Non-contact Micro Mass Evaluation Method Using an X-ray Microscope

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For the mass measurement of attached foils such as printed electrodes and a finished product, mass should be measured by a non-contact method with the capacity to measure a small mass of micrograms. In this study, the masses of 1 mg to 10 mg electrodes were evaluated using an X-ray microscope. The results were compared with the masses determined by using a digital scale with a 0.005 mg error. The average of the relative error between the mass measurements using the X-ray microscope and those using the digital scale was less than 2.51%. The results show that X-ray mass evaluation method can be used for mass measurement of micro objects by replacing a digital scale.

I. INTRODUCTION

Printing techniques such as screen printers [1] and dispensers [2] are used to coat electrode material to make circuits. To test the completeness of the electrodes using a non-contact technique, their shape should be measured [3] but this does not provide sufficient information on their electrical properties and any non-homogeneity or bubbles that may exist within the applied material. In contrast, examining a printed electrode's mass provides information not only on its structural performance, including bubbles and non-homogeneity, but also its indirect electrical performance. However, a piezoelectric sensor or scale cannot be used to measure the mass of an already printed semiconductor element.

Thus, a non-contact mass evaluation method that uses X-rays or other techniques [4] is required. Despite this need, there had been no research on mg level mass measurement using X-rays. This research was carried out to determine the feasibility of non-contact mass measurement at a level of 10 mg or below using an X-ray microscope.

I.A. METHOD

When a material is irradiated with x-rays, there is an attenuation response proportional to the substance's number of electrons, and an array of detectors (generally, image plates) that can measure the degree of x-ray attenuation in two dimensions is used to acquire the x-ray image. In the case of homogenous material and x-rays under 100 keV, there is a fixed relationship between the number of electrons and the mass, so it is possible to evaluate mass using x-ray images.

Generally, the spatial resolution of x-ray scanning equipment is at the 1 mm level, and only the data accumulated from a few x-rays penetrating within 1 mm^2 can be gathered. The REVOLUTION x-ray microscope (design from X-TEK Ltd., UK) that was used in this research can analyze the data accumulated from 10,000 pixels within 1 mm^2 when imaging at a 40x ratio. Equipment with high spatial resolution is advantageous in that it produces systematically significant results for mass determination as well as reducing the errors that occur within the borders of the imaging subject.

The semiconductor elements used in our experiment were printed using a dispenser and made into a 1 mm or 2 mm diameter solder bump. To measure the mass of the printed electrodes using an x-ray microscope and confirm it with a digital scale, the electrodes must be well separated from the board. To correct methodological errors, silver foil was used when measuring.

II. CONCLUSIONS

It was demonstrated that it is possible to measure the mass of small electrodes using an x-ray microscope with a relative error under 3.05% at the 3 mg level and 6.57% at the 1 mg level, respectively, compared to using a digital scale. The error of small sample is increased, because it is more effective in error from human and eviroment error.

The average relative error demonstrate that this technique is useful as an effective replacement for scale. This would be the only way of measuring the mass of the human organ or finished product that is difficult to measure directly without non-destructive method.

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