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Structural Analysis of Passive Film on Iron Surface by Grazing Incidence X-Ray Scattering Method II

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The origin of the high corrosion resistance of a stainless steel is attributed to very thin passive film on the surface stabilized by specific alloying elements, Cr, Ni, etc. The mechanism of the stabilization has not yet been elucidated because the structure of the passive film is not unclear. The clarification of the structure needs the technique of the X-ray scattering measurement on the thin oxide films of a few nm thickness. We tried to measure the X-ray scattering from the oxide films on the pure iron substrates by grazing incidence X-ray scattering (GIXS).

We prepared two samples of pure iron substrates. Their surfaces were polished as smooth as mirrors. One was oxidized in the air (sample 1), and the other (sample 2) was treated as follows. At first, the air-formed film was removed by cathodic reduction. Secondly, the specimen was potentiostatically polarized at an anodic potential in a boric acid. The thickness of the oxide films was estimated at about 2 nm. In order to suppress the penetration depth of the X-ray, the glancing angle of the incident X-ray (E = 12 KeV) to the surface were fixed at about 0.1 degree, which is below the critical angle of total reflection (about 0.5 degree).

Figure 1 shows the profiles of the X-ray scattering from the surface of the samples. One can see in the figure that the X-ray scattering profile of the sample 2 exhibits hallo pattern, while that of the sample 1 has diffraction peaks. This means that the film formed in the air is crystallized, but the film formed under anodic potential has the amorphous structure.

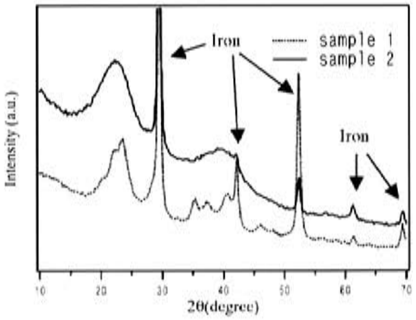

Fig.1 The X-ray scattering profiles from the oxide films formed on the pure iron substrates.

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3-dimensional Microstrucure Analysis of Thermal Fatigue Damage in BGA Solder Joints

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Introduction

High-density packaging technology of LSI (Large Scale Integrated circuit) chips on PCBs (Printed Circuit Boards) has become an obstacle in the way of developing new electronic components. Especially, one of the most important problems is reliability on μm-order sized joints connecting the chips to the PCBs electrically and mechanically. In order to enhance the reliability, it is expected to develop nondestructive testing methods with high spatial resolution. Our research group has developed a micro X-ray CT (Computed Tomography) system called SP-μCT with spatial resolution of about 1μm1). In this work, microstructural evolution appearing as thermal fatigue damage in BGA (Ball Grid Array) solder joints is analyzed by using the SP-μCT system at BL47XU.

Experiment

The specimens were fabricated by joining a Sn-37wt%Pb eutectic solder ball with 100μm in diameter to a steel pin in usual reflow soldering process. Thermal cycle test was performed under an accelerating condition with upper temperature 125°C, lower temperature -40°C and holding time 30min. The specimens were picked up at any number of cycles in the test and the microstructure of the solder balls were observed by using the SP-μCT system at BL47XU. In typical measurement condition, 750 projections were taken by 0.24° steps in 180° rotation and exposure time for each projection was 1sec. X-ray energy of 29.0 keV was selected to obtain absorption images with high contrast between Sn and Pb phases.

Results

Figure 1 shows reconstructed images obtained at the same cross section of the same specimen. Bright and dark parts correspond to the Sn phase and the Pb phase, respectively. At the initial state, the Pb phase is dispersed with characteristic shape, which appears in reflow soldering process of the Sn-Pb solder. And remarkable phase growth is also observed clearly as the thermal cycle test proceeds. Such reconstructed images enable us evaluate the lifetime of the micro joints by periodically monitoring the phase growth, since the increase in the average phase size corresponds to the fatigue damage newly accumulated in the solder joints2). This result shows the possibility that nondestructive testing by micro CT system is useful for the evaluation of the reliability in micro joints. Figure 2 shows a three-dimensional image of the Pb phase distribution in the same joint as shown in Fig. 1(c). Characteristic dendrite structure of the Pb phase is clearly observed, while such three-dimensional information has not been obtained at all by SEM (Scanning Electron Microscope) two-dimensional observations on cross sections of micro joints. Three-dimensional microstructure analysis of micro joints will bring us valuable knowledge on the reliability of the joints.

References

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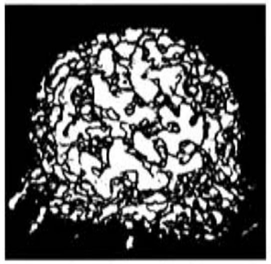
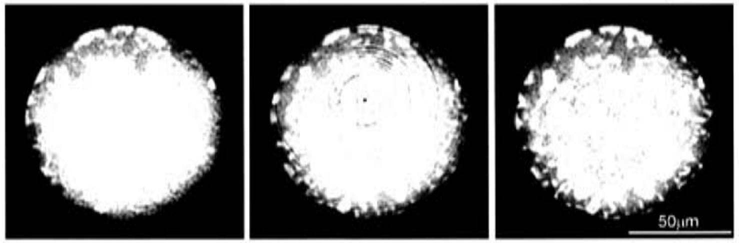


Fig. 2 A 3-dimensional image of the Pb phase in the joint



(a) Initial state (b) After 100 cycles (c) After 300 cycles

Fig. 1 Reconstructed images showing phase growth in an Sn-Pb eutectic solder joint