Advanced Thin Film Coating for Electroplating Metals

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Environmental Problem

Thin film coatings play a prominent role in the manufacture of electric and microelectronic devices, but some deposition methods have negative environmental effects. Electroplating, for example, uses toxic chemicals and generates significant process waste and water pollution. Chemical vapor deposition (CVD) employs toxic gaseous organic precursors. The most common coating processes—sputtering, evaporation, CVD, and plating are not always compatible with heat sensitive substrates and semiconductor processes, and they provide only moderate output at a high cost. The trend in microelectronics toward ever smaller feature sizes requires micron-sized solder bumps at high density for packaging. These bumps cannot be made with bulk metal foil preforms but must be vapor deposited or electroplated. This is difficult to accomplish with conventional techniques.

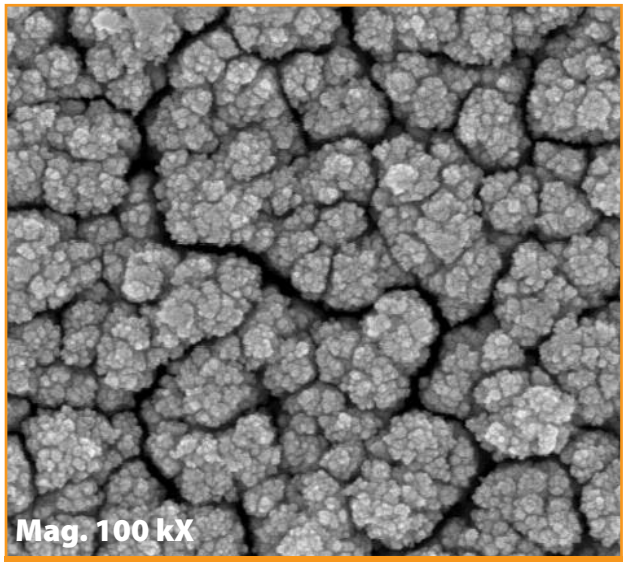
SBIR Technology Solution

With support from EPA's Small Business Innovation Research (SBIR) Program, Jet Process Corporation (Jet Process) has developed an innovative, carbon-free process without toxic precursors or effluents to manufacture high-quality coatings on substrates for various applications. The Jet Vapor Deposition™ (JVD™) process vaporizes wire of appropriate composition completely into atoms, which are carried by sonic inert gas carrier jets and deposited on the substrate. With this pollution-free method, virtually any solder—elemental or multi-component—can be deposited at a high rate on photo-resist patterned substrates such as multi-micron thick films. Subsequent resist lift-off yields the solder bumps. When the bumps must be very small, with pattern window aspect ratios ~ 1, it is better to deposit metal nanoclusters. Once accelerated by the jet, the relatively heavy nanoclusters move directly to the substrate, unaffected by collisions with lighter carrier gas atoms, and with no shadowing by the walls of the resist windows. Nanoclusters of any solder can be nucleated, grown, and deposited by simple alterations in jet operating conditions. In addition, nanocluster generation and deposition in JVD™ can be performed at high rates, making it more economical to use this technology to produce the thick films (1 to 10 microns) usually needed for solder bumps. The company also has deposited test coatings of 20 or more microns on large substrates. The JVD™ capability for using various material sources, in sequence or together, leads to layered structures or alloys of multiple metal components, including gold (Au), chromium (Cr), nickel (Ni), copper (Cu), zinc (Zn), iron (Fe), tin (Sn), and silver (Ag). In a reactive mode with oxygen or nitrogen, JVD™ can make reproducible combinations of complex oxide and nitride dielectrics not achievable by other thin film methods.

Commercialization Information

The versatility of JVD™ has enabled Jet Process to develop a wide range of systems for low- and high-volume production. At present, the major focus at Jet Process is to provide a coating service for lead-free solders such as AuSn, indium (In), InSn, SnAg, SnInAg, or SnCuAg, along with ancillary adhesion and diffusion barrier layers such as titanium-platinum-gold (TiPtAu) or TiNiAu.

This coating service is being used by leading manufacturers of microelectronics, semiconductor packaging, advanced sensors, solid state lighting, optoelectronics, telecommunications, and micro-electro-mechanical systems (MEMs) components and products for many advanced metallizing requirements. For example, JVD™ eutectic gold-tin and other solder layers (1-20 microns) and titanium-platinum-gold or titanium-tungsten bond/barrier layers are replacing preforms in laser and



SEM image of platinum nanocluster films made using Jet Vapor Deposition™, an innovative and environmentally friendly dry process on wafers.

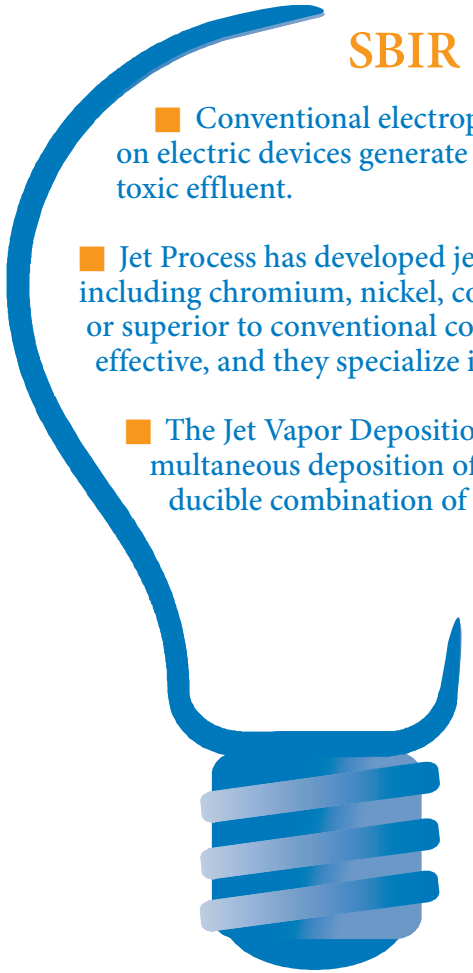
microelectronics packaging applications, meeting wafer level processing requirements for smaller dimensions, high reliability, longer life, thermal management solutions, simplified assembly, semiconductor process compatibility, higher device yields, low temperature processing, and cost.

Jet Process also uses the nanocluster capability for applications other than solder deposition, including deposition of platinum nanocluster films on photoresist patterned wafers as a replacement for "platinum black," which usually is produced via wet chemical methods, for electrochemical and biomedical applications. The high surface area Pt nanocluster film shown in the scanning electron microscopy (SEM) image had excellent electrochemical response for several reactions of biomedical interest.

Jet Process has worked for and/or received development support from many advanced technology leaders, including: IBM, Intel, Motorola, Texas Instruments, General Electric, Hewlett-Packard, BAE, Ericsson, Lucent, Raytheon, Agilent, Lockheed Martin, 3M Company, Pratt & Whitney, and SEMATECH.

Company History and Awards

Founded in 1991, Jet Process is based in North Haven, Connecticut, and specializes in rapid turnaround thin coating services for gold-tin solders, other lead-free metal solders, and advanced thin film dielectrics. The company holds more than 30 U.S. and foreign patents and provides high-quality coatings for diverse industrial, consumer, and military applications, including for microelectronics, semiconductor packaging, optoelectronics, solid state lighting, advanced sensors, microelectro-mechanical systems, photonics, and telecommunications and microwave devices. Jet Process' global partners include Fortune 500 corporations, government, and advanced technology leaders around the world.



SBIR Impact

- Conventional electroplating processes used to apply thin film coatings on electric devices generate significant water pollution, process waste, and toxic effluent.
- Jet Process has developed jet sources for metals done by electroplating, including chromium, nickel, copper, zinc, iron, tin, and silver, that are equivalent or superior to conventional coatings, environmentally friendly, and more cost effective, and they specialize in deposition of AuSn and other lead-free solders.
- The Jet Vapor DepositionTM (JVD™) process allows easy sequential or simultaneous deposition of multiple metal components, enabling a reproducible combination of complex layers and alloys.
- JVD™ coatings are used by leading manufacturers of microelectronics, semiconductor packaging, advanced sensors, solid state lighting, optoelectronics, telecommunications, and MEMs components.