

A REVIEW ON STUDY AND ANALYSIS OF NICKEL COATING ON SOLAR COLLECTOR APPLICATIONS

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ABSTRACT

In order to improve the deposition rate and microstructure of pyro carbon, nickel was introduced by electroplating on carbon fibres and used as a catalyst during the deposition of pyro carbonate at 1000 degree Celsius using methane as a precursor gas. A Nano particle layer of bright nickel base was deposited on copper substrates using electro deposition technique before spraying the paint. The efficiency of the constructed solar collectors using black paint and black paint combined with bright nickel was found to be better than black paint individually. Silicon electroplating offers a low-cost method for the production of high-performance low-cost silicon solar cells that can be used in small portables and large-scale applications, like the grid. Silicon remains the semiconductor of choice because silicon has the best combination of efficiency, cost, durability, and availability.

Key words: Nickel, Electro deposition, Electroplating, Copper, Silicon.

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INTRODUCTION:

The earth receives about 10,000 times more energy from the Sun than the global energy consumption. In order to meet a sizeable part of the world's demand solar energy conversion will have to reach TW size. Over 80% of the solar market is dominated by technology based on silicon partially due to the maturity of the silicon industry. Silicon is an indirect gap semiconductor and requires silicon wafers thicker than 200 microns to work well as a solar cell. Silicon solar cells have reasonable efficiency (up to 15%) and excellent reliability and since silica is abundant, silicon depletion is not a worry. Silicon electro deposition offers an effective alternative to CVD for making silicon devices with substantially reduced processing costs so that solar photovoltaics can be cost competitive with the typical cost for installing new electrical power generators in the grid.

Electro deposition has been shown to provide improved benefits in several solar cell technologies. It is one of the most selective processes because deposition only occurs at positions on a substrate where the substrate conductivity is highest. Unlike evaporation, sputtering, chemical vapour deposition, and some of the wet chemical processes, the materials utilization rate in electro deposition is better than 90% partly due to the selectivity and partly because there is extensive know-how on the re-use and recycle of electro deposition chemistries.

Due to an increasing interest in the exploitation of renewable energy sources, absorbers for solar thermal applications are becoming increasingly important. The efficiency of the photo thermal energy conversion is strongly dependent on the optical properties of the absorber. The absorber consists of an absorber plate (the substrate) which is coated with the paint coating. The absorber substrate must be made of a material with good thermal conductivity to transfer the heat to fluid. Copper is the most metal used as substrate as it has high thermal conductivity. The absorber coating is responsible for the conversion of UV and VIS radiation to heat. A selective paint that has a minimum reflection in the solar spectrum (high absorptance) and maximum reflection in the thermal spectrum (low emittance) can achieve this objective. Because of the generally high emittance, the main selection criterion of non-selective paint coatings has high absorptance, good durability and low cost. For solar thermal applications, the paint material and substrate should not greatly change their physical and chemical properties within operation. This may have adverse affect on the solar absorptance and thermal emittance. Thin metal base layer is deposited onto absorber metal substrates to avoid the diffusion into the composite film during accelerated aging tests, which decreases the optical performance of the coatings. Coating material selection is the key to find the acceptable solution to overcome the inter diffusion and higher emittance problems in solar selective coatings. Pigments were dispersed in silicone resin binder imparting the TISS paint coatings high-temperature tolerance, excellent adhesion, UV resistance, flexibility and weather-durability, which make them suitable coatings for glazed or unglazed solar absorbers.

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Nanoparticles layer of bright nickel base was deposited on copper substrates using electrodeposition technique before spraying the paint. IR reflectance of the paint was found to be around 0.4 without bright nickel layer and the reflectance increased to 0.6 at a Ni layer thickness of 750 nm. The efficiency of the constructed solar collectors using black paint and black paint combined with bright nickel was found to be better than black paint individually. After aging tests under high temperature, Bright nickel improved the stability of the absorber paint. The collector optical gain FR(sa) was lowered by 24.7% for the commercial paint and lowered by 19.3% for the commercial paint combined with bright nickel. The overall heat loss FR(UL) was increased by 3.3% for the commercial paint and increased by 2.7% for the commercial paint combined with bright nickel after the temperature aging test.

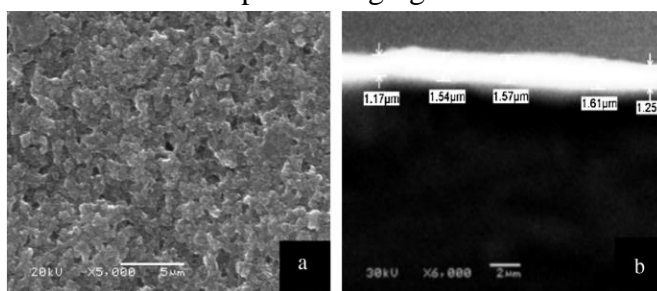


Figure 1 SEM of as-received black paint; (a) plain image, and (b) cross section of sprayed paint.

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The distribution of nickel catalyst and the microstructure of pyrocarbon were characterized by scanning electron microscopy (SEM), energy dispersive spectroscopy (EDS), X-ray diffraction (XRD), and Raman micro-spectrometry. Results show that nano-sized nickel particles could be well distributed on carbon fibers and the pyrocarbon deposited catalytically had a smaller d_{002} value and a higher graphitization degree compared with that without catalyst. In addition, the deposition rate of pyrocarbon in each hour was measured. The deposition rate of pyrocarbon in the first hour was more than 10 times when carbon cloth substrates were doped with nickel catalysts as compared to the pure carbon cloths. The pyrocarbon gained by rapid deposition may include two parts, which are generation directly on the nickel catalyst and formation with the carbon nanofibers as crystal nucleus.

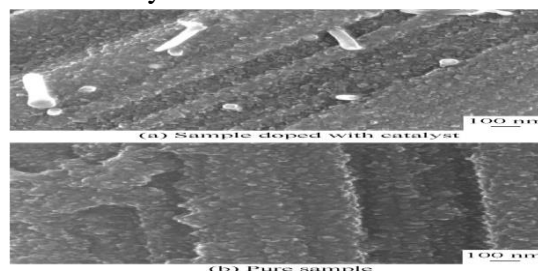


Figure 2 High-resolution SEM photographs of pyrocarbon

Introduction about Electroplating

Electroplating is a process that uses electric current to reduce dissolved metal cations, so that they form a coherent metal coating on an electrode. The term is also used for electrical oxidation of anions onto a solid substrate, as in the formation of silver chloride on silver wire to make silver/silver-chloride electrodes. Electroplating is primarily used to change the surface properties of an object (e.g. abrasion and wear resistance, corrosion protection, lubricity, aesthetic qualities, etc.), but may also be used to build up thickness on undersized parts or to form objects by electroforming.

The process used in electroplating is called **electro deposition**. It is analogous to a galvanic cell acting in reverse. The part to be plated is the cathode of the circuit. In one technique, the anode is made of the metal to be plated on the part. Both components are immersed in a solution called an electrolyte containing one or more dissolved metal salts as well as other ions that permit the flow of electricity. A power supply supplies a direct current to the anode, oxidizing the metal atoms that it comprises and allowing them to dissolve in the solution. At the cathode, the dissolved metal ions in the electrolyte solution are reduced at the interface between the solution and the cathode, such that they "plate out" onto the cathode. The rate at which the anode is dissolved is equal to the rate at which the cathode is plated, that is the current through the circuit. In this manner, the ions in the electrolyte bath are continuously replenished by the anode.

Other electroplating processes may use a non-consumable anode such as lead or carbon. In these techniques, ions of the metal to be plated must be periodically replenished in the bath as they are drawn out of the solution. The most common form of electroplating is used for creating coins such as pennies, which are small zinc plates covered in a layer of copper.

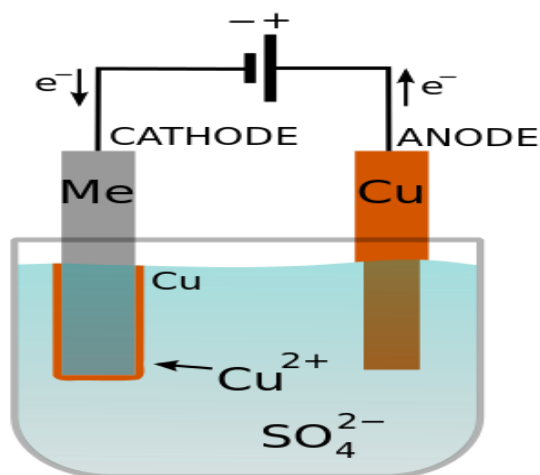


Figure 3 Electroplating

Strike process

Initially, a special plating deposit called a "strike" or "flash" may be used to form a very thin (typically less than 0.1 micrometer thick) plating with high quality and good adherence to the substrate. This serves as a foundation for subsequent plating processes. A strike uses a high current density and a bath with a low ion concentration. The process is slow, so more efficient plating processes are used once the desired strike thickness is obtained.

The striking method is also used in combination with the plating of different metals. If it is desirable to plate one type of deposit onto a metal to improve corrosion resistance but this metal has inherently poor adhesion to the substrate, a strike can be first deposited that is compatible with both. One example of this situation is the poor adhesion of electrolytic nickel on zinc alloys, in which case a copper strike is used, which has good adherence to both.

Special Type of Electroplating process

Pulse electroplating or Pulse Electrodeposition (PED)

A simple modification in the electroplating process is the pulse electroplating. This process involves the swift alternating of the potential or current between two different values resulting in a series of pulses of equal amplitude, duration and polarity, separated by zero current. By changing the pulse amplitude and width, it is possible to change the deposited film's composition and thickness

Major types of Electroplating

There are also specific types of electroplating such as

- copper plating
- silver plating
- chromium plating
- Nickel Plating
- Gold Plating

Effects of Electroplating

- Electroplating changes the chemical, physical, and mechanical properties of the workpiece. An example of a chemical change is when nickel plating improves corrosion resistance. An example of a physical change is a change in the outward appearance. An example of a mechanical change is a change in tensile strength or surface hardness which is a required attribute in tooling industry. Electroplating of acid gold on underlying copper/nickel-plated circuits reduces contact resistance as well as surface hardness. Tin-plated steel is chromium plated to prevent dulling of the surface due to oxidation of tin.

Uses

Electroplating is widely used in various industries for coating metal objects with a thin layer of a different metal. The layer of metal deposited has some desired property, which the metal of the object lacks. For example, chromium plating is done on many objects such as car parts, bath taps, kitchen gas burners, wheel rims and many others for the fact that chromium is very corrosion resistant, and thus prolongs the life of the parts. Electroplating has wide usage in industries. It is also used in making inexpensive jewelry. Electroplating increases life of metal and prevents corrosion.

Suggestions for improvement

The striking method is used to form thin plating with high quality. First, before plating the Ni in Cu, Nickel is electroplated with carbon fibres to increase the deposition rate. Then after that, if coating of Copper coating is given, the properties of both the metals can be achieved. Since the deposition rate is increased, the corrosion resistance is improved and the coating lasts for many years. Since Copper is also plated over that, the properties like IR reflectance get increased, the efficiency of the solar cell gets increased, the stability of the absorber paint gets increased, the collector optical gain is lowered, the overall heat loss gets reduced etc. Silicon is also given preference since it is of less cost and can be used in large scale applications. Silicon has the best combination of efficiency, cost, durability, and availability, so if it is used, solar panel cost reduces considerably with high efficiency and quality.

Conclusion

Although commercial paint has good thermal stability, a layer of electrodeposited bright Ni decreased the thermal emittance and improved the thermal stability of the commercial paint. IR reflectance of the paint was around 0.4 without the deposited bright Ni layer and the reflectance became around 0.6 at 7.8 μm when the bright Ni had been deposited on the substrate. After temperature aging test, the collector optical gain FR(sa) was lowered by 24.7% and 19.3% for the paint and the paint combined with bright Ni base layer, respectively. Also, the overall heat loss FR(UL) was increased by 3.3% and 2.7% for the paint and the paint combined with bright Ni base layer, respectively.

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