Skysong Innovations
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Conductive Adhesion Promoters for Reactive Inks

Background

Conductive inks and pastes are a $2-billion-per-year industry that is ripe for a disruptive technology to broaden its application base. The silver pastes that currently dominate this market are suitable for photovoltaic applications, but their feature resolutions do not scale well below 50 µm, can damage delicate substrates, and require thick layers to achieve desired conductivity. For applications where higher feature resolution, high conductivity, and softhandling are paramount (e.g., thinfilm or substrate photovoltaics, flexible electronics, or sensors) dropondemand (DoD) printing of particle-based inks is an attractive alternative. DoD printing, colloquially called inkjet printing, offers precise placement, minimum ink waste, and good alignment without contact. Unfortunately, the particle-based inks used in DoD printing are often expensive to manufacture and require low metal fill loadings to avoid nozzle clogging.

Reactive inks offer a lowcost, higher performance alternative to traditional, particle-based inks. Unlike traditional, particle-based inks, reactive inks print chemical reactions that result in a high-quality material at low temperatures without an annealing step. These inks consist of metal cations (from dissolved metal salts), reducing agents, ligands and chelating agents, and fluid property modifiers. Unfortunately, reactive metal inks show poor adhesion to metal and oxide surfaces and existing adhesion promoters increase the electrical contact resistance between the substrate and the printed reactive ink metal. Therefore, a reliable adhesion promoter with high electrical conductivity would enable reactive inks to confer benefits across a wide range of applications.

Invention Description

Researchers at Arizona State University have developed a new printable adhesion promoter that preserves electrical conductivity between metals and oxides. The adhesion promoter consists of a solution containing: tin chloride, polar solvent (water, ethanol, etc.), acid (HCl, H_2SO_4, HNO_3, etc.) to adjust the pH to between 0 and 7, along with droplet stabilizing agents (2,3butanediol, ethanol, acetone, glycerol, etc.) to adjust viscosity and surface tension. Although tin chloride is often used as an adhesion promoter for electrochemical and electroless deposited metals, it has not been applied to reactive ink systems. The net result is a highly conductive interface with ohmic contact between the substrate (such as silicon) and the printed metal (silver, copper, gold, nickel, platinum, palladium, iron, etc.).

Tests show that application of the promoter results in lower interfacial resistance between printed silver reactive inks and substrate compared to cases using screen-printed silver pastes and printed silver nanoparticle inks. Additionally, this method uses one tenth the amount of silver, which can potentially save the industry between $1.5 and $3 billion annually.

Potential Applications

- Drop-on Demand (DoD) and inkjet printing
- Additive manufacturing and 3D printing
- Photovoltaic (PV) cells
- Flexible, lightweight electronics

Benefits and Advantages

- Cost Effective – Reactive inks are substantially less expensive to use than traditional particle-based inks
- Precise – Higher feature resolution than conventional conductive pastes
- Efficient – Promotes secure adhesion to metal and oxide surfaces while increasing electrical conductance at the interfacial contact boundary

This technology is covered by U.S. Pat. No. 10,286,713

Laboratory Homepage of Professor Owen J. Hildreth

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