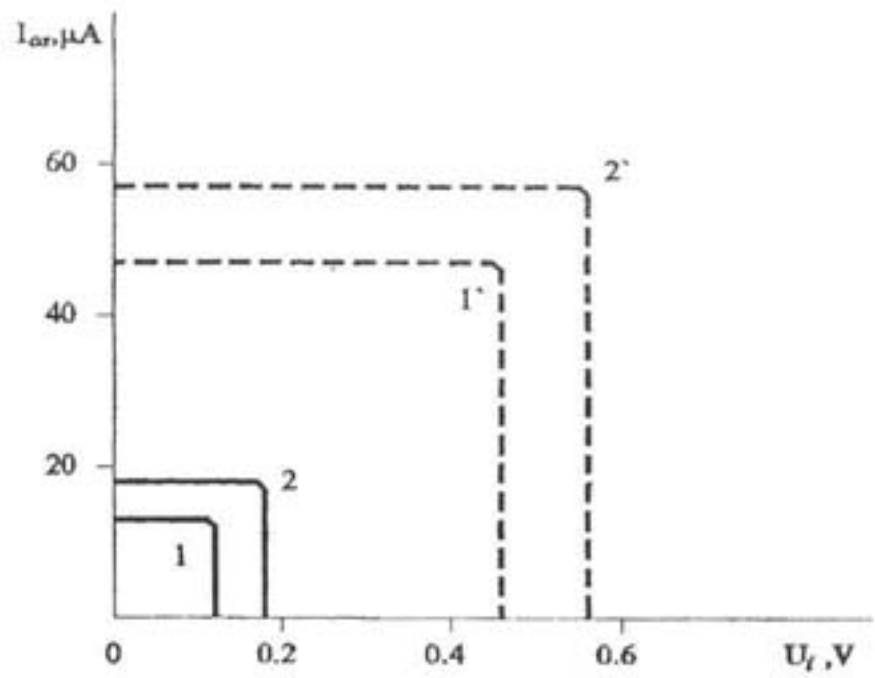

Fig. 1. I-V-characteristics before and after electrical formation fine grain (1,1') and large grain (2,2') poly-Si films.

In electrically formed films in a high resistance state *U(I)* and *I(OS)* were increased in 3-4 times. The supposition was made that the abrupt increase of poly-Si photocells efficiency is connected with the anomalous photoelectric voltage effect conditioned by the photo-EMF summing arising in space charge regions of grain boundaries after the electrical forming. According to the physical mechanism of switching suggested by the authors [3], the role of the electrical forming was in the thermal breakdown of one of the space charge regions of grain boundaries which at a given polarity of bias applied was reserve biased. These summing of photo-EMF, arising at the opposite grain boundaries is taking place in a way described in [4] for the periodic structures of p-n junctions connected with every other by metal jumper. As result of the electrical forming the efficiency of the fine grain sized poly-Si films with the incident light power being 93 mV/cm² is increased from 5 to 15%.

The electrically formed poly-Si was also measured in a light irradiation pulse mode. The light pulses were supplied by the light-emitted diode (LED) AL106 with the wavelength radiation and power being 0.9 μm and 2 mW, respectively. The LED was fed by the generator G5-54. The readings from the oscilloscope C1-65 showed the value of the output pulse height from the poly-Si film being 150 mV. The form of the output pulses from the poly-Si film was similar to that of the rectangular pulses supplied by the generator to LED up to maximum frequency being in the order of 90 kHz.

The absolute sensitivity spectral dependencies for the fine (curve 1) and large (curve 2) grain sized electrically formed

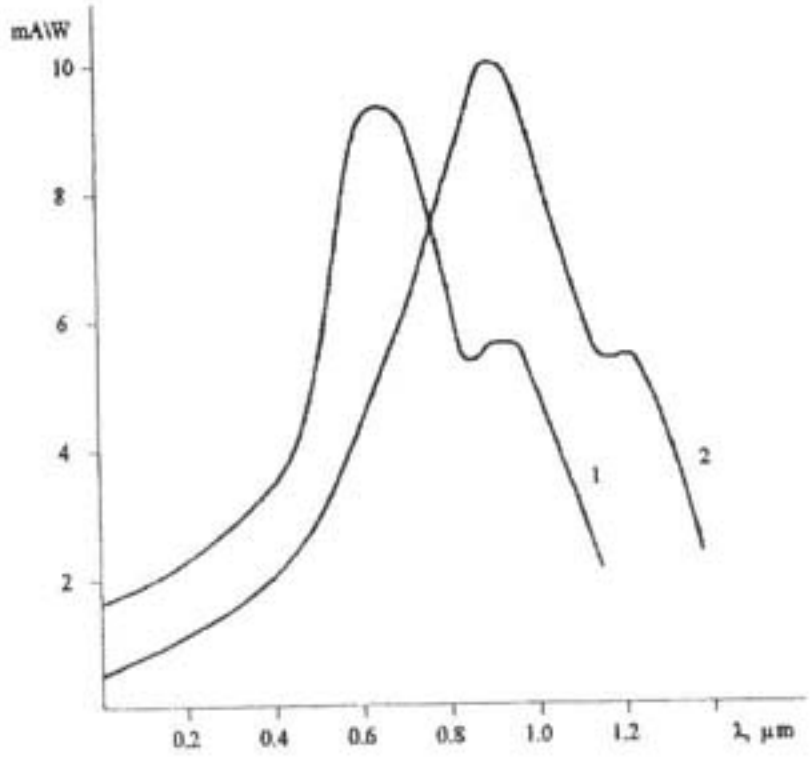

Fig. 2. Spectral dependence absolute sensitivity electrical formed poly-Si films. Curve 1 – fine grain sized; curve 2 – large grain sized.

poly-Si films are presented on Fig.2. As could be seen from the figure with the increase of grain size the pick of sensitivity is biased towards the longer waves. For the fine grain sized films the absolute sensitivity is 3.2 mA/W at the wavelength being 0.5 μm and its maximum rating of 10 mA/W is observed at λ=0.7 μm.

For the large grain sized films at 0.5 μm the sensitivity is 12 mA/W and its maximum rating of 11 mA/W is reached at the wavelength being 0.84 μm.

The integral sensitivity of poly-Si films was measured in a photo-resistive mode and for the fine grain sized film increases from 15 to 300 nA/Ix and for the large grain sized films one to 600 nA/Ix.

The investigations of photocurrent properties of poly-Si films showed the possibility of their use both as solar cells and photoresistors rated over wide range of the spectrum. The rather high sensitivity at short waves allows their use as photodetector in optic memory devices to read information with lasers having the wave's length of 514.5 or 632.8 μm [5].

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QISA DALĞALI POLİSİLİSİUM FOTOQƏBULEDİCİLƏRİ

İşıqlanmanın xırda və iri dənəcikli polikristallik silisisium təbəqələrin fotoelektrik xassələrinə tə'siri tədqiq olunub.

Göstərilib ki, polisilisium dənəciklərinin sərhədlərində dayaz p-n keçidlər olduğuna görə, xırda dənəcikli təbəqələr ultrabənövşəyi fotoqəbuledicilərdir.

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КОРОТКОВОЛНОВЫЕ ФОТОПРИЕМНИКИ НА ОСНОВЕ ПЛЕНОК ПОЛИКРИСТАЛЛИЧЕСКОГО КРЕМНИЯ

Исследовано влияние освещения на фотоэлектрические свойства крупнозернистых и мелкозернистых пленок поликристаллического кремния в режиме солнечных элементов. Показано, что мелкозернистые пленки, благодаря неглубокому уровню залегания p-n переходов на границах зерен, являются ультрафиолетовыми фотоприемниками.

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