SILICON BASED COLOR PHOTOSENSITIVE CELLS WITH DEEP COLOR SEPARATION ON P+-P JUNCTIONS: CONSTRUCTIVE AND TECHNOLOGICAL DESIGN PROBLEMS

Modern semiconductor color matrix photo receivers have a great variety of applications in different science and society areas. Most of them are based silicon technology. This technology offers the opportunity to unite two processes: first - image processing and second analog to digital conversion on a single chip

Silicon photocells have high quantum sensitivity but low spectral selectivity in the visible light spectra.

That is why there are used polymer microlenses and color filters to obtain color images. They are require some additional technological operations for example hybrid technology operations and makes final devices more expensive.

In the present work is proposed semiconductor photocells design method which is based on deep color separation. The main princilpe of deep color separation method is the relationship of light absorption versus light quantum wave length.

Modern silicon based photo matrices utilize complicated transistor- or tiristor based spatial structures, as for example it can be mentioned devices developed by Foveon Inc. There are used opposite p-n junctions electric fields to separate photocurrent on three components.

Unfortunately the technological process is very expensive in this case, because to form deep color separation layers requires high precision epitaxy process and former specific operations.

The design program of matrix photo receivers based on complementary metal-oxide semiconductor (CMOS) technology was started in Russia. The program was based on the proposed method of colors photocurrent separation in the structures with isotype p+-p junctions.

However, there are several problems we used to overcome:

1) low reproducibility of doping profiles because of deep layers implantation,
2) how to unite two different processes: color photo matrix production and image reading elements
3) how to meet control schematics requirements.

First of all we found that fact that to split diffusive current of not main charge carriers we do not need high electric fields, and that values which can be found in p+-p on n+-n junctions are enough. Because there are no light n-type impurities we decided to realize our construction based on p+-p isotype junctions.

The curve slope in low waves area and slight fluctuations are occurred because of absorption and interferention of light in multilayer dielectric cover of the tested IC.

BB layer is formed with implanted Boron in the depth of 2.5 mkm. We see that spectral sensitivity curve demonstrates the significant reduction in the red and IR parts of the spectra.

This effect is originated because of that BB layer prevents collection of the charge carriers which are formed on the depths responsible for red and infra- red parts of the spectra. In the case of p+ barrier depth reduction we will see the sensitivity curve moving to the side of shorten waves.

However during the technology process optimization it was found the problem of barrier layers joint. This effect occurred because of ion implantation and former annealing these processes can lead to the cross diffusion of the impurities of both barrier layers.

The final results:

1. In the present work it is demonstrated that for effective color separation in the silicon based photo receivers can be used isotype p+-p energy barriers instead of opposite p-n junctions. These barriers are formed by layer implantation with two orders difference of the concentration magnitude.

2. The vertical integration of "red", "green" and "blue" photo sensitive elements is formed with lateral electron diffusion in p+-p-p+ channels which provides effective electron pathway to the remote n+ contacts.

3. The effective color photocell spectral sensitivity optimization is provided by the variation of the barrier layers depth. The quantum spectral sensitivity dispersion is measured to be 12% for p-n junction, and three times less (4 %) for isotype p+-p junction. These results are obtained in the case of technology process implantation energy dispersion which resulted in color separation border depth drift for 0.1*10-6 m.

4. It is found that depth distance between barriers the most critical parameter for the green color part of the spectra. It is proposed to apply compensative n-layer to eliminate p+ layers joint.

5. It is proposed to apply epitaxial substrates or p+ barrier layer for the photo matrix IR sensitivity reduction.

6. The presented results describe integration of the high-resolution silicon based photo reciever, image reading and processing schematics on the single crystal manufactured with the standard CMOS technology process.