Characterization and Formation of Selectively Deposited Solar Electrode using Electroless Plating Process

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Abstract

A power system using solar cells has the benefit of being able to produce silent, pollution-free energy semi-permanently. It can also produce electricity ranging from a few W to few hundred MW at a consistent efficiency. It is simple to operate and maintain, and it is highly reliable. However, despite these merits, the solar cell industry is not sufficiently cost competitive to survive in the marketplace. Solar cells are limited by a variety of energy conversion losses; transmission loss, quantum loss, electron-hole recombination loss, loss due to the P-N junction, loss through the surface of the solar cell, and loss due to current and voltage characteristics. We can improve conversion efficiency by investigating in which part of the solar cell these losses occur, and improving the structural design and process of the solar cell.

As described above, the shading loss on the metallic electrode due to sunlight the loose contact between the electrode and the board, and the resistance loss of the electrode material reduce the efficiency of solar cells. For the manufacture of solar cells using screen printing, Ag screen printing paste is commonly used for the overall electrode. For this reason, the Ag screen printing paste market was worth 48.77 billion won in 2008, and it is expected to be worth 2.5 trillion won in 2012. Furthermore, as the electrode material is not only pure Ag, but also a glass frit substance, the electricity conductivity level is reduced by 1/3 after the heat treatment process.

We also anticipate limitations to Ag usage due to low aspect ratio, high contact resistance, and poor cell efficiency for the high price. To overcome such problems, we studied the use of Ti/Pd/Ag formed through evaporation as an electrode of the high-efficiency solar cells. Although such methods enhance the conversion efficiency of electrodes, they have problems in producing the solar cells because these methods use a vacuum apparatus, and the cost of the electrode material itself is extremely high. Hence, it is necessary to develop a cheap but efficient electrode formation method using materials that can maintain the solar cell function. In order to achieve high-efficiency, low cost and industrialization of solar cells, there exists an electrode formation using plating.

The plating method is easy to manufacture, cheap, and mass producible. The metal purity is also high; therefore, this method is being used in the production of various electronic equipment. Ni and Cu, in particular, are materials that can be easily formed through plating and are widely applied in various
electronic devices; Wenham et al. demonstrated their applicability in solar cells, by applying them to BCSC buried contact cells through electroless plating. Electroless Ni acts as a seed layer for electroless Cu plating, making the adhesion between the silicon board and the Cu electrode strong, thus improving the mechanic and electronic characteristics of the board and the electrode. The Ni also acts as a diffusion barrier that prevents the Cu from spreading onto the silicon board. Moreover, when heated to around 400–600 °C, Ni enhances the mechanic and electronic characteristics of the board and electrode as it strengthens the adhesion between the silicon board and Cu electrode by forming a NiSi type metallic compound.

The conductivity of the Cu electrode that is formed through an electroless plating process does not lag far behind the Ag that is used for most of the solar cell electrode, and it is much cheaper than Ag.

This research reports on a study of the SEF electrode formation method to replace the Ag screen printing method in solar cell construction. In our electrode formation, Cu, which is a metal with high conductivity and relatively cheap cost, was applied as the main electrode using an electroless Ni plating solution and electroless Cu plating solution, and the process of forming Ni was applied to prevent spreading. By evaluating the selective characteristics of Si and the ARC layer of the Ni/Cu electroless plating process, we studied the formation of the electrode without PR patterning. This electrode formation method employs electroless plating, forming electrode without high-cost equipment in a short time period; furthermore, we expect this method to be of sufficiently low-cost and high-efficiency to be industrialized. The main objective of this study will describe the SEF device design, the refined structure and shape of the plating layer, and the characteristics of the selective electrodeposition.