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PHOTOCONDUCTIVITY IN BILATERAL MACROPOROUS SILICON

The specific photoconductivity and the excess minority carrier concentration in bilateral macroporous silicon depending on the pore depth and the bulk lifetime of minority charge carriers are calculated. The diffuse model is used to calculate the photoconductivity and the excess minority carrier concentration. The mathematical description of the diffusion model contains a general solution to the diffusion equation and a boundary condition written at the boundaries of a monocrystalline substrate and a sample of bilateral macroporous silicon. It is taken into account that light illuminates the monocrystalline substrate through the bottom of the pores. The dependence of the specific photoconductivity of bilateral macroporous silicon on the pore depth and the bulk lifetime of minority charge carriers decrease, if the pore depth increases, and if the bulk lifetime decreases. The dependence of the excess minority carrier concentration on the coordinate and bulk lifetime of minority charge carriers in bilateral macroporous silicon has one maximum in the case of uniform generation of excess charge carriers or two maxima in the case of inhomogeneous generation of excess charge carriers.

Keywords: bilateral macroporous silicon, photoconductivity, porous, excess charge carriers.

1. Introduction

Bilateral macroporous silicon is a new material. The work on improving the light trapping of macroporous silicon led to the idea that the light scattering should be enhanced by creating pores on the other side. The light scattered by the first macroporous layer is additionally scattered by the second macroporous layer, which increases the scattering angles and the total scattering of light in the material. Reflection of light in one-sided macroporous silicon occurs as follows. The layer of macroporous silicon reduces the reflection of light from the porous surface, compared to the flat surface of a silicon single crystal, due to the penetration of light into the pores. Light entering the pores is reflected from the walls of the pores. It partially passes through the surface of the pores at each reflection. The layer of macroporous silicon scatters light due to multiple reflections from the walls of the pores and a non-flat profile of the bottom of the pores. Scattered light penetrates into a monocrystalline substrate at different angles, which increases its optical path and absorption [1]. The absorption of light depends on the structure of the surface and the pores. The duration and modes of the photoelectrochemical etching of macroporous silicon affect the silicon thickness between pores, the pore diameter, and the surface structure. Improving the light trapping by macroporous silicon is achieved by optimizing the conditions of photoelectrochemical etching. Macroporous silicon, which strongly absorbs light or black silicon, can be created from nanospike arrays [2]. Macropores on the surface of a silicon monocrystal improve the light absorption. Therefore, the structure of macroporous silicon is used in solar cells. A macroporous silicon solar cell is fabricated with an implanted boron emitter. The macroporous silicon layer in the solar cell has a pore volume fraction of 26 and a thickness of 34 μm. The energy conversion efficiency in a macroporous silicon solar cell reaches 13.5% [3]. Films of aluminium-doped zinc oxide are sputtered onto the surface of macroporous silicon to fabricate a solar cell heterojunction. Such solar cells made of macroporous silicon are inexpensive, clean, and durable and efficiently convert light into electricity [4]. A theoretical model was proposed for the optimization of silicon solar cells. The model optimizes key parameters of surface textured silicon solar cells such as open circuit voltage, short circuit current, and photoconversion efficiency. The computational model accounts for the existing recombination mechanisms and additionally includes the recombination of electron-hole pairs in the space charge region and non-emitting Auger recombination of excitons through deep impurity levels [5]. The experimental temperature dependences of the photo-emf were measured in a two-dimensional structure of macroporous silicon during the generation of excess charge carriers by light with wavelengths of 0.7, 0.94, and 0.95 μm, and have a maximum at a temperature of 230 K. The relaxation of the photoconductivity of a two-dimensional structure of macroporous silicon was measured in the temperature interval $T = 80 \div 300$ K. The temperature dependence of the relaxation time of photoconductivity has an activation section with an activation energy of 0.3 eV in the interval $T = 180 \div 300$ K and does not depend on the temperature at $T < 100$ K [6]. A theoretical model was developed to determine the effective lifetime of minority charge carriers in macroporous silicon with a periodic arrangement of macropores. Theoretical calculations were compared with experimental measurements of the effective lifetime of minority charge carriers in macroporous silicon with an average pore diameter of 2.4 μm and an average distance between pore centers of 5.2 μm. The experimental results agree with the theoretical ones at a surface recombination rate of 24 m/s [7]. Analytically derived equations determine the effective lifetime of minority charge carriers in bilateral macroporous silicon. The bulk lifetime, the surface recombination velocity, the diffusion of minority carriers, and the distance to the recombination surfaces affect the effective lifetime of minority carriers in a two-dimensional structure of macroporous silicon. The depth and diameter of the pores, the distance between the pores, and the volume fraction of macropores determine the effective lifetime of minority charge carriers in the macroporous silicon layer. The thickness of a monocrystalline substrate and effective recombination in macroporous layers determine the effective lifetime of minority charge carriers in bilateral macroporous silicon [8]. The dependence of the excess minority carrier concentration on the coordinate in a bilateral structure of macroporous silicon has one or two maxima, when the sample is illuminated with light of 0.95 μm and 1.05 μm, respectively. The thickness of each porous layer was different. Diffusion of excess charge carriers to porous layers and their recombination on the pore surface change the distribution of excess minority carrier concentration in the bilateral structure of macroporous silicon [9]. Photoconductivity in porous silicon with spherical and cylindrical pores was calculated by analytical and numerical methods. It decreases with an increase in the surface recombination rate and an increase in the pore diameter. The difference between analytical and numerical calculations is observed in the cases where the pore diameter is small, and the distance between them is large [10]. The works cited above describe photovoltaic and electrical characteristics in single and bilateral macroporous silicon and in solar cells based on macroporous silicon. The photoconductivity in one-sided macroporous silicon was described in [10]. Bilateral macroporous silicon is a new material. The study of the photoconductivity of this material is relevant for those involved in bilateral solar cells. The purpose of this work is to find and analyze the dependence of the photoconductivity in bilateral macroporous silicon on the pore depth and the bulk minority carrier lifetime. To this end, expressions will be written that describe the concentration distribution of excess minority charge carriers and the photoconductivity in bilateral macroporous silicon. The excess minority carrier concentration depending on the coordinate and bulk minority carrier lifetime in bilateral macroporous silicon is calculated by a numerical method. The work will be useful for developers of solar cells and devices based on bilateral macroporous silicon.

2. Excess Carrier Concentration Depending on the Coordinate and Bulk Lifetime of Minority Charge Carriers in Bilateral Macroporous Silicon

Figure 1 shows a scheme of bilateral macroporous silicon, which consists of a frontal macroporous layer (light is incident on it), a monocrystalline substrate, and a back macroporous layer. The excess minority carrier concentration in the frontal macroporous layer ($i = 1$), monocrystalline substrate ($i = 2$), and the back macroporous layer ($i = 3$) under a steady-state condition is written as:

$$\delta p_i(x) = A_i \cosh\left(\frac{x}{L_i}\right) - B_i \sinh\left(\frac{x}{L_i}\right) - G_i(x), \quad (1)$$

where A_i, B_i are constant, $i = 1, 2, 3$, $G_i(x) = K_i G_i^*(x)$, $K_1 = 1$, $K_2 = K_3 = 1 + P_1(\exp(\alpha h_1) - 1)$, $G_i^*(x) = g_{0p}(\alpha)\alpha\tau_i \exp(-\alpha x)/(\alpha^2 D_p \tau_i - 1)$, α is the absorption coefficient of silicon, $g_{0p}(\alpha)$ is the rate of generation of excess minority charge carriers on the surface of the frontal macroporous layer, $L_i = \sqrt{D_p \tau_i}$ is the diffusion length, τ_i is the bulk lifetime of excess minority charge carriers in the frontal macroporous layer ($i = 1$), monocrystalline substrate ($i = 2$), and rear macroporous layer ($i = 3$), respectively, D_p is the diffusion coefficient of minority charge carriers, $P_1 = \pi D_{\text{por1}}^2/(4a_1^2)$ is the volume fraction of pores, h_1, D_{por1}, a_1 are the pore depth (thickness), pore diameter, and the distance between the centers of the pores of the frontal macroporous layer, respectively (see Fig. 1). Expression (1) contains constants that are found from the boundary condition written at the boundary of porous layers with a monocrystalline substrate and at the boundary of the material. On the frontal surface of a bilateral macroporous silicon sample, the boundary

$$A_1 \frac{s_1 L_1}{D_p} + B_1 - G_1(0)\left(\alpha L_1 + \frac{s_1 L_1}{D_p}\right) = 0. \quad (2)$$

The boundary condition at the boundary of a monocrystalline substrate with frontal and rear macroporous layers:

$$\left[A_1 \sinh\left(\frac{h_1}{L_1}\right) - B_1 \cosh\left(\frac{h_1}{L_1}\right)\right] \frac{D_p}{s_{\text{por1}} L_1}(1 - P_1) + $$
$$+ A_2 \left[P_1 \cosh\left(\frac{h_1}{L_2}\right) - \frac{D_p}{s_{\text{por1}} L_2} \sinh\left(\frac{h_1}{L_2}\right)\right] + $$
$$+ B_2 \left[P_1 \sinh\left(\frac{h_1}{L_2}\right) + \frac{D_p}{s_{\text{por1}} L_2} \cosh\left(\frac{h_1}{L_2}\right)\right] + $$
$$+ \alpha D_p \delta p_{g1}(h_1) - G_2(h_1)\left(\frac{\alpha D_p}{s_{\text{por1}}} + P_1\right) = 0, \quad (3)$$

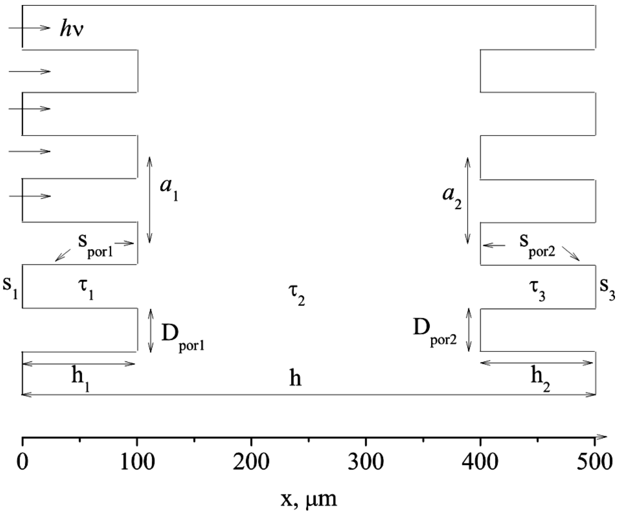

Fig. 1. Scheme of bilateral macroporous silicon

$$A_2 \left[P_2 \cosh\left(\frac{h - h_2}{L_3}\right) - \frac{D_p}{s_{\text{por2}} L_2} \sinh\left(\frac{h - h_2}{L_2}\right)\right] + $$
$$+ B_2 \left[P_2 \sinh\left(\frac{h - h_2}{L_3}\right) + \frac{D_p}{s_{\text{por2}} L_2} \cosh\left(\frac{h - h_2}{L_3}\right)\right] + $$
$$+ \left[A_3 \sinh\left(\frac{h - h_2}{L_2}\right) - B_3 \cosh\left(\frac{h - h_2}{L_2}\right)\right] \times $$
$$\times \frac{D_p}{s_{\text{por2}} L_3}(1 - P_2) + \alpha D_p \delta p_{g1}(h - h_2) - $$
$$- G_2(h - h_2)\left(\frac{\alpha D_p}{s_{\text{por2}}} + P_2\right) = 0, \quad (4)$$

where $P_2 = \pi D_{\text{por2}}^2/(4a_2^2)$ is the volume fraction of pores, h_2, D_{por2}, a_2 are the pore depth (thickness), pore diameter, and the distance between the centers of the pores of the rear macroporous layer, respectively (see Fig. 1). The concentration at the boundary of a monocrystalline substrate with macroporous layers should not have a discontinuity. Therefore, we have

$$A_1 \cosh\left(\frac{h_1}{L_1}\right) - B_1 \sinh\left(\frac{h_1}{L_1}\right) - A_2 \cosh\left(\frac{h_1}{L_2}\right) + $$
$$+ B_2 \sinh\left(\frac{h_1}{L_2}\right) - G_1(h_1) + G_2(h_1) = 0, \quad (5)$$

$$A_2 \cosh\left(\frac{h - h_2}{L_2}\right) - B_2 \sinh\left(\frac{h - h_2}{L_2}\right) - $$
$$- A_3 \cosh\left(\frac{h - h_2}{L_3}\right) + B_3 \sinh\left(\frac{h - h_2}{L_3}\right) - $$

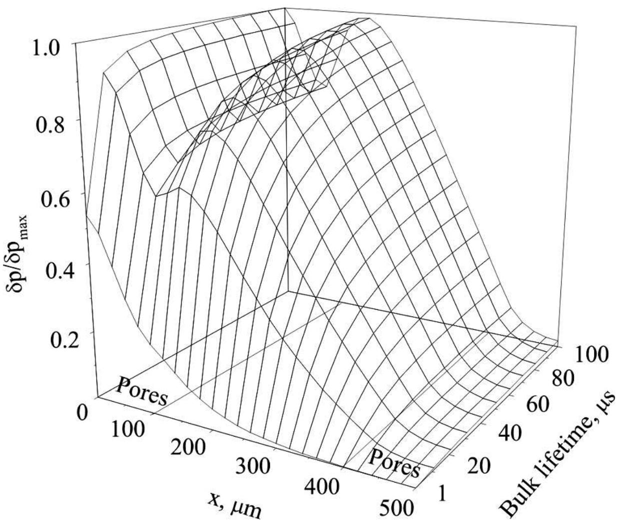

Fig. 2. Excess minority carrier concentration depending on the coordinate and bulk lifetime of minority charge carriers in bilateral macroporous silicon. Excess charge carriers are generated by light with a wavelength of 0.95 μm

$$- G_2(h - h_2) + G_3(h - h_2) = 0. \tag{6}$$

On the back surface of a bilateral macroporous silicon sample, the boundary condition can be written as:

$$A_3 \left[\sinh\left(\frac{h}{L_3}\right) + \frac{s_3 L_3}{D_p}\cosh\left(\frac{h}{L_3}\right)\right] - \\ - B_3 \left[\frac{s_3 L_3}{D_p}\sinh\left(\frac{h}{L_3}\right) + \cosh\left(\frac{h}{L_3}\right)\right] + \\ + G_3(h)\left(\alpha L_3 - \frac{s_3 L_3}{D_p}\right) = 0, \tag{7}$$

where s_1, s_{por1}, s_{por2}, s_3 are the rate of surface recombination on the frontal surface of the sample, the pore surfaces of the frontal and rear macroporous layers, and on the rear surface of the sample, respectively (see Fig. 1). Equations (1)–(7) mathematically model the dependence of the excess minority carrier concentration on the distance in bilateral macroporous silicon. Specific conductivity parallel to macropores should be considered as a series connection of elements. So, we can write:

$$\sigma = e(\mu_n + \mu_p)h\left(\frac{1}{1-P_1}\int\limits_0^{h_1}\frac{dx}{\delta p_1(x)} + \\ + \int\limits_{h_1}^{h-h_2}\frac{dx}{\delta p_2(x)} + \frac{1}{1-P_2}\int\limits_{h-h_2}^{h}\frac{dx}{\delta p_3(x)}\right)^{-1}. \tag{8}$$

The conductivity perpendicular to the macropores should be considered as a parallel connection of elements, and we can write:

$$\sigma = \frac{e(\mu_n + \mu_p)}{h}\left(\frac{1-P_1}{1+P_1}\int\limits_0^{h_1}\delta p_1(x)\,dx + \\ + \int\limits_{h_1}^{h-h_2}\delta p_2(x)\,dx + \frac{1-P_2}{1+P_2}\int\limits_{h-h_2}^{h}\delta p_3(x)\,dx\right). \tag{9}$$

3. Calculation of the Excess Carrier Concentration Depending on the Coordinate and Bulk Lifetime of Minority Charge Carriers in Bilateral Macroporous Silicon

The excess minority carrier concentration depending on the coordinate (distance from the illuminated surface, see Fig. 1) and bulk lifetime of minority charge carriers in bilateral macroporous silicon, when light with a wavelength of 0.95 μm or 1.05 μm generates excess charge carriers, are shown in Figs. 2 and 3, respectively. Expressions (1)–(7) were used to calculate the excess minority carrier concentration. The pore depths of each macroporous layer were the same and equal to 100 μm. Sample thickness is 500 μm. The average diameter of macropores is $1mu$m. The average distance between the centers of the pores is 2 μm. The surface recombination rate on the sample surface and on the pore surface of each macroporous layer was 1 m/s. The bulk lifetime of minority charge carriers varied from 1 μs to 100 μs. The effective bulk lifetime of minority charge carriers in both layers of macroporous silicon varied in accordance with the bulk lifetime of minority charge carriers.

3.1. Generation of excess charge carriers by light with a wavelength of 0.95 μm

Figure 2 shows that the dependence of the excess minority carrier concentration on the coordinate and bulk lifetime of minority charge carriers in bilateral macroporous silicon has two maxima, when light with a wavelength of 0.95 μm generates excess charge carriers.

3.1.1. The dependence of the excess minority carrier concentration on the coordinate

The maxima of the dependence of the excess minority carrier concentration on the coordinate are observed in the frontal macroporous layer and monocrystalline substrate, near the illuminated surfaces. Light falls on the surface of the monocrystalline substrate, which is the bottom of the pores, due to the propagation of light through the pores. The maxima are due to the long bulk lifetime of minority charge carriers and illumination of the surface of the frontal macroporous layer and the monocrystalline substrate. They are observed near surfaces, because the generation of excess charge carriers by light with a wavelength of 0.95 μm is superficial. The maxima of excess minority carrier concentration decrease, as the bulk lifetime of minority charge carriers decreases, and the maximum observed in a monocrystalline substrate decreases much faster.

3.1.2. Dependence of the excess minority carrier concentration on the bulk minority carrier lifetime

If the bulk lifetime of minority charge carriers is 1 μs, the excess minority carrier concentration has only one clearly pronounced maximum, which is located in the frontal macroporous (see Fig. 2). The maximum of excess minority carrier concentration, which was observed in a monocrystalline substrate, gradually decreased and became almost imperceptible. The generation of excess charge carriers in bilateral macroporous silicon is inhomogeneous due to the high absorption of light with a wavelength of 0.95 μm and the illumination of the monocrystalline substrate. Despite the fact that the generation of excess charge carriers in bilateral macroporous silicon is inhomogeneous, only one clearly pronounced maximum is observed. The surface lifetime of minority charge carriers is 1 μs, if the surface recombination rate is 1 m/s. If the bulk lifetime of minority charge carriers is equal to the surface lifetime, then excess charge carriers do not need to move to the recombination surfaces, since they have time to recombine in the bulk of the monocrystalline substrate. Excess charge carriers generated by the illumination of the substrate create a concentration gradient that is blurred by the diffusion of excess charge carriers throughout the volume. Under these conditions, the maximum concentration in the monocrystalline substrate is almost invisible. The diffusion of excess charge carriers determines the distribution of the excess carrier concentration in a monocrystalline substrate, because light with a wavelength of 0.95 μm is strongly absorbed, and the generation of excess charge carriers occurs on the surface. The effect of the back macroporous layer on a change in the excess carrier concentration in bilateral macroporous silicon consists only in the fact that excess charge carriers that have diffused from the monocrystalline substrate recombine on the surface of macropores.

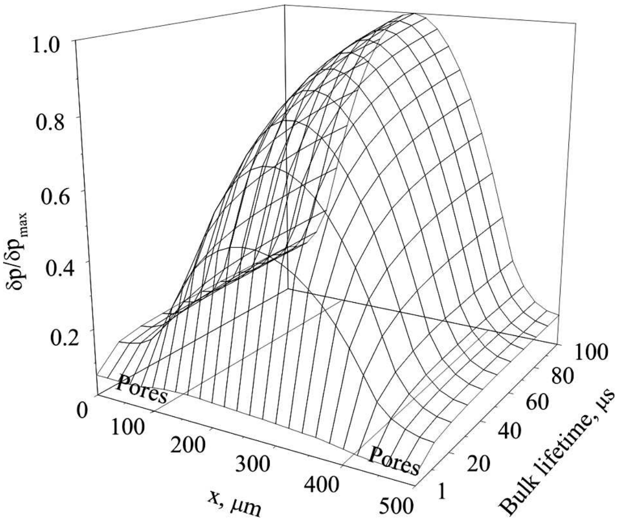

Fig. 3. Excess minority carrier concentration depending on the coordinate and bulk lifetime of minority charge carriers in bilateral macroporous silicon. Excess charge carriers are generated by light with a wavelength of 1.05 μm

3.2. Dependence of the excess minority carrier concentration on the bulk minority carrier lifetime

In Fig. 3, we show the excess minority carrier concentration depending on the coordinate (distance from the illuminated surface, see Fig. 1) and bulk lifetime of minority charge carriers in bilateral macroporous silicon, when light with a wavelength of 1.05 μm generates excess charge carriers. The dependence of the excess minority carrier concentration has one maximum located in the middle of the monocrystalline substrate (see Fig. 3). Illumination of the surface of the frontal macroporous layer and the monocrystalline substrate does not create maxima in the excess minority carrier concentration due to the weak absorption of light with a wavelength of 1.05 μm. The generation of excess charge carriers by light with a wavelength of 1.05 μm occurs throughout the entire volume of the macroporous silicon sample, and

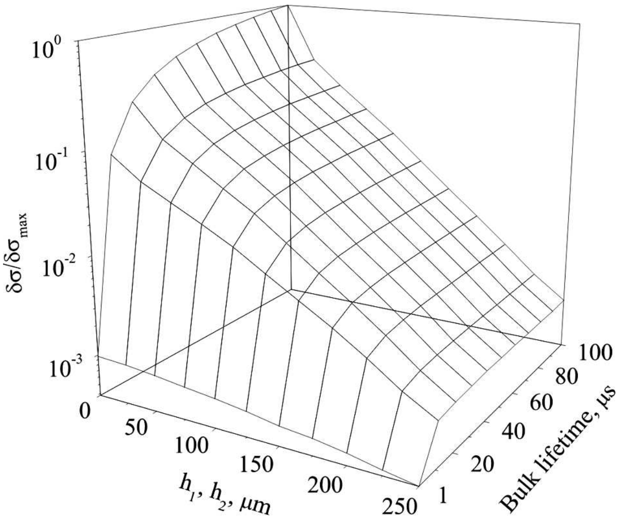

Fig. 4. Normalized specific photoconductivity in bilateral macroporous silicon depending on the pore depth and the bulk lifetime of minority charge carriers. Excess charge carriers are generated by light with a wavelength of 0.95 μm

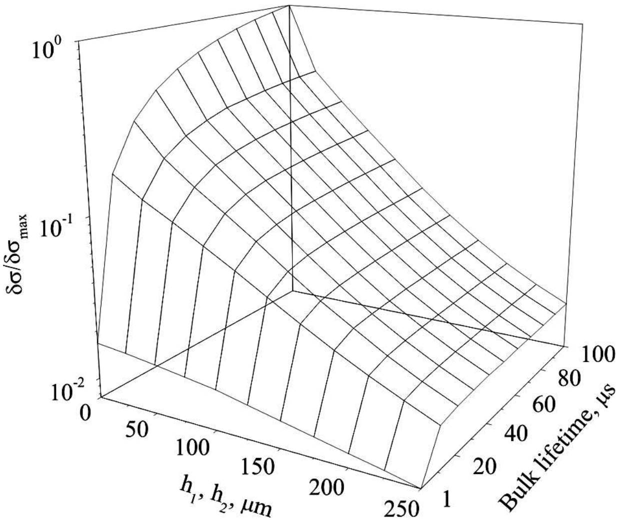

Fig. 5. Normalized specific photoconductivity in bilateral macroporous silicon depending on the pore depth and the bulk lifetime of minority charge carriers. Excess charge carriers are generated by light with a wavelength of 1.05 μm

not only at the illuminated surfaces. The diffusion of charge carriers from the monocrystalline substrate to the recombination centers located on the surface of the pores of each macroporous layer causes a decrease in the excess minority carrier concentration in the monocrystalline substrate. The maximum of excess minority carrier concentration is located in the middle of the monocrystalline substrate due to the symmetry of the sample of bilateral macroporous silicon, since the pores of each macroporous layer have the same depth, diameter, and distance between the pores. Figure 3 shows that the maximum of excess minority carrier concentration decreases and becomes wider with a decrease in the bulk lifetime of minority charge carriers. It is higher, when a smaller amount of excess charge carriers recombines in the bulk.

4. Photoconductivity in Bilateral Macroporous Silicon

The specific photoconductivity in bilateral macroporous silicon depending on the pore depth and the bulk lifetime of minority charge carriers during the generation of excess charge carriers by an electromagnetic wave with lengths of 0.95 μm or 1.05 μm is shown in Figs. 4 and 5, respectively. Expressions (1)–(8) were used to calculate the specific photoconductivity in the direction parallel to the pores. Specific photoconductivity in bilateral macroporous silicon is normalized to the maximum value of photoconductivity in monocrystalline silicon. The pore depth of each macroporous layer was the same and varied from zero to 250 μm. When the pore depth of both macroporous layers is 250 μm, i.e., half the thickness of the macroporous silicon sample, the pores become through. The average diameter of macropores is 1 μm. The average distance between the centers of the pores is 2 μm. The surface recombination rate on the sample surface and on the pore surface of each macroporous layer was 1 m/s. The bulk lifetime of minority charge carriers in a silicon single crystal (monocrystalline silicon substrate) varied from 1 μs to 100 μs. The effective bulk lifetime of minority charge carriers in both layers of macroporous silicon varied in accordance with the bulk lifetime of minority charge carriers.

4.1. Dependence of photoconductivity in bilateral macroporous silicon on pore depth

In Figs. 4 and 5, we show the specific photoconductivity in bilateral macroporous silicon depending on the pore depth and the bulk lifetime of minority charge carriers. The specific photoconductivity in bilateral macroporous silicon decreases, if the pore depth increases, and if the bulk lifetime decreases. It decreases sharply, as the pore depth increases from 0 to 50 μm. The decrease in photoconductivity is due to an increase in the recombination area of excess charge carriers with an increase in the pore depth. This is observed, when the recombination on the surface determines the photoconductivity. In the case where the bulk minority carrier lifetime varies from 1 μs to 10 μs, no sharp decrease in photoconductivity is observed, when the pore depth increases from 0 to 50 μm (see Figs. 4 and 5). The decrease in photoconductivity in bilateral macroporous silicon occurs almost exponentially with an increase in the pore depth from 50 μm to 250 μm. Despite the fact that the distribution of the excess minority carrier concentration in macroporous silicon is different, when excess charge carriers are generated by light with a wavelength of 0.95 μm or 1.05 μm(see Figs. 2 and 3), the dependence of the normalized photoconductivity on the pore depth is similar (see Figs. 4 and 5).

4.2. Dependence of photoconductivity in bilateral macroporous silicon on the bulk minority carrier lifetime

Photoconductivity in bilateral macroporous silicon increases rapidly, when the bulk minority carrier lifetime increases from 1 μs to 20 μs (see Figs. 4 and 5). In this case, the bulk lifetime determines the photoconductivity, because the recombination in the bulk dominates over the recombination at the surface. The photoconductivity does not depend on the bulk lifetime, when the bulk lifetime increases from 20 μs to 100 μs. In this case, the bulk lifetime does not affect the photoconductivity, because the recombination at the pore surface determines the photoconductivity. This is observed, when the pore depth changes from 50 μm to 250 μm. The photoconductivity increases, when the bulk minority carrier lifetime increases from 1 μs to 100 μs, and the pore depth is no more than 50 μm (see Figs. 4 and 5). This indicates that the recombination in the bulk dominates over the recombination on the surfaces of the sample and pores.

4.3. Dependence of photoconductivity in macroporous silicon with through pores and silicon single crystal on the bulk minority carrier lifetime

In Figs. 4 and 5, we show the photoconductivity in a silicon single crystal (no pores) and macroporous silicon with through pores (pore depth is 250 μm). The bulk lifetime of minority charge carriers has the greatest effect on the photoconductivity in a silicon single crystal. Photoconductivity decreases, if the bulk lifetime in a silicon single crystal decreases. The effective bulk lifetime of minority charge carriers plays a major role in macroporous silicon with through pores. The recombination of excess charge carriers on the pore surface, which is characterized by the surface lifetime of minority charge carriers, determines the effective bulk lifetime. In Figs. 4 and 5, we demonstrate that the photoconductivity in macroporous silicon with through pores does not depend on the bulk lifetime, if the bulk lifetime of minority charge carriers varies from 10 μs to 100 μs. Photoconductivity in bilateral macroporous silicon decreases sharply, when the bulk lifetime decreases from 10 μs to 1 μs. Photoconductivity in bilateral macroporous silicon with through pores depends on the bulk lifetime and sharply decreases, if the bulk lifetime is commensurate with the surface lifetime on the pore surface of each macroporous layer.

5. Conclusions

The specific photoconductivity in bilateral macroporous silicon, depending on the pore depth and the bulk lifetime of minority charge carriers, decreases, if the pore depth increases, and if the bulk lifetime decreases. Specific photoconductivity in macroporous silicon with through pores does not depend on the bulk lifetime, if it is much shorter than the surface lifetime on the pore surface, and decreases sharply otherwise. The excess minority carrier concentration depending on the coordinate and the bulk lifetime of minority charge carriers in bilateral macroporous silicon has one or two maxima, if excess charge carriers are generated by light with a wavelength of 1.05 μm and 0.95 μm, respectively.

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ФОТОПРОВІДНІСТЬ У ДВОСТОРОННЬОМУ МАКРОПОРИСТОМУ КРЕМНІЇ

Розраховано питому фотопровідність та концентрацію надлишкових неосновних носіїв заряду в двосторонньому макропористому кремнії в залежності від глибини пор та часу життя неосновних носіїв заряду в об'ємі зразка. Для розрахунку фотопровідності та концентрації надлишкових неосновних носіїв заряду використовувалась дифузійна модель. Математичний опис дифузійної моделі містить загальний розв'язок рівняння дифузії та граничну умову, записану на межах монокристалічної підкладинки та зразка двостороннього макропористого кремнію. Враховувалось, що світло потрапляло на монокристалічну підкладинку через дно пор. Питома фотопровідність у двосторонньому макропористому кремнії в залежності від глибини пор та часу життя неосновних носіїв заряду зменшується, якщо глибина пор зростає, а час життя зменшується. Концентрація надлишкових неосновних носіїв заряду в залежності від координати та часу життя неосновних носіїв заряду в двосторонньому макропористому кремнії має один максимум при однорідній генерації надлишкових носіїв заряду або два максимуми – при їх неоднорідній генерації.

Ключові слова: двосторонній макропористий кремній, фотопровідність, пористий, нерівноважні носії заряду.