# Study of anti-Stockes photoluminescence process in semiconductors

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**Abstract**

We start to introduction and study of Anti-stock photoluminescence process in this article, which is very considered in semiconductors industry recently. In Anti-Stockes photoluminescence process, the energy of output photons is bigger than energy excitation of sample. For this reason, we have described completely, mechanisms which use often for explanation of this process. Thus, we have studied factors which are effective for efficiency increase of this process.

**Keywords:** Anti-stock photoluminescence, semiconductors.

**Resumen**

En este artículo empezamos nuestra introducción y el estudio del proceso fotoluminiscente anti-Stockes, el cual es muy considerado recientemente dentro de la industria de los semiconductores. En el proceso fotoluminiscente anti-Stockes, la energía de los fotones de salida es mayor que la energía de excitación de la muestra. Por esta razón, hemos descrito completamente los mecanismos que se utilizan en la explicación de este proceso. Entonces, hemos estudiado los factores que son efectivos para incrementar la eficiencia de este proceso.

**Palabras clave:** Fotoluminiscencia anti-Stockes, Semiconductores.

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## I. INTRODUCTION

Semiconductor materials are located in fourth column and beside columns of periodic table. Silicon (Si) and Germanium (Ge), semiconductors of fourth group, are called single element semiconductors, because, they have organized of compatible atoms. In addition to, single element materials, combination of the fifth and third group's atoms and also special combinations of sixth and second group's elements, create compound semiconductors. The expansive variety of semiconductor materials properties, lets to electronical sectors engineers which plan many electronical and optoelectronical orbits. We can find out their properties, with study of radiation's an electromagnetism ray to a semiconductor and observation the results of this reaction with semiconductor element. If descending photon energy be equal or bigger band gap of the sample, is absorbed by a sample and with stimulate an electron from valence band to conduction band causes hole-electron pair. The process of photon extinction which lead to production of hole-electron pair, is called absorption process. As we know, the nature, always wants to locate at energy's minimum, and stimulating electron by entrance photon is in this form. Therefore, after short time, electron returns to valence band and with extinction hole-electron pair produce energy again, which this process of electron's returning to valence band, is called recombination. If electrons of the semiconductor are instigated by ray of laser, emission ray (photon form) results from hole-electron pair's recombination process, which is called luminescence and the way of an optical study of this process, is called photoluminescence. Luminescence term is extracted from Latin term (LUMENE) which means ray.

## II. THE PROBLEM

The physicist, Eihard Widemann, for the first time, in 1888, introduced luminescence for describing all of the ray's processes that they haven't existed with temperature increase. But, photoluminescence, is one of the strongest and the most useful techniques of optical studies [1, 2, 3, 4, 5]. In this way, for stimulating of electron, we should use of laser which it should have bigger wave length than a sample of band gap. But, sometimes, we don't have enough tool for stimulation a sample of laser with higher frequency toward band gap, and we must use of laser with lower frequency toward band gap. The quality of this process lead to introduction of photoluminescence Anti-stock process and study of effective mechanisms in it. In

photoluminescence Anti-stock process, descending's photon energy for stimulation a sample is less than emission photon energy. For an example, we stimulate a sample by laser with red photons and the sample transmits from itself blue photons. Observation and study of this process is very important at efficiency increase of photic diods (LED). Photoluminescence Anti-stock's process is in this manner, which electron of valence band with absorption's descending photon energy, take itself to a virtual level at band gap's area and from there, take itself to the edges of conduction band by suitable mechanism which would be explained and then, radiative recombination's process is done in valence band by settled hole. The process of absorption's lower energy by a sample and sending of higher energy, is named energy conversion [6, 7, 8, 9, 10].

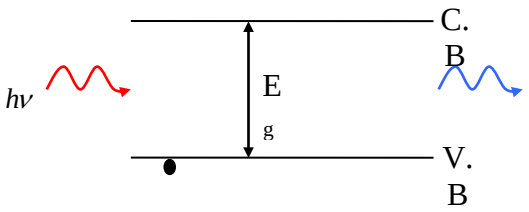


**FIGURE 1.** The sketch of photoluminescence Anti-stock's process, descending photon's energy (hv) is smaller than band gap (hv<Eg).

For explanation energy conversion in Anti-stock photoluminescence process, we introduce mechanisms:

**A.One step two photon absorption**

This process, will be explained with coherence two photon's absorption at one step by a sample and with assumption of a middle state in sample. The energy of a photon is less than sample's band gap. At first, the valence band's electron with absorption descending's photon, take itself to virtual level, and then, is moved to conduction band. Radiative recombination's result of an electron with settled hole in valence band is a photon that is size of band gap and or total two descending photon from the point of view of energy.

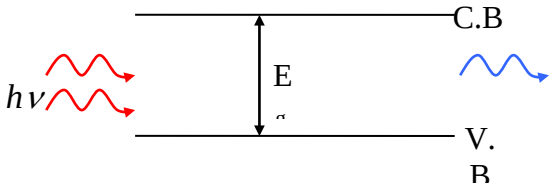


**FIGURE 2.** The sketch of one step two photon absorption's process.

**B. Two step two photon absorption**

In this process absorption of excitation photons is done at two steps. At the first step, after absorption of a photon, is formed an electron and hole near to common border of heterostructure and semiconductor of area with smaller band gap. Then, the other photon, is absorbed by settled hole at valence band of semiconductor with smaller band gap, and this hole get enough energy for penetration valence band of semiconductor with bigger band gap. At last, is done radiative recombination between this hole and electron which is delivered to conduction band of semiconductor with bigger band gap.

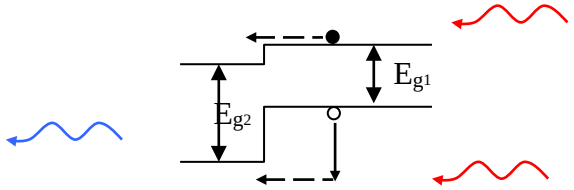


**FIGURE 3.** The sketch of two step two photon absorption's process at heterostructure, type (II).

It is mentionable, this process, is done at heterostructure, type -I with absorption of three photon and at three step. descending photon's energy is bigger than semiconductor's band gap with smaller band gap, but is smaller than semiconductor's band gap with bigger band gap. Therefore, bandalighnment, type –II at common border of heterostructure is effective factors at efficiency increase of Anti-Stockes photoluminescence.

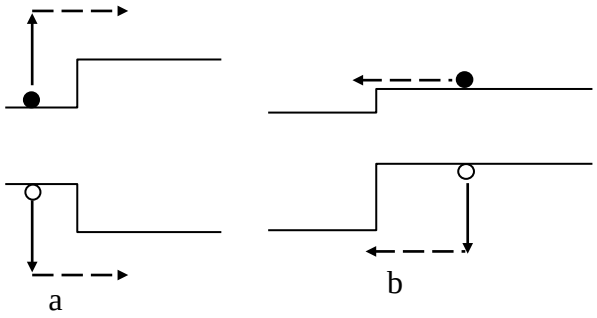


**FIGURE 4.** The sketch of energy conversion for :A hetrostrucre type- I, b. :a.hetrostrucre type-II.

Because, as you see in picture (4), in heterostructure, type -I, the hole and the electron should overcome, obstacle energy and take itself to semiconductor's area with bigger band gap, whereas in heterostructure, type -II, it is enough to do energy conversion only for one type of carriers. In fact, for observation of photoluminescence Anti-stock's signal of a sample, absorption three photon in heterostructure, type -I and absorption two photon in heterostructure, type -II, is necessary .The other factor, that is very important in efficiency increase of photoluminescence Anti-stock's process, is band's jump and decline (localized state at conduction band) at semiconductor's area with bigger band gap, (in heterostructure, type -I) which avoids of carrier's return to material with smaller band gap.

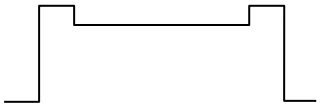

**FIGURE 5.** The sketch of the presence localized mechanisms at conduction band. According to studies, the sample.

## III. CONCLUSION

In this article, we have introduced photoluminescence Anti-stock's process which is very important at semiconductor's industry, and also we have studied mechanisms which are used for explanation this process.

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