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Correlation between MEMS Adhesive cure Degree and acoustic Impedance determined with Differential Scanning Calorimetry and Scanning Acoustic Microscopy

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1. Introduction

The motivation for this work has been to gain a fast, reliable and quantitative adhesive cure QA method for MEMS and microelectronics. In earlier studies the feasibility and advantages of using Scanning Acoustic Microscopy (SAM) in order to area detect whether Compression UnderFill (CUF) is cured or not cured at all have been demonstrated [1, 2]. The method relies on comparison of adhesive acoustic impedances Z_x calculated from C-SAM grey values g_x by using equation (1) which is based on the assumption that g_x varies linearly with the reflection coefficient R.

$$Z_x = Z_1 \frac{g_a(Z_a + Z_1) + g_x(Z_a - Z_1)}{g_a(Z_a + Z_1) - g_x(Z_a - Z_1)} \tag{1}$$

In (1) Z_1 is the acoustic impedance of the top material, Z_a, g_a are acoustic impedance and grey tone respectively for some reference material, typically water, underneath the top material.

Here it is demonstrated that the method can be used to determine not only whether an adhesive is cured or not cured at all, but also to determine cure degrees in between these limits.

2. Results

The two component EpoTek T7110 epoxy adhesive was studied. The reaction kinetics was analysed using Differential Scanning Calorimetry (DSC). A single chip with adhesive underneath was used to avoid sample to sample variations. I.e. adhesive between the four corners of flip chip with 30 μm bump height and four PCB corners was cured at different times at 100 °C. Slightly different gate positions and widths were used to explore the reproducibility in determining $Z_{adhesive}$ by C-SAM, figs. 1-3.

3. Discussion

The grey tone depends on the reflected amplitude with polarity (2):

$$A(R)_{12} = A_0 R_{12} = A_0 \frac{Z_2 - Z_1}{Z_1 + Z_2} \tag{2}$$

where A_0 is the incoming wave amplitude, R_{12} is the reflection coefficient corresponding to the interface between materials 1 and 2, Z_1 and Z_2 are the acoustic impedances of materials 1 and 2 respectively. R is not very sensitive to changes in Z_2, as can be seen from (3) inserting typical values (e.g. $Z_{1\,=\,water}$ = 1.48 MRayl, $Z_{2\,=\,microelectronics}$ = 20 Mrayl) though for many applications sensitive enough as also shown by these experiments.

$$\frac{\Delta R}{R} = \frac{2Z_1Z_2}{Z_2^2 - Z_1^2} \cdot \frac{\Delta Z_2}{Z_2} \tag{3}$$

Using grey tones directly to determine reaction degree is not feasible due to the small relative changes. Acoustic impedances here changes approx. 30 % from 68 % reacted to 100 % reacted adhesive. The method is quite sensitive to the SAM gate adjustment, i.e. when the gate is changed the grey tones change and therefore also the determined acoustic impedances change. However, the grey tone relative values do not change. They can therefore be used as a quick gate-insensitive detection of more or less reacted areas. For quantitative evaluations a reference is needed and the grey tone values should be converted to acoustic impedances.

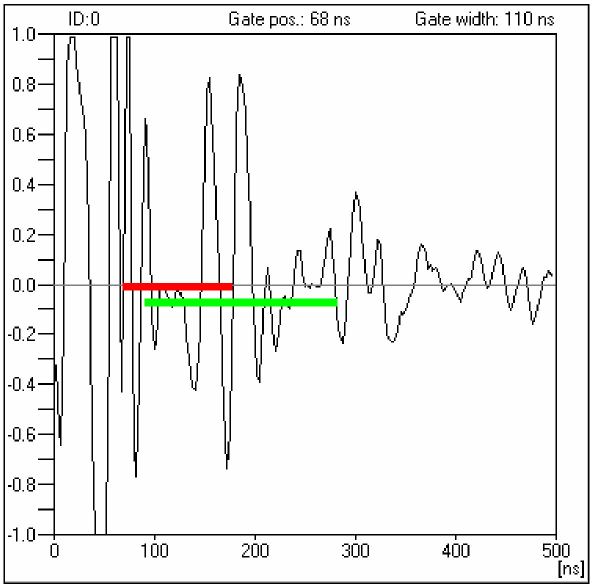

Fig. 1. A-scan in the centre of fig. 2. The top bar is the gate for the reflected signal from the chip / adhesive interface. In another Z determination the gate position was e.g. 85 ns and the width 98 ns.

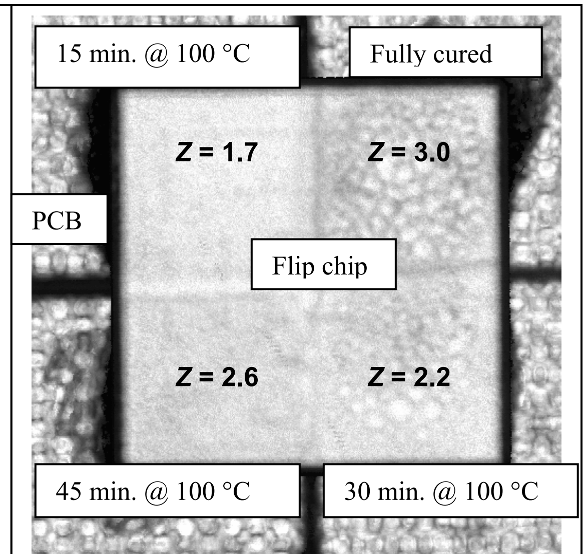

Fig. 2. Acoustic impedance / cure degree of EpoTek T7110 adhesive between flip chip (2.5 cm x 2.5 cm, 30 µm bump height) and PCB (4 pieces, bottom up) determined from SAM grey values. Corresponding A-scan is shown in fig. 1.

4. Conclusion

Generally, it has been shown that a linear correlation between acoustic impedance and adhesive reaction degree can be established. To determine the reaction degree from acoustic impedance a known reference and careful adjustment of the SAM gate is required.

Independent of a reference and precise SAM gate adjustment grey tones can be used as a quick qualitative comparison of more or less reacted areas.

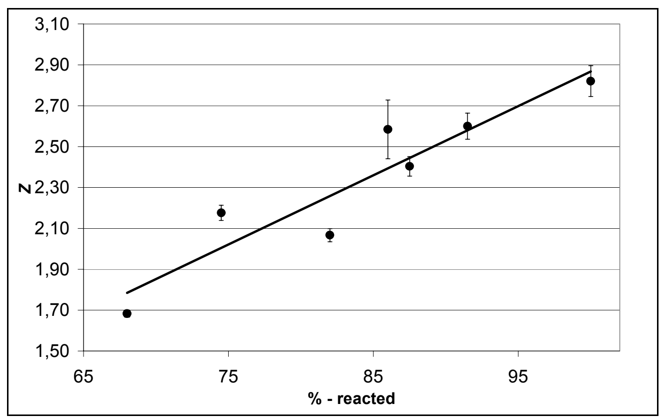

Fig. 3. Average acoustic impedance of EpoTek T7110 adhesive as a function of the reaction degree. Z = (0.0339 MRayl/%reacted) % reacted - 0.5183 MRayl, R = 0.93. The reaction degree was determined by DSC kinetic analysis.

5. Acknowledgement

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6. References

[1] Jakob Janting, Dirch Hjorth Petersen, Scanning Acoustic Microscopy Investigation of Adhesive cure Degree, In these proceedings.

[2] J. Janting, D. H. Petersen, B. V. Schönwandt, Scanning Acoustic Microscopy Study of Flip-Chip Underfill Cure Degree, in proceedings of Materials Week 2002, Munich