

Test Method for Dispensing Electronic Process Materials

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ABSTRACT

Robotic dispensing provides flexibility for electronics production not possible from screen-printing processes. As well as the application of solder paste and surface mount adhesive, dispensing systems are utilised with newer technologies such as the application of conductive adhesives, chip on board, glob-tops and flip chip underfills.

This document describes test methods for characterising the behaviour of these material types, which should help in optimising the dispensing process and in improving dispensing results.

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Approved on behalf of Managing Director, NPL, by Dr C Lea,
Head, Materials Centre

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1 INTRODUCTION

Robotic dispensing is used for the application of a range of electronic production materials, including solder paste, conductive adhesives, surface mount adhesives, glob-tops and underfills. This document provides a test method for the characterisation of deposits and it is recommended that it is used in conjunction with the previous NPL Code of Practice [1].

2 DEPOSIT MEASUREMENT TECHNIQUES

Current measurement techniques are of two types. The first is based on a camera system accompanied by a grid and collimated light source, as seen in Figure 1. The light traces produced by grid slits are focused on surface features and viewed from above they appear deformed by surface features. These deformations (L) can be detected by a camera system and from the known angle α (usually 45°) the average feature height (H) can be calculated (Equation 1).

$$H = L \cdot \tan \alpha \quad (1)$$

The second technique for height measurement is based on the triangulation (CCD laser displacement) method and assumes a scanning of the feature with a single light beam. A semiconductor laser beam is reflected off the target surface and passes through a receiver lens system. The beam is focused on a CCD sensing array. The CCD detects the peak value of the light distribution of the beam spot for each pixel (individual CCD sensing element) within the area of the beam spot, and determines the precise target position as illustrated in Figure 2. As the target displacement changes relative to the sensor head (H_1 , H_2), the reflected beam position changes on the CCD array. These positional changes are analysed by the controller and transposed into the scanned feature height profile.

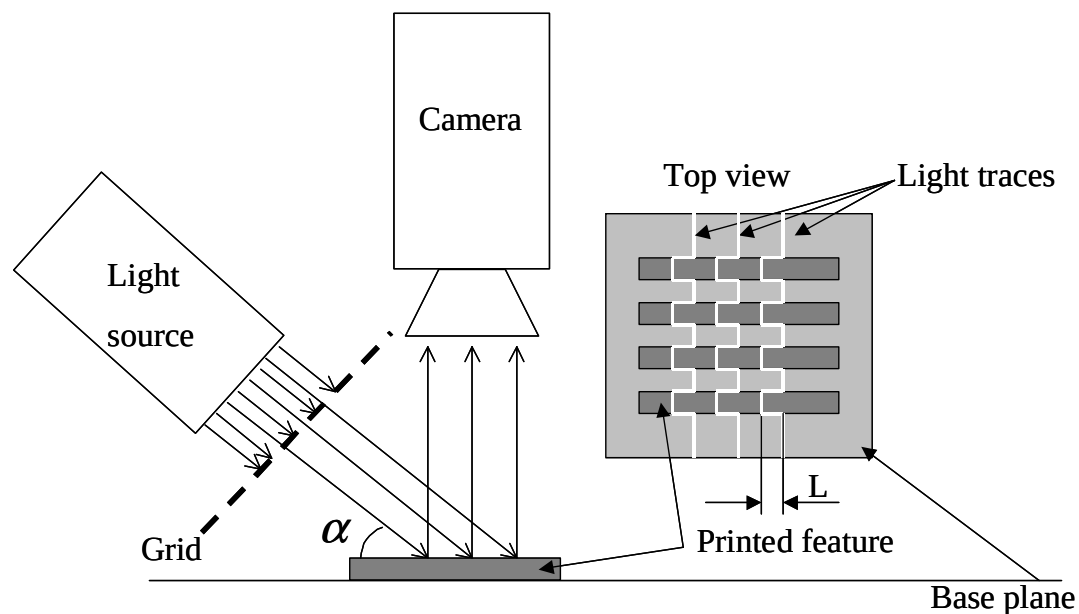


Figure 1. Schematic of camera based measurement system

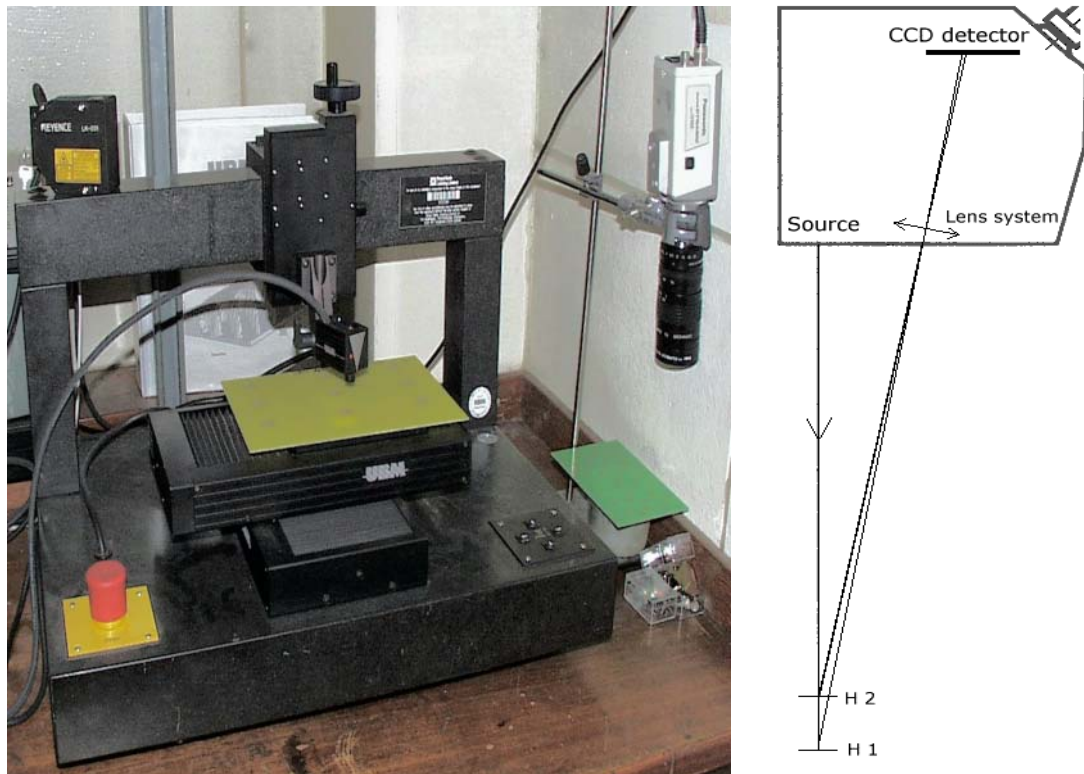


Figure 2. Schematic of laser displacement sensor and example of scanning measurement instrument

Data from any of the described systems can be stored in a two-dimensional matrix and processed using special algorithms to give characteristic feature dimensions. The accuracy of the measurement for solder paste deposits is typically between 1 and 20 μm . An example of a scanned matrix contour plot of a printed deposit is given in Figure 3.

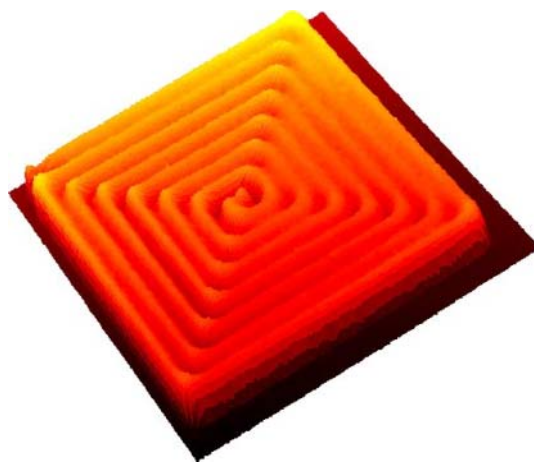


Figure 3. Example of contour plot of a glob top

Using laser profiling to create a profile matrix the height, base radius or width and volume of the deposit can be easily determined. Simple visual inspection can be sufficient [1] when studying characteristic dispensing defect modes.

3 CHARACTERISING DOTS

The size and shape requirements for materials applied as dots (solder pastes, surface mount adhesives and conductive adhesives) are described in a previous NPL report¹. Here an approach for characterising the dispense set-up in order to help achieve those requirements.

3.1 Test Pattern

To characterise the formation of dots from a dispense set-up the following dispense test pattern can be used:

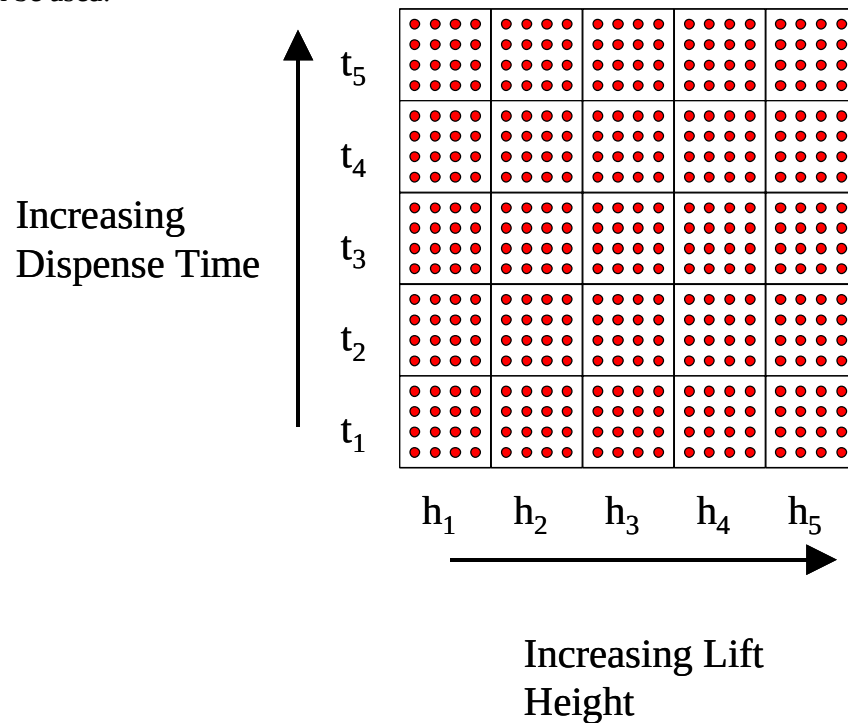


Figure 4. Dot characterisation test pattern

This pattern will facilitate dot characterisation for:

- A particular material
- A specific material temperature
- A specific nozzle design (inner diameter, chamfering, foot height)

If any of these parameters are changed the deposit behaviour must be re-characterised.

A range of dispense times and lift heights should be chosen, which provide a range of behaviours, providing they are reasonably representative of the settings used in practice. For example, the minimum dispense time should be just long enough to prevent missing dot defects [1] occurring and the minimum lift height to produce a small amount of smearing of the deposit.

3.2 Measurement and Analysis of Deposited Test Pattern

The laser profiling method should be used to measure a representative dot from each of the squares in the test pattern, and obtain its radius, height and volume. These figures can then be plotted to highlight the effect of the dispensing parameters and allow the optimal ones to be chosen.

3.2.1 Dot Height

Solder paste materials tend to break away from the nozzle readily without stringing or distortion of the deposit as the needle lifts. As a result the deposit height is dictated by the height of the nozzle tip during dispensing, and remains constant for a range of volumes dispensed for a particular footed needle design. If the needle lift height is extremely low there may be some smearing which will reduce the deposit height slightly. This behaviour is illustrated as a schematic in Figure 5.

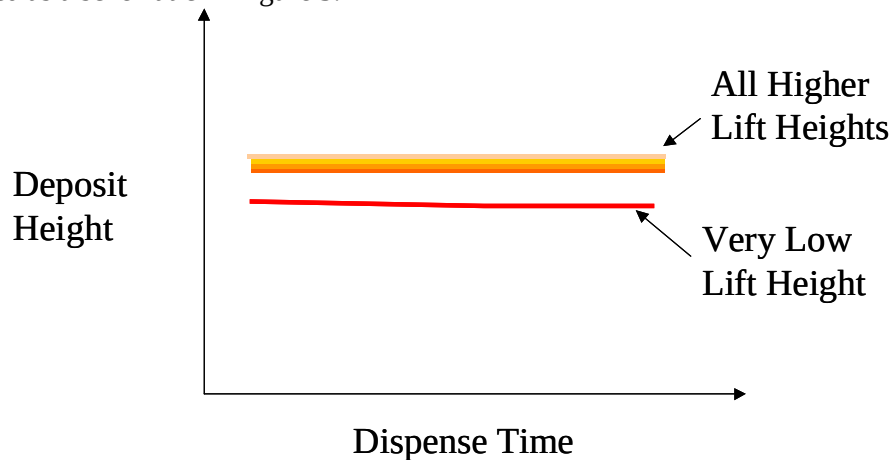


Figure 5. Schematic of typical deposit height behaviour for solder paste

Adhesives (both surface mount and conductive) generally behave differently from the pastes with the material remaining connected to the nozzle tip as it lifts. For these products height depends mainly on the nozzle lift height, as shown in Figure 6.

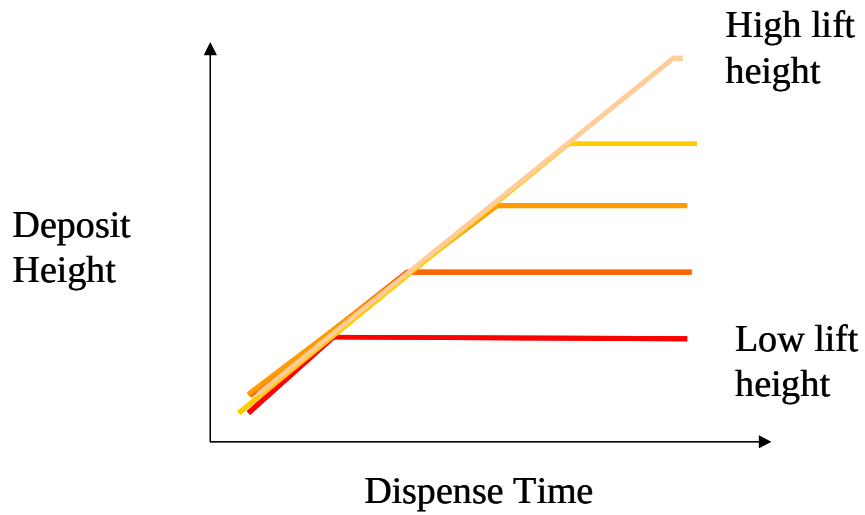


Figure 6. Schematic of typical deposit height for adhesives

3.2.2 Dot Volume

Dot volume should be proportional to the dispense time for both adhesives and solder pastes (Figure 7).

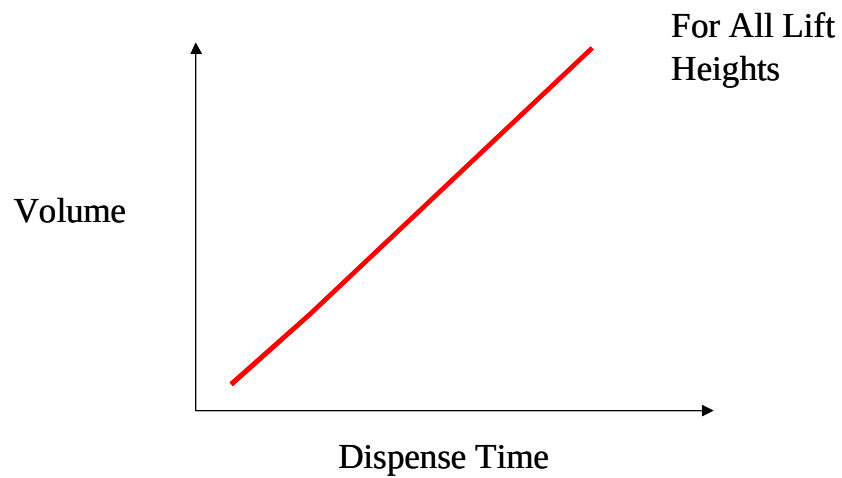


Figure 7. Schematic of typical deposit volume for solder paste and adhesives

3.2.3 Dot Radius

The radius of the dot increases with the dispense time, following a curve similar to that shown in the schematic Figure 8.

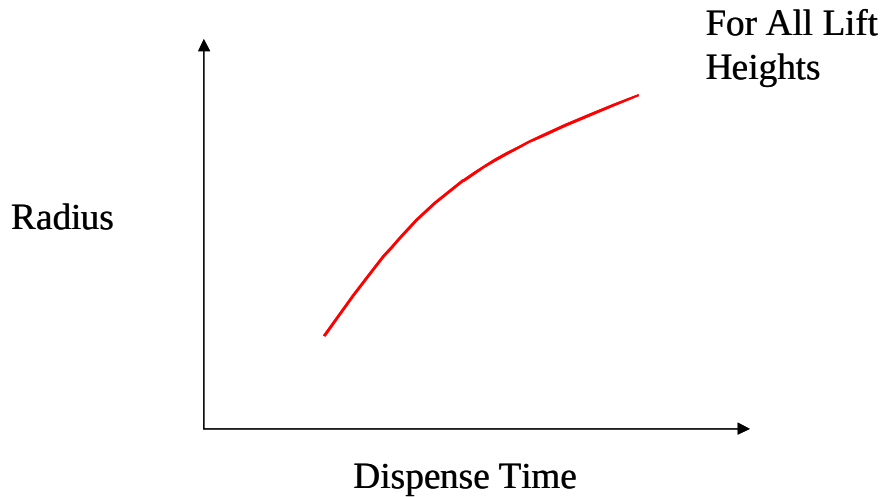


Figure 8. Schematic of typical deposit radius for solder paste and adhesives

4 CHARACTERISING GLOB-TOPS

The size and shape requirements for glob-tops are described in a previous NPL report¹. Here an approach is presented for characterising the dispense set-up in order to help achieve those requirements is presented.

To characterise the formation of dots from a dispense set-up the following dispense test pattern can be used:

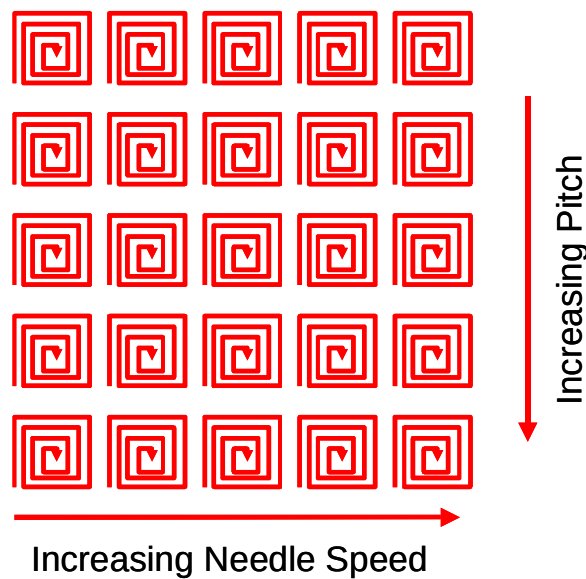


Figure 9. Glob-top characterisation test pattern

This pattern will facilitate glob-top characterisation for:

- A particular material
- A specific material temperature
- A specific nozzle design (inner diameter, chamfering)

If any of these parameters are changed the deposit behaviour must be re-characterised.

A range of dispense times and lift heights should be chosen, which provide a range of coalescence behaviours, providing they are reasonably representative of the settings used in practice. For example, the maximum pitch should produce an un-coalesced deposit.

By inspecting the deposits, and determining if their heights are sufficient the appropriate settings for needle speed and pitch can be found.

5 CHARACTERISING GLOB-DAMS

5.1 Dam Height and Width (Dispense Speed)

A simple trial with various needle speeds can be used to find the appropriate dam height.

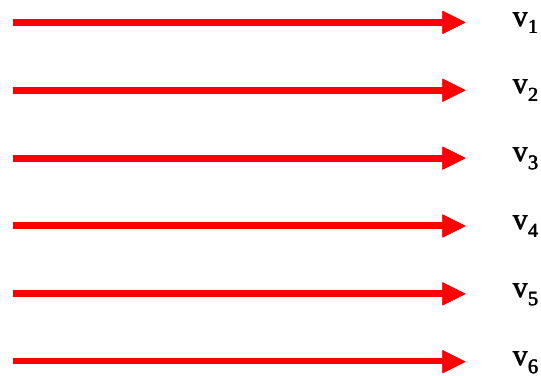


Figure 10. Dam height characterisation test pattern

Measure the height and width of the lines and plot the results against dispense speed. The typical behaviour of a dam material is shown in Figure 11 and Figure 12.

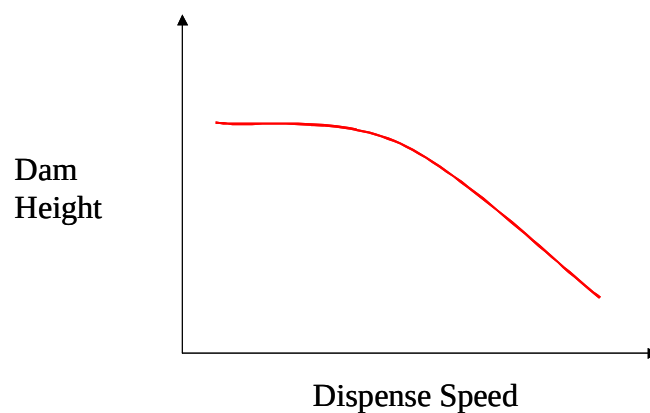


Figure 11. Schematic showing the change in dam height with dispense speed

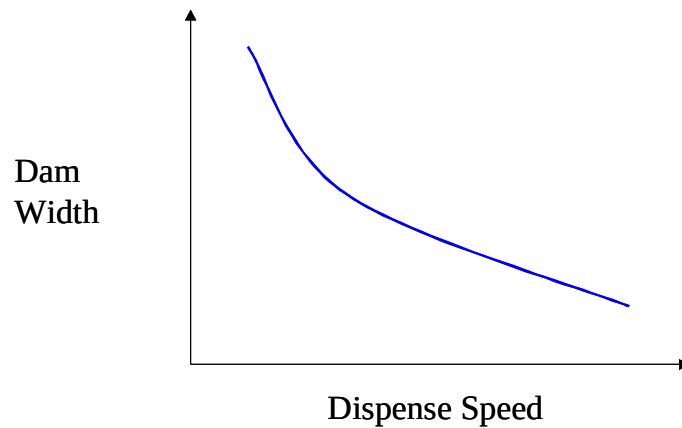


Figure 12. Schematic showing the change in dam width with dispense speed

5.2 Dam Closure

For dam and fill style glob-tops the formation of a good dam enclosure by optimising the ON-delay and OFF-delay is critical [1].

To characterise the formation of a glob-top dam the following dispense test pattern can be used:

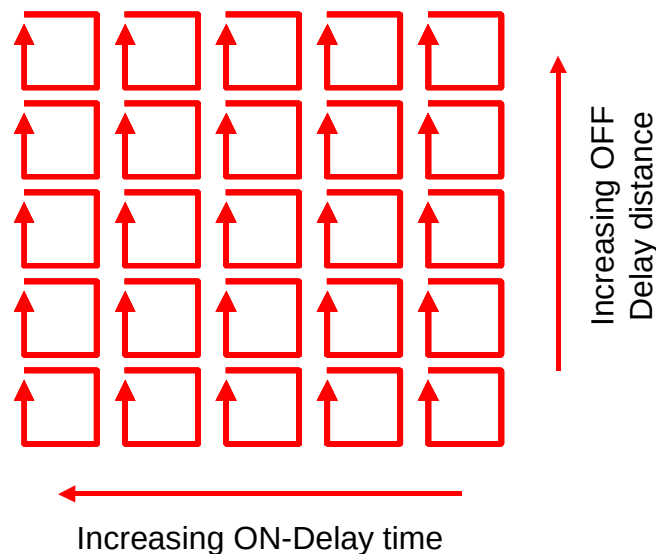


Figure 13. Dam closure characterisation test pattern

This pattern will facilitate dam characterisation for:

- A particular material
- A specific material temperature
- A specific nozzle design (inner diameter, chamfering)
- A specific dispense speed (as determined in Section 5.1)

If any of these parameters are changed the deposit behaviour must be re-characterised.

Delays, providing a range in behaviour should be chosen, providing they are reasonably representative of the settings used in practice. For example, some open dams and some

pooling may be present at the extremes of the dispensed pattern. Somewhere in the middle of the array of dam deposits there is likely to be one with a sealed enclosure but no pooling. This will indicate the appropriate delay settings.

6 UNDERFILL WETTING TIME

6.1 Underfill Model

To make an inexpensive physical model for testing underfill materials it is convenient to use a microscope cover slip (20mm x 20mm is suitable). To achieve a controlled stand-off some controlled diameter glass balls should be mixed into surface mount adhesive and a deposit placed at each corner of the cover slip. It is sensible to use glass balls that will best represent the stand-off height of the components to be underfilled, ensuring that there are at least 20 or so balls in each deposit (Figure 14). The glass balls often have a range of diameters depending on how they are sieved and this ensures that there are some with the largest diameter at each corner to provide correct levelling of the cover slip.

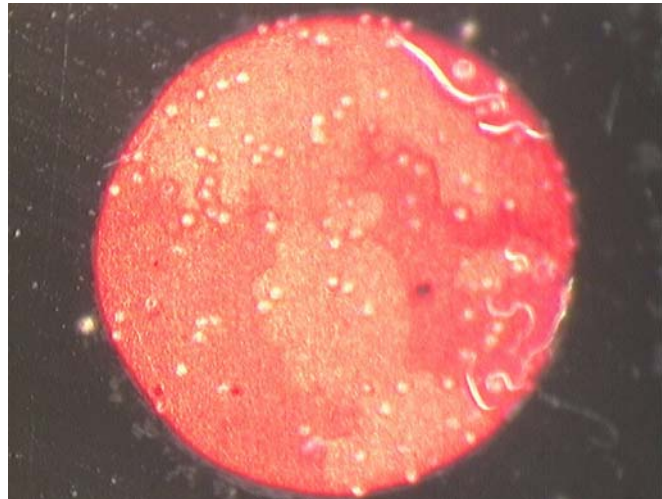


Figure 14. Glass balls within SM adhesive compressed under cover slip

The cover slip is then pressed down firmly onto some test laminate, and then placed in an oven to cure the surface mount adhesive in accordance with the manufacturers' recommendations (Figure 15).

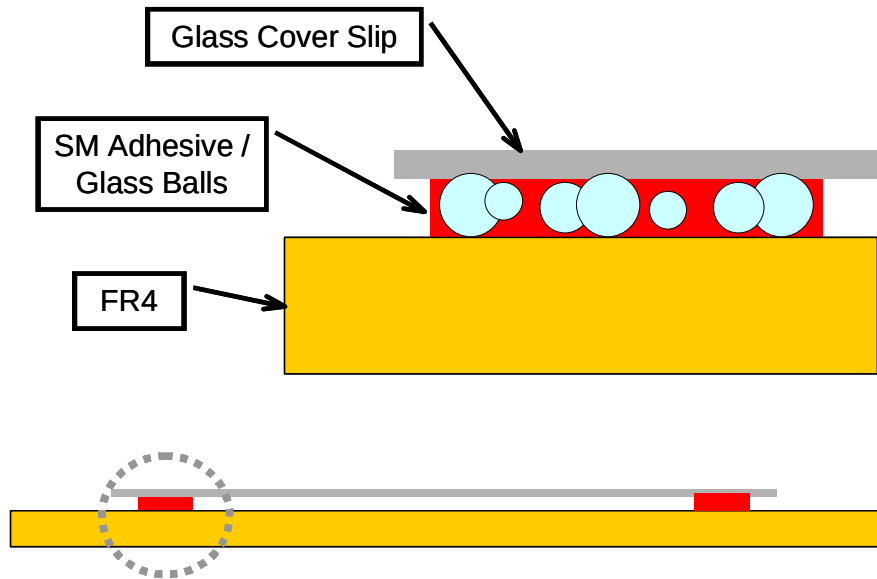


Figure 15. Schematic of underfill test model

6.2 Dispense Patterns and Fill Times

There are several possibilities for the dispense pattern employed to underfill a component, and the most common are shown in Figure 16. A full explanation of the effects of dispense pattern are detailed in a previous NPL Code of Practice [1].

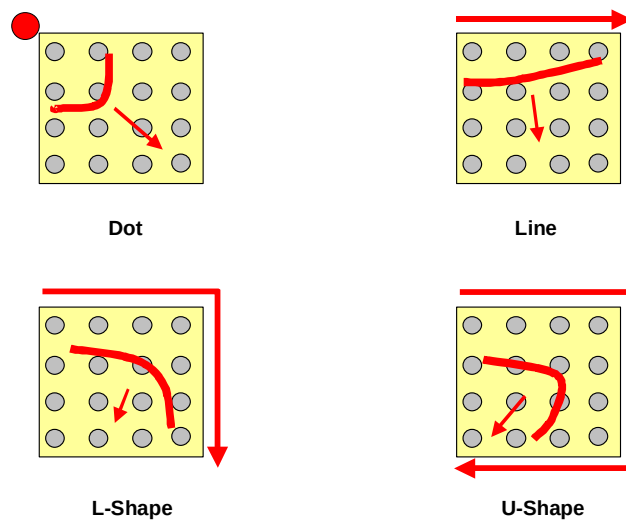


Figure 16. Underfill dispense patterns

Since the chip is modelled by a transparent cover slip the movement of underfill beneath can be clearly seen and the fill time with different dispense patterns and substrate temperatures determined.

Figure 17 and Figure 18 illustrate trends for underfill materials that are likely to be exhibited.

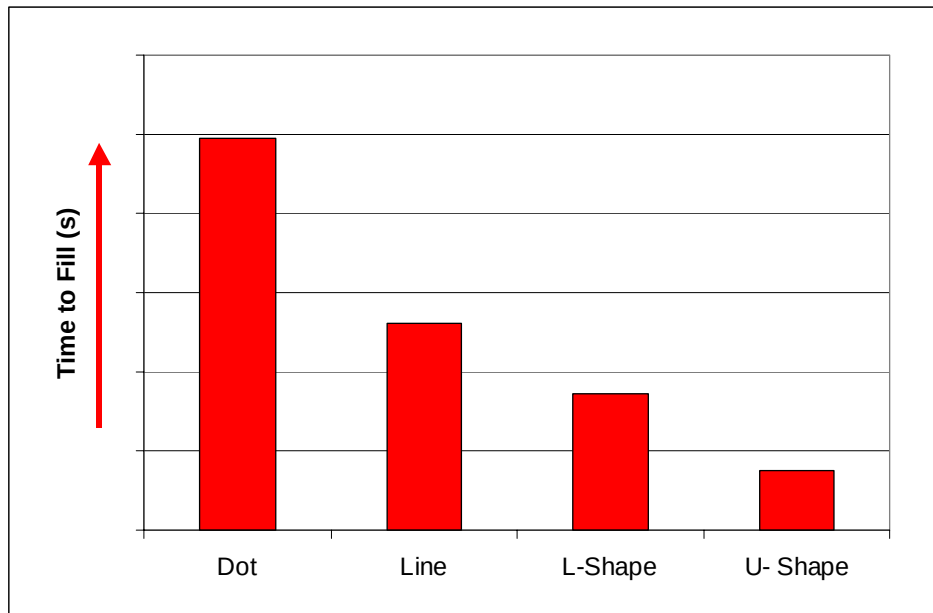


Figure 17. Schematic showing effect of dispense pattern on fill time

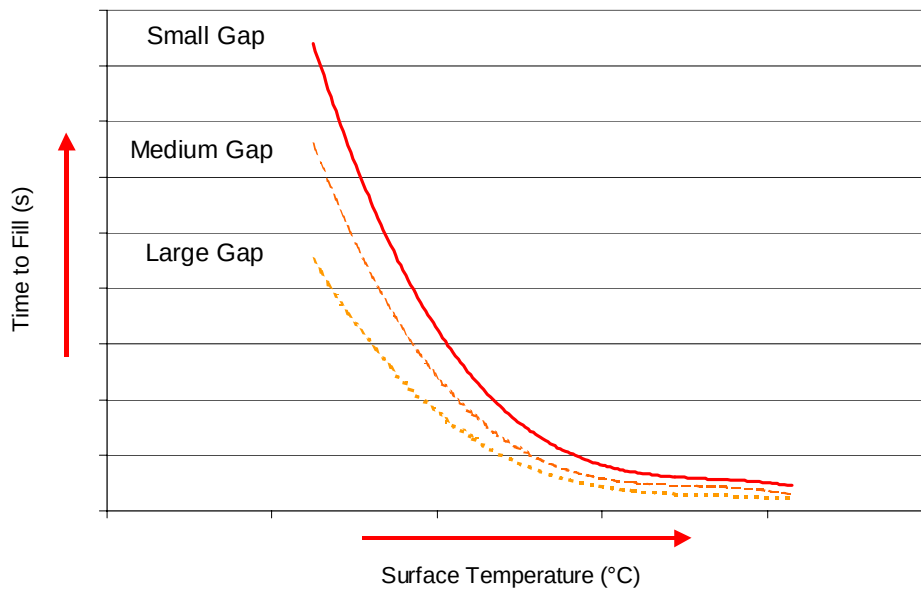


Figure 18. Schematic of effect of temperature on fill time

This method is suitable not only for comparing underfill products, but also for assessing the comparative effects of dispense patterns and heating. However, there will be differences when the material is applied to underfill real chips, for example:

- The surface energy of the chip underside may differ from that of glass
- The presence of solder resist may have an effect (FR4 can be used with resist for trials to compensate for this effect)
- The presence of interconnect balls can affect fill rate and air entrapment

7 CONCLUSIONS & RECOMMENDATIONS

- A range of test dispense patterns are described which facilitate understanding of the effects of the main processing parameters on dispense behaviour
- A better understanding is achieved if laser profilometry is applied to measure deposit profiles, but visual inspection alone can provide some guide, especially when characteristic defect modes occur
- Trials using these test methods can be performed easily and at low cost, only the underfill test method (which uses a glass slide and balls with adhesive) requires anything other than FR4 test pieces
- There are important variables for each material type, which if changed, will require re-characterisation of the dispensing behaviour

8 ACKNOWLEDGMENTS

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OMG Americas – Chris Palin

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9 REFERENCE

1. NPL Report - MATC(A) 82 'Code of Practice for Dispensing Electronic Materials', *Alan Brewin, Christopher Hunt and Ling Zou*. December 2001.