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Raghu N. Bhattacharya

Editor PPT

Biography

- Dr. Bhattacharya received his PhD degree from IIT, Kharagpur, India in the field of Electronic Materials in 1983. Before joining NREL, he held several research positions at The Weizmann Institute of Technology, The University of Texas at Arlington and Brooklyn College of CUNY. Dr. Bhattacharya worked on a variety of thin film semiconductors that are important for energy conversion, storage and transportation. Dr. Bhattacharya has published over one hundred and seventy technical papers in the field of processing PV materials and superconductors and has been awarded twenty patents. Dr. Bhattacharya is the author of several book chapters. Dr. Bhattacharya collaborated with several other National Laboratory (ORNL, LANL, and BNL) researchers and worked with several industrial groups [e.g., SoloPower (Board Member), SuperPower Inc. (CRADA), American Superconductor, Oxford Superconducting Technology, UES, Inc., and Dasstech. Inc. (CRADA)]. Dr. Bhattacharya served on various committees of technical conferences and delivered numerous invited lectures at national/international meetings. Dr. Bhattacharya was an adjunct faculty member of University of Colorado at Boulder in 1996.

Research interests

- His Research interests include Electrodeposition, thin-film photovoltaics, focusing on the semiconductor based on copper indium gallium diselenide (CIGS)

Electrodeposition

Electrodeposition is the process that exploits the creation of solid materials directly from electrochemical reactions in liquid compositions with substrate materials.

It is also known as Electroplating.

An electrochemical process where metal ions are transferred from a solution and are deposited as a thin layer onto surface of a cathode.

Two technologies for plating:

Electroplating: Substrate is placed in electrolyte. When an electrical potential is applied between a conducting area on the substrate and a counter electrode in the liquid, a chemical redox process takes place resulting in the formation of a layer of material on the substrate and usually some gas generation at the counter electrode.

Electroless plating: Substrate is placed in a more complex chemical solution, in which deposition happens spontaneously on any surface which forms a sufficiently high electrochemical potential with the solution. No external electrical potential and contact to the substrate are required, but more difficult to control the thickness and uniformity of the deposits.

Bulk electrodeposition: slow and leads to low-grade materials

Template-assisted/mold-guided electrodeposition:

Arrays of nanostructured materials with specific arrangements

Employing either an active or restrictive template as a cathode in an electrochemical cell

Important technique for synthesizing metallic nanomaterials with controlled shape and size

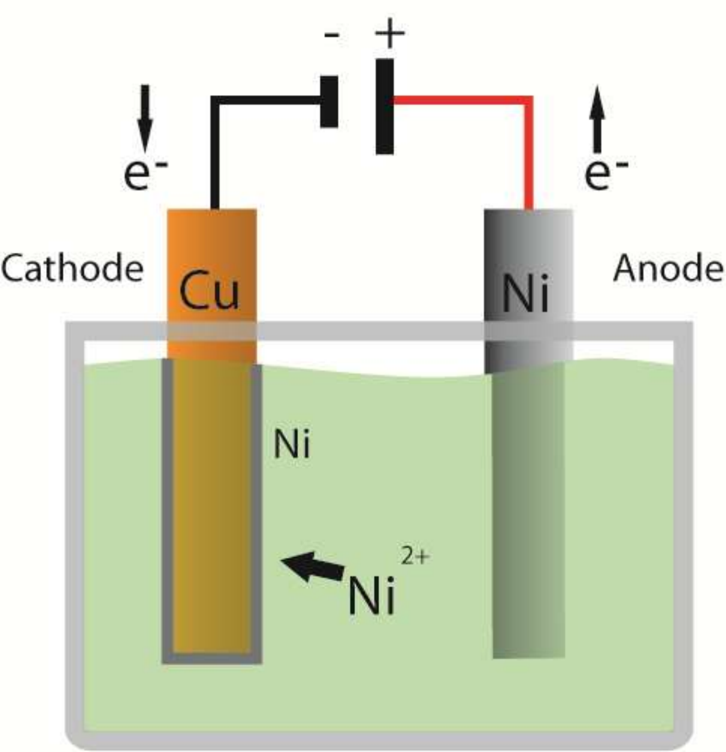
Electroplating can enhance;

- Chemical properties---increase corrosion resistance
- Physical properties---increase thickness of part
- Mechanical properties---increase tensile strength & hardness

Limitations

- Typically restricted to electrically conductive substrate materials
- Difficulties in the preparation of desired templates.
- Additional high temperature annealing steps are expensive and unsuitable for polymer substrates

Experimental Setup



Copper Cathode is reduced (accepts electrons)

Nickel Anode is oxidized (gives us electrons)

Ni^{2+} ions within solution become attracted to Copper cathode

A three-electrode electrochemical cell (a reference electrode, a specially designed cathode, and an anode or counter electrode)

Accessories for applying controlled current at a certain voltage (dc or Ac power supply or potential stat)

The template can be made of either nonmetallic or metallic materials

The surface morphology of the deposits depends on the surface structure and chemical composition of the cathode substrate as well as other electrochemical parameters.

Thermodynamic and Kinetics of Electrodeposition

The nucleation of nanostructures on the electrode substrate is influenced by the crystal structure of the substrate, specific free surface energy, adhesion energy, lattice orientation of the electrode surface, and crystallographic lattice mismatch at the nucleus-substrate interface boundary.

The final size distribution of the electrodeposits strongly depends on the kinetics of the nucleation and growth:

Instantaneous nucleation: all the nuclei form instantaneously on the electrode substrate, and subsequently grow with the time of electrodeposition.

Progressive nucleation: the number of nuclei that are formed is a function of time of electrodeposition. These nuclei gradually grow and overlap, and therefore, the progressive nucleation process exhibits zones of reduced nucleation rate around the growing stable nuclei.

Active template-assisted electrodeposition:

The formation of nanostructures results from growth of the nuclei that invariably nucleate at the holes and defects of the electrode substrate.

Subsequent growth of these nuclei at the template yields the desired surface morphology of the nanostructures, which can therefore be synthesized by choosing the appropriate surface of the electrode

Restrictive Template-Based Electrodeposition

It involves the deposition of metal into the cylindrical pores or channels of an inert, nonconductive nanoporous substrate.

To prepare nanometer-sized particles, fibrils/wires, rods, and tubules.

Examples: nanoindented holes; mesoporous silica; nanoporous polymers; porous alumina

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28th Oct. 2014

re:

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