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Study of prediction method for thermal fatigue of Lead-free solder joints by EBSD analysis

- Comparison between the bench test parts and the recovered parts -

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GROD (Grain Reference Orientation Deviation) analysis is an image map analysis by being image-processed the diffraction pattern in EBSD and it shows how much the orientation of another crystal differs from the reference orientation. The GROD map can visualize the degree of fatigue by changing the color, however it is necessary to quantify it for correlation verification. Fig.1 is a gragh of the area occupancy of each color when the entire cross section is set to 1 and the GROD color map which shows the change in crystal orientation is set to 0 to 40 and quantified. In this case as the solder joint cross section, the average index was 5.91 and maximum index was 23.5.

As the points where solder fatigue accumulates in the BGA, the points where cracks have occurred in the past test results and the points where the strain amplitude becomes large in the simulation can be used as a reference. In a BGA solder cross section, it has the four corners as shown the GROD map in Fig.1. These points are boundary where the copper pattern of the substrate and solder are jointed, and cracks are likely to occur due to the difference in the coefficient of linear expansion on the material properties. The GROD analysis was performed the four corners of the solder ball cross section in the bench test samples.

In this case 250 cycles data was deleted after analysis. It is because the recrystallization of soder joint from initial state and the formaction of subgrain boundaries became remarkable in 250 to 500 cycles in this sample, and the GROD index decreased and then increased. Fig.2 shows the result of creating a graph with the index showing maximum estimated to be the most affected points of the strain among the four corners of the BGA. In this analysis with this consideration, the correlation coefficient showed about 0.6.

We collected the same samples in the market and verified the correlation with the bench test result. It can be estimated that the recovered samples has undergone thermal fatigue equivalent to 500 cycles of the bench test. In addition, it can be assumed that running 200K km will cause stress equivalent to 1000 cycles.

We predict the thermal fatigue stress of electronic components by considering four temperature parameters and their frequency. These are the air temperature change (ΔT1), cabin temperature change by solar radiation (ΔT2), temperature impact by heat radiation from around the part (ΔT3), self-heating impact (ΔT4).

Predicting the stress of this recovered parts with our estimation tool is 964 to 1389 cycles with different soder radiation conditions at 250K km. It is almost same cycles at 250K km in Fig.3. We need to continue to investigate the values of ΔT2 that correspond to the actual market. We could confident this prediction method for the solder thermal fatigue is sufficiently applicable by this analysis and our consideration.

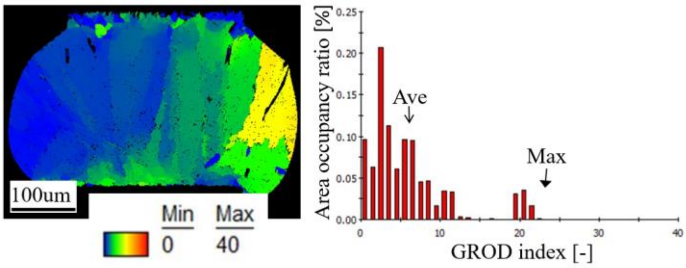

Fig.1 GROD color map and area occupancy ratio histogram

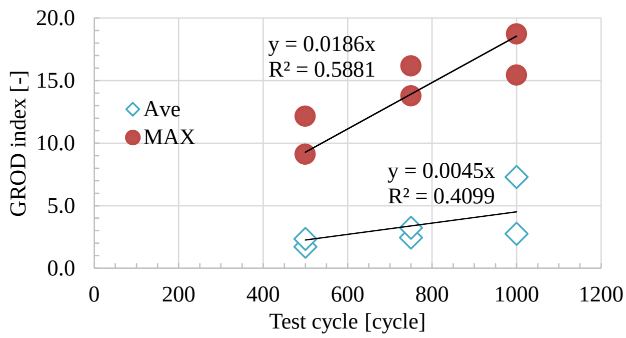

Fig.2 The graph of GROD MAX /Ave index analyzed as the largest value in 4 corners vs test cycle graph for each heat cycle test samples and approximate linear graph without 250 cycle data

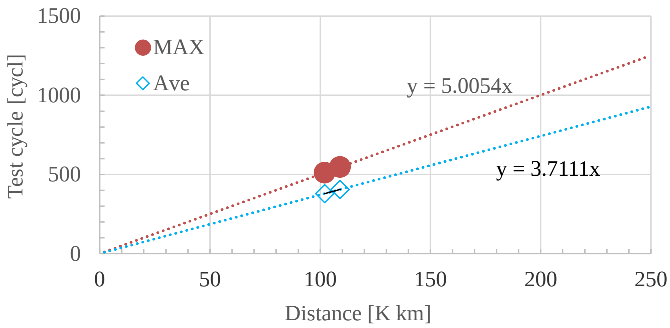

Fig.3 Correlation graph of running distance vs test cycle for soldering ball

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