A FINE PITCH INTERCONNECTION METHOD FOR HIGH FREQUENCY λ-SPACED LINEAR ARRAYS USING MICROFLEX TECHNOLOGY

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1. Abstract

High frequency arrays working with frequencies above 15 MHz will be more and more integrated in industrial and medical applications. They are interesting because of their resolution and capability for real-time imaging especially in catheters and other small devices.

The electrical interconnection of the single elements of a fine pitch array is one of the most challenging tasks in array technology. To be acoustically invisible the thickness of interconnection layers should not exceed 1/10 of the wavelength. Common flexible circuits surpass this limitation and are not easy to adapt to the acoustic device.

In this presentation a technology will be presented which allows to interconnect elements with a spacing down to 75 µm using the Fraunhofer MICROFLEX (MFI) technology for backside contact and sputtering for front side contact with low acoustic influence. The MFI technology allows a high flexibility in the design and shape.

This paper focuses on the influences and contributions of the PZT material concerning its surface, the consistence of the applied electrodes, sputtering and galvanic, as well as the influence of the structuring dicing process.

2. Introduction

The Fraunhofer MFI technology is a multilayer process to receive very thin flexible circuit lines with the capability of mounting small electrical and acoustical devices together. The aim is to be able to contact electrodes of arbitrary shape and size. In micro systems technology die packages are very common and they use a fine pitch bond connection to be mounted on printed circuit boards. High frequency transducer arrays for acoustical imaging use a pitch down to 75 µm. The flexible circuit is used to connect both worlds.

Since ball bonding technologies are very common to interconnect electrical parts they have not been used to connect thin electrodes on PZT-ceramics. There the problem is to overcome the low adhesion between the ceramic material and the electrode.

3. Process technology

The process to achieve the flexible circuit is performed in a clean room class 100. Photolithography was used to achieve the fine pitch of 75 μm. Polyimide is spin coated on a silicon wafer and is dried afterwards. The typical layer thickness is chosen to 5 μm as an compromise between flexibility and mechanical stability. After appliance of the carrier material it is activated by a plasma process to ensure the adhesion of a thin film metal layer which is used to form interconnection lines and pads. The structures are formed by a photolithography process. To achieve multilayer flexible circuits the polyimide spin coating is repeated as well as the metallisation and the photolithography.

The achieved flexible circuit offers the possibility to connect other metal surfaces through via holes which are produces in a fast plasma step. The flextape is coated with an Al-Layer which works as an etching mask. The vias are produced then by oxygen plasma.

4. Microflex Interconnection

As in wire bonding technologies in MFI a gold ball is bonded to a gold pad. The gold ball is achieved by electrically melting the bondwire with a diameter of 17 μm and then welded to the pad by ultrasound. The substrate to be bonded onto is placed under the via holes and the gold ball is welded through the hole with a small neck capillary at a temperature of 140°C. After lifting the capillary the bond ball remains on the surface connecting the substrate through the hole. For the fine pitch array circular pad sizes of 60 μm with a hole of 35 μm have been achieved (see Figure 3). Ceramic is held with vacuum while the flextape is adjusted to the ceramic with a micro positioning tool. After the bonding process an epoxy filling material is used to fix the connection between the tape and the electrode. For further reference of MFI technique and properties refer [1] and [2].

5. A λ-spaced transducer array

To achieve the connection of the flex tape to the ceramics several approaches has been taken. To prove the fine pitch connectivity of the MFI the first efforts to place on a gold sputtered Si-wafer with a 75μm pitch flextape. Because of the good adhesion between the gold layer and the Silicium and the mechanical stability of Silicium the bond ball stand after lifting off the bond capillary. The MFI connected flextape to the Si-wafer. These results encouraged to apply the flexible circuit to a conventional gold coated Motorola PZT (3202HD). There the bond ball broke out after lifting the capillary and left a hole in the PTZ’s gold electrode. This lead to the conclusion that the lift up force of the capillary was too strong through the small area of the via hole of the flextape.

To control the influence of the thickness of the gold coating the conventional electrode was removed by a fine lapping process. Best results have been achieved after preparing the Piezo ceramic to a surface roughness of 3μm and an intensive cleaning of the surface with Acetone and Isopropanol. An own electrode with an chrome adhesion layer was used as a basis. As a good combination 10nm Cr and 700nm Au was used. To maximize adhesion between Cr and PZT the ceramic had to be activated with Argon