論文の内容の要旨

論文題目：

Fabrication Technology of High Density Cu/Polyimide Interconnection by Hybrid Imprinting with Selective Electroless Plating
（ハイブリッドインプリントと選択的無電解メッキを用いた銅／ポリイミド高密度配線作製技術）

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This thesis describes the application of thermal/ultraviolet (UV) hybrid imprint and selective electroless copper plating using vacuum ultraviolet (VUV) light induced surfactant masking concepts to fabrication process of high density interconnection (HDI) interposer.

Transistors have been integrated to one chip, since the transistor was developed in 1947. The integrated circuit (IC) chips speed up invention of computing devices such as a handheld calculator and computer. In semiconductor industry, the number of transistors on IC doubles approximately every two years following Moor's Law. However, interconnections in a system board such as printed circuit board (PCB) and large scale integrated (LSI) circuits are failing to follow the integration speed of IC. The interconnection gap between IC and system board is widening more. As one of the solutions to make up interconnection gap between IC and system board, an interposer

have been proposed in packaging industry. In addition, demand for miniaturization of a system board in the electronic devices such as a smart-phone and a tablet personal computer (PC) is increasing. Therefore, heterogeneous integration system or three dimensional (3D) integration systems using interposer has been studied to meet the demand for the system integration. The interposer consists of HDI on dielectric layer. Copper plating on polyimide (PI) technology has been widely used for fabricating interconnections of microelectronic devices such as flexible printed circuit board (FPCB). Copper patterns are conventionally fabricated on PI film by lamination technology or electroplating. However, these conventional methods have some problems such as poor fine pattern formation capability, high-cost and low electrical properties. Recently, electroless Cu plating has an attraction as an alternative to conventional metallization technology because of its low cost and high purity Cu deposition. In addition, the electroless plating technology permits to deposit a metal selectively on a substrate. Many selective metallization approaches using screen printing, ink jet printing, micro-contact printing or selective surface modification by vacuum ultraviolet irradiation have been attempted to simplify the metal interconnect formation process without lithography patterning technology.

This thesis aims to simplify the fabrication process of HDI which can be applied to interposers. To achieve this, thermal/UV hybrid imprint (TUHI) using soluble block copolymer polyimide (SBC-PI) resin is invented for high precision and low temperature patterning process. Even though the imprint process is performed at temperatures lower than 120 °C, precise replication of SBC-PI with shape error less than 4% was achieved by TUHI after optimizing process parameters. In addition, very small patterns of 150 nm line-and-spaces was also successfully replicated

Adhesion between Cu and SBC-PI is enhanced by surface modification using VUV irradiation with wavelength of 184.9 nm and 253.7nm. The influence of VUV irradiation on surface properties of soluble block copolymer polyimide (SBC-PI) was

investigated. The changes of topological and chemical properties of SBC-PI were investigated through water droplets test, dynamic force microscope (DFM) measurement, and X-ray photoelectron spectroscopy (XPS) analysis. Analysis results revealed that the surface properties of VUV irradiated SBC-PI film changed from hydrophobic to hydrophilic without the increase of surface roughness, as a result of the generation of hydrophilic group. The Cu layer was deposited on modified SBC-PI film by electroless plating. Then it was also revealed that the adhesion of electroplated Cu to SBC-PI substrate can be controlled by varying VUV irradiation dose.The VUV induced surfactant masking (VISM) process is proposed to simplify selective copper metallization process using electroless plating. This selective electroless Cu plating using VUV treatment is based on the following two essentials. One is that most surfactants used as a pretreatment process for electroless plating composited of organics. The other is that the organics can be decomposed by VUV treatment. Firstly, hydrophobic PI film surface was modified to hydrophilic by VUV irradiation. Then surfactant layer absorbed on whole hydrophilic PI surface was selectively removed by VUV irradiation using a photo mask. After palladium (Pd) catalyzing process, Cu patterns with ranging from 10 to 150 μm in width were fabricated on residual surfactant layers by electroless plating.

Finally, fabrication of Cu/PI interconnection is demonstrated by TUHI and VISM processes. The Cu/PI interconnections with 50 μm line width and various lengths were fabricated. The electric resistance of the fabricated Cu interconnections with 300 nm thickness was evaluated.