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Sintering Process of Inkjet-Printed Silver Patterns using a Heated Inert Gas

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Abstract

In this study, we introduce a thermal sintering process using a heated inert gas as a new sintering method. The heated gas flow is formed by passing nitrogen (N_2) gas through a heating head of 300 to 700 ^{o}C, and the desired substrates are then exposed to the heated gas flow through a 400 mm long and 5 mm wide slit-nozzle. Sintering performance of Ag films was characterized by analyzing the electrical resistivity and metallographic structures according to the temperature change of the heating head. The temperature distribution of the heating region is analyzed by infrared (IR) thermal imaging and surface temperature measured by thermo-label tape. To test the feasibility of the proposed method for application to printed circuit board (PCB) manufacturing, we performed a reliability evaluation using the printed Ag patterns under the standard of the Institute for Interconnecting and Packaging Electronic Circuit (IPC), TM650. Various reliability test patterns were created by Ag inkjet-printing on both a rigid flame retardant 4 (FR4) substrate and a flexible polyimide (PI) film substrate. The reliability evaluation includes withstanding voltage, adhesive strength, thermal shock, pressure cooker, and bending tests. The surface wettability of the substrates was controlled to obtain high quality fine and uniform patterns by UV/O_3 treatment after coating a fluoropolymer thin film.

Keywords

Inert Gas, Sintering, Inkjet, Silver, Printing

1. Introduction

Printed electronics is a technology used to create electrical devices on various substrates using printing methods such as screen printing, flexography, gravure, offset lithography and inkjet-printing [1]. Recently, the scientific community has shown a growing interest of developing low-cost flexible electronics by printed electronics. This interest is driven by several factors: (1) the need for low-cost and mass-production processes; (2) numerous applications require shapeable and disposable devices; and (3) the demand for the quick realization of electronics [2, 3]. Typical printed devices include printed strain sensors, temperature sensors, printed image sensors, printed humidity sensors, printed biosensors and RFID tag with light detection [2-5].

In the last decade, inkjet-printing has been attracting growing interest for the production of micro-patterns as an alternative to the conventional photolithography process. The inkjet-printing method has many advantages including low-cost manufacturing, a low-temperature process and patterning compatibility on a non-planar substrate or a flexible substrate due to the direct-writing