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NASA TECH BRIEF

NASA Pasadena Office

Oxygen-Layer Structure Improves Lithium-Doped Silicon Solar Cells

The problem:

Solar cells made from lithium-doped silicon with a high oxygen content recover up to 100 times more slowly after irradiation than cells made with silicon of low oxygen content; on the other hand, cells made with silicon of low oxygen content are considered unstable, for after recovery, their electrical characteristics are found to be degraded. It was considered desirable to fabricate a cell which combined the advantage offered by oxygen-poor silicon in aiding bulk recovery with the superior stability of oxygen-rich silicon.

The solution:

Fabricate a hybrid structure which utilizes low-oxygen-content silicon as the bulk cell material and a shallow overlay of silicon with a high oxygen concentration.

How it's done:

A slice of low-oxygen-content silicon is selected of a size, resistivity, and surface finish similar to the usual lithium-doped cells. Then a thin oxygen-rich layer is formed by heating the slice for several hours at 1150° to 1300°C in an oxygen-rich atmosphere. Calculations based on published diffusion coefficients for oxygen in silicon indicate that a 0.00254-cm oxygen-rich layer will be formed in 20 hours at 1250°C; in such a layer, the distribution of oxygen will range from a high value of about 10^{18} atoms per cm^3 at the surface of the silicon slice to a low value of less than $10^{15}/cm^3$ near the oxygen diffusion front within the slice.

Surface oxide films are then removed by dipping the slice in hydrofluoric acid or other solutions that will not attack and remove any of the diffused-oxygen layer. At this point, it is useful to establish the depth to which the oxygen-rich layer has been formed; several methods are available: 1) The slice is sectioned and etched with a solution that exposes edge dislocations; since the density and size of etch pits will be different in the diffused-oxygen layer than in the matrix, the depth of oxygen penetration can be measured; 2) The slice is heated at 450°C for several hours to convert some oxygen atoms to donors so that the oxygen-diffused layer becomes N-type and can be located and delineated (with difficulty) on the N-type slice; however, it is simpler to locate the N-type oxygen-diffused layer on a control P-type slice which has been treated with oxygen in the same way as N-type silicon slices; 3) The absorption of infrared radiation at approximately 9 μm that is transmitted through the sample is determined; increased absorption, compared with an identical sample that is not oxygen-diffused, indicates that an oxygen layer has been formed (but does not provide a quantitative value unless calibration curves are prepared for each batch).

Subsequently, a P-layer is formed on the slice by boron diffusion, using sources such as boron oxide, boron nitride, or boron tribromide; the process must not remove appreciable amounts of the oxygen-rich layer (preferably none). A front-surface grid contact and antireflective coating are applied to the cell and then the back surface is treated (lapped, etched, etc.)

(continued overleaf)

to expose the starting N-silicon; lithium is diffused into the cell as usual. Finally, a back contact is applied and, if necessary, the PN junction is cleared of shorting paths.

Notes:

1. Tests have shown that the perfection of the starting silicon crystal is not degraded as a result of the oxygen-diffusion process.
2. Requests for further information may be directed to:

Technology Utilization Officer
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Patent status:

No patent action is contemplated by NASA.

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