Optimization of structuring silicon-based thin film solar modules using means of laser scribing

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At the moment search, production and use of renewable energy sources is a very actual task. One of approaches, which allow to resolve this problem is development of high-effective thin-film solar cells based on silicon. Recently laser technologies have been widely used to increase energy conversion efficiency. However some disadvantages of use of laser processing are that the areas of the solar cell, treated by laser, become unable to participate in the transformation of energy. Therefore, it is, necessary to minimize the area of the solar cell treated by laser.

At the moment, search, production and use of renewable energy sources is a very actual task. One of approaches, which allows one to resolve this problem is development of high-effective thin-film solar cells based on silicon. In last years laser technologies are widely used in this field to increase their energy conversion efficiency [1-4]. However some disadvantages of use of laser processing are so that the areas of the solar cell, treated by laser, become unable to participate in the transformation of energy. Therefore, it is necessary to minimize the area of the solar cell treated by laser.

The aim of this study was to investigate such modes of laser treatment which can provide better structuring of thin-film elements, and minimize the area which is not used in the transformation of energy.

Currently, the technology of production consist of a series of steps, a sequence of alternating processes of applying the next layer and the laser structure (these are so called processes P1, P2, P3) [2-4].

To verify the theoretical calculations, a series of experiments on laser scribing by setting parameters of laser system LSS 1200 [5] have been carried out in our work. Laser generating at the wavelength of 532 nm with output power varied in the range (from 1.2 to 12 W) has been used for scribing.

Analysis of spatial profile laser scribing lines, carried out by means of atomic force microscopy showed that minimal output power of laser beam impulse required for removal of conductive material is 0.4 W. Using the maximum output power of laser beam impulse (more than 2 W) is impractical because there is a partial destruction of the conductive front contact.

At high levels of output power laser removes too much of the front-side layer of ZnO (the higher the power, the larger the area of thermal treatment) [6]. When layer of ZnO is removed, its thickness is decreased and the series resistance ($R = \rho/d$) is increased.

Series resistance causes electric losses in cell, which lead to a decreasing the shape factor of the current-voltage characteristic.

The optimization of the laser scribing process opens the possibility to minimize series resistance and the losses of electrical energy in thin-film solar cells, which is very important for improving the technology of production of solar modules [7-10].

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