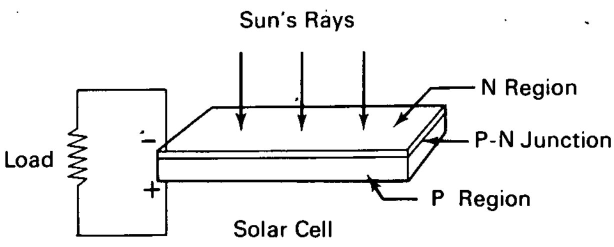
NASA TECH BRIEF

Improved Silicon Solar Cells

It has been discovered that redistribution of the phosphorus within the n-type layers of n-on-p silicon solar cells results in significant improvements in cell performance. Electrical current output is increased from seven to ten percent, reduction in current output due to radiation damage is substantially lessened, and very shallow junctions are no longer needed.



Redistribution of the phosphorus in the n-type silicon layer is accomplished following initial diffusion of the phosphorus into the silicon wafer. The silicon wafer is simply held at the diffusion temperature for a period of time after the source of the phosphorus is removed. This achieves a reduction in the precipitates present in the phosphorus-diffused region and in the corresponding condition of high silicon lattice strain. Electron micrograph experiments, independent of solar cell studies, have shown the presence of precipitates and, generally, conditions of high lattice strain in phosphorus-diffused regions in silicon. Solar cell experiments have shown a correlation between low current output from diffused regions in silicon and the condition of lattice strain.

As shown in the figure, silicon solar cells consist of a thin layer of n-type (phosphorus-diffused) silicon in contact with a thicker layer of p-type (boron-diffused) silicon. The addition of phosphorus causes the electrical potential of the silicon to decrease when exposed to sunlight; the addition of boron causes the electrical potential to increase when exposed to sunlight. Each photon of sunlight produces a useful current carrier in the silicon. These current carriers diffuse through the silicon to the junction between the two layers; when they cross the junction, they become excess current carriers and thus produce voltage. The n-layer becomes negatively charged, and the p-layer becomes positively charged. However, it has been observed that very little power can be collected from the n-layer. The current carriers produced in this layer are largely trapped or recombined before they can diffuse to the junction and pass across it. Consequently, n-layers have been made very thin to minimize the distance these current carriers must travel to the junction. By redistributing the phosphorus diffused in the n-layer, more current carriers cross the junction and the current output of the cell is significantly increased. In effect, the distance that the current carriers can diffuse in the silicon before they are lost is increased. Therefore, n-layers can be thicker and the disadvantages of very shallow junctions eliminated. Reduction in current output due to space radiation damage, which also has the effect of reducing current carrier diffusion length, is correspondingly lessened.

Notes:

1. The observed increase in short circuit current in diffusion-redistribution silicon solar cells indicates that appropriate design can lead to cells with equally improved total power output.
2. The discovery may also be useful in studying the effects of lattice imperfections on the electrical properties of other materials.
3. This redistribution process should be of interest in the semiconductor field.

(continued overleaf)

4. No. further documentation is available. Technical questions, however, may be directed to:
   Technology Utilization Officer
   Lewis Research Center
   21000 Brookpark Road
   Cleveland, Ohio 44135
   Reference: B70-10029

Patent status:

Inquiries about obtaining rights for the commercial use of this invention may be made to NASA, Code GP, Washington, D.C. 20546.

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