The use of solar energy becomes more and more important as the energy crisis was happening now. However, it is still not popular enough to reduce the energy consumption since the efficiency of the solar cell is still low. In this project, we have fabricated different kinds of solar cells to determine the best performance. We have conducted a thorough research on the related topics to make the concept clear before the solar cells were produced. After that we designed the mask pattern and the process flow to fabricate the solar cells inside the NPP laboratory throughout the whole process. Solar cells with maximum efficiency of 11.3% have been produced finally. A number of problems have also been discovered during the fabrication process.

**Abstract**

The use of solar energy becomes more and more important as the energy crisis was happening now. However, it is still not popular enough to reduce the energy consumption since the efficiency of the solar cell is still low. In this project, we have fabricated different kinds of solar cells to determine the best performance. We have conducted a thorough research on the related topics to make the concept clear before the solar cells were produced. After that we designed the mask pattern and the process flow to fabricate the solar cells inside the NPP laboratory throughout the whole process. Solar cells with maximum efficiency of 11.3% have been produced finally. A number of problems have also been discovered during the fabrication process.

**Methodology**

Photolithography is an important step in fabricating solar cells. Masks are used to transfer pattern onto the wafers. Two front contact disks and one rear contact mask have been designed. Each of the masks has 21 anode cells (each 3.5mm x 3.5mm). For front contact of the solar cell, finger is the primary current collector to receive all photovoltaic current and busbar is the secondary current collector to pick up current from fingers. Patterns having different finger width and finger spacing are designed and the best combination can be obtained by experiments. For rear contact of the solar cell, different rear pattern types, total rear contact area ratio and spacing of each contact area are designed and the best of each can be obtained by experiments.

**Anti-Reflection Coating Design**

- Anti-reflection coating (ARC) is a SiN:H layer using Plasma-enhanced chemical vapor-deposition (PECVD) to deposit. It can penetrate on both surface and bulk of silicon and reduce light reflection. The appearance of the layer is blue in color. Destructive interference occurs between the ARCs in order to enhance the probability of photon absorption. Quality of ARC, reflectivity index and the reflectance were tested by varying the gas flow ratio, N\textsubscript{2}O, SiH\textsubscript{4}, and H\textsubscript{2}. Different SiN:H ratios are designed, and the optimized thickness and reflectance can be obtained by experiments.

**Experimental Design**

Experiments were designed having improved efficiency step by step as shown in the figure. Characteristics of modified PERM:
- Two steps emitter
- TMAH etching
- Totally diffused pattern
- Single anti-reflection coating
- Nitride passivation (amorphous)

**Result & Suggestions**

**Experimental Design**

1. Phosphorus Doping Optimization:
   - The optimal value for phosphorus doping is 3.8E15 among three samples, because the blue line has more shadow area and higher Voltage and Current.
   - Phosphorus+ Doping Optimization:
   - The optimal value for phosphorus+ is 3.6E16, because the pink line has greater Voltage and Current.

2. Modified three designs:
   - The cross section of modified designs is shown. The yellow line represents modified PERM. And it performs better than the other, e.g. 9.6% efficiency, 60mA, 0.5V.

**Suggestions**

1. Ion implantation:
   - Avoid implanting many times because of surface damaging and hena bad surface passivation.
2. TMAH surface roughening:
   - Roughening should not take place on alignment mark.
3. Mask Design parameters:
   - Parameters changes should be larger in order to have a more observable and significant result.
4. Anti Reflection Coating
   - Use FTIR to analyze the bond density with the Voc in order to test the quality of refractive index of ARC.

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