WLCSP Handling Guidelines

nAN-038

Application Note v1.0

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1 Introduction

WLCSP eliminates most of the first-level package materials found in traditional packages (lead frame or substrate, die attach, wire bonds, and mold compound which results in better electrical connectivity and conductivity). It also reduces the weight and three-dimensional space consumed by a lead frame-based package or laminate-based CSP.

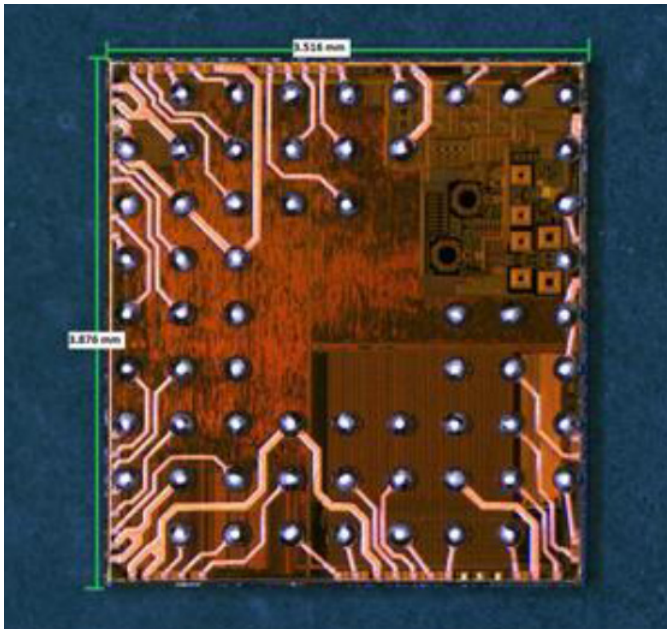

Figure 1 *An example of WLCSP (nRF51-series)*

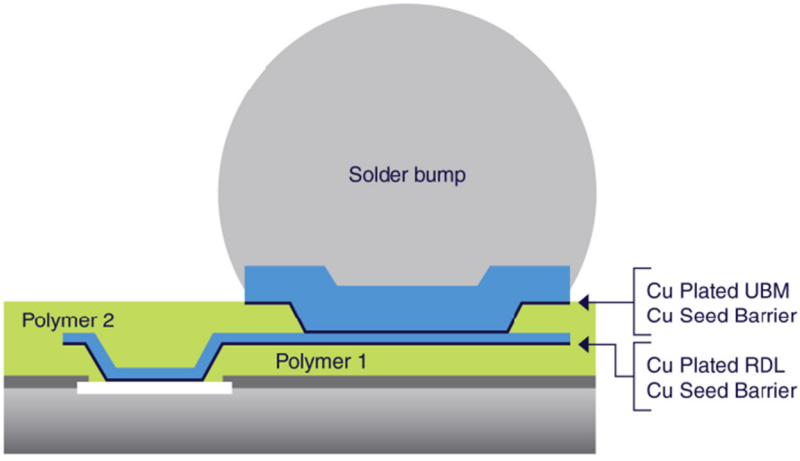

Figure 2 *WLCSP construction*

Figure 3 shows a WLCSP solder joint with the main geometric factors: UBM pad, under bump via, and Printed Circuit Board (PCB) pad.

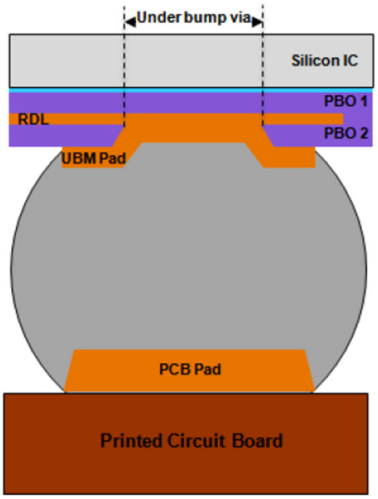

Figure 3 *WLCSP solder joint*

2 Mounting recommendations

2.1 WLCSP PCB layout guidelines

2.1.1 Land pad pattern recommendations

PCB fabrication uses two types of land pad patterns during surface mount assembly, (see ***Figure 4***).

- Non-solder mask defined (NSMD) - The metal pad on the PCB (to which a package pad or pin will be attached) is smaller than the solder mask opening.
- Solder mask defined (SMD) - The solder mask opening is smaller than the metal part.

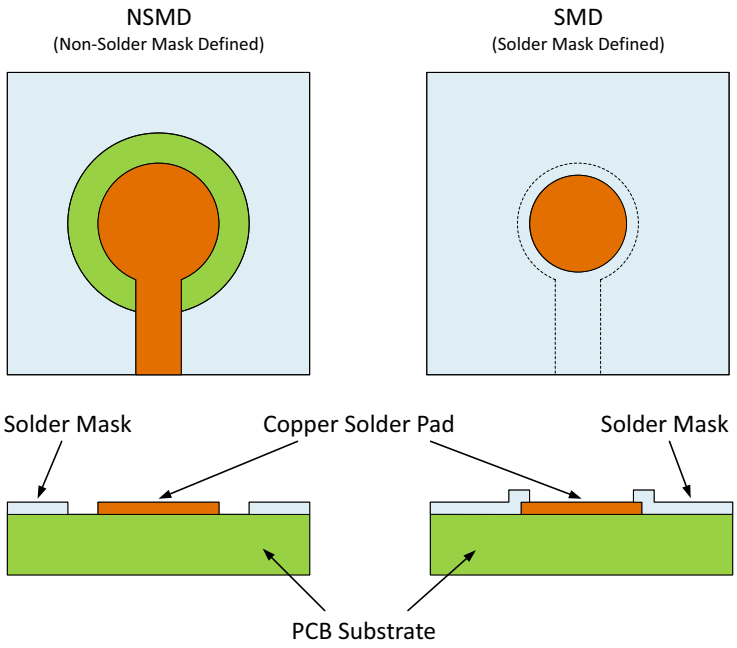

Figure 4 *NSMD and SMD land patterns*

NSMD and SMD each have their pros and cons, as shown in ***Table 1***.

NSMD		SMD	
PROS	**CONS**	**PROS**	**CONS**
Solder ball wets on the sidewall of the exposed copper pads thus improving solder joint reliability.	Solder mask opening creates moats that allow underfill deposits. This irregular distribution of underfill may introduce stress on the solder mask and copper trace.	Copper pads are stronger since the solder mask overlaps the copper thus improving bond adhesion between the pad and the laminate.	Less space is formed in-between pads when routing signal traces.
Wider space is formed when routing signal traces due to small copper area.	Potential underfill voiding as the solder mask opening provides challenges on the underfill's capillary action.	Copper pads have a bigger area thus improving PCB to pad chemistry during flexing and excessive thermal exposure.	Solder joint reliability failures during thermal cycle stress due to absence of copper pad sidewall.
	Prior to pad lift due to fully exposed copper pad without solder mask overlap.		

Table 1 *Pros and cons of NSMD and SMD*

If NSMD pads are used, the NSMD pad diameter should be approximately 90% of the UBM diameter on the package. If SMD pads are used on the motherboard, the SMD pad diameter should be equivalent to the diameter of the UBM on the WLCSP package.

2.1.2 Pad recommendations for nRF51 series chips

When mounting WLCSP to rigid PCBs we recommend that NSMD pads are used. For flexible printed circuit (FPC) board applications where underfill is required, Nordic Semiconductor recommends SMD pads. NSMD is not recommended when the PCB applications require potential rework because NSMD is prone to pad lift at multiple thermal exposure. However, in terms of solder joint reliability, NSMD produces a more reliable solder joint during thermal cycle stress due to the available copper sidewall to which the solder can wet.

Nordic strongly suggests that you carry out a complete Design Of Experiments (DOE) and reliability testing to determine the most suitable pattern for the given PCB application.

Here are some recommendations for the nRF51422-CEAA and nRF51822-CEAA WLCSP packages:

Description	Value
UBM pad size	155 µm
NSMD	CSP UBM Pad diameter x 0.9
SMD	Equal to CSP UBM Pad diameter

Table 2 *Pad recommendations*

2.2 WLCSP SMT guidelines

WLCSP board assembly starts with solder paste screen-printing on the board prior to component pick and place. Consider the following steps for all WLCSP applications:

- Stencil design guidelines: The stencil design guidelines outlined in the IPC-7525 should be followed for all assemblies.
- Solder paste: A no-clean solder paste with a particle size no larger than 40 µm (Type 3) is recommended.
- Package pick-up and placement:
  - Z-height distance between the WLCSP and the pick-up tool should be set to zero or with minimal gap. The vacuum lifts out the package from the pocket of the carrier tape.
  - Similarly, Z-height during placement should be set to zero or with a minimum gap height to avoid overdrive during board placement.
- Reflow: All Nordic Semiconductor WLCSP are Pb-Free and are qualified at 260 °C reflow with MSL1. Typical temperature profiles for the lead-free (Sn-Ag-Cu or Sn-Ag) solder and the corresponding critical reflow parameters are shown in ***Figure 5*** and ***Table 3***.

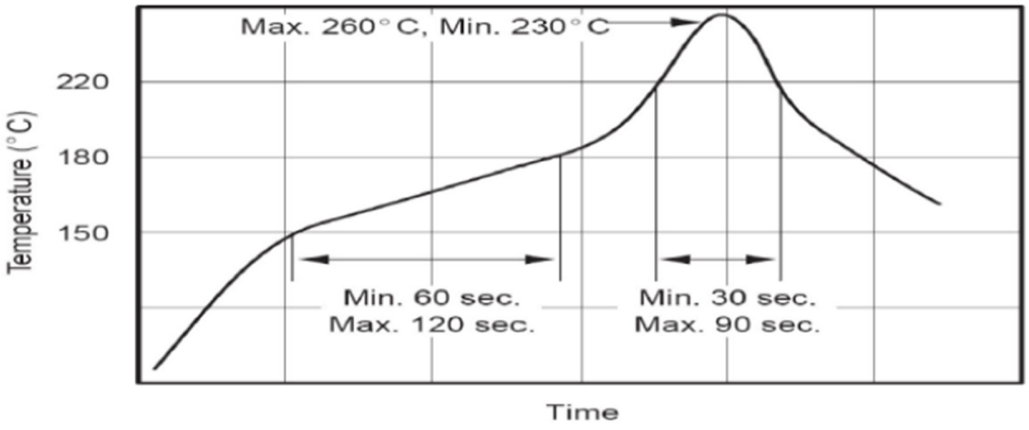

Figure 5 *Recommended reflow profile for Sn-Ag-Cu paste*

Process step	Lead-Free solder
Ramp rate	3 °C/second
Pre-heat	150 °C to 180 °C, 60 to 180 seconds
Time above liquidus, 220 °C	30 to 90 seconds
Peak temperature	255 °C ±5 °C
Time within 5 °C of peak temperature	10 to 20 seconds
Ramp down rate	6 °C/second maximum

Table 3 *Recommended reflow parameters for Sn-Ag-Cu paste*

- Underfill: Optional
- SMT Rework: It's not recommended to re-solder demounted WLCSP. For demounting see ***Chapter 3 "Demounting recommendations"*** on page 8.

3 Demounting recommendations

Careful handling of WLCSP devices must be ensured in case devices are sent to Nordic Semiconductor for analysis. WLCSP devices are very vulnerable and easily damaged. To proceed with the analysis, good physical condition is a requirement.

Chipouts prevent further electrical analysis on the device as it covers the real failure. Meaning, chipouts introduced during the transport might mask the original problem and make further analysis impossible or can lead to a wrong conclusion.

You must ensure that the devices are handled carefully to allow analysis to proceed. Recommended handling and shipping conditions can be found in ***Chapter 4 "Packing"*** on page 9.

The key factor for a successful demounting (device removal from PCB) is that the WLCSP device must be lifted from the board in a vertical direction. Use a BGA repair station to ensure the device is lifted in a vertical direction.

> **Note:** When the device is not lifted vertically, the solder distributes throughout the CSP randomly, making short circuits between the pins. This makes the sample preparation process longer. Some chipouts can also be covered by solder and will only be revealed after cleaning.

When necessary, other components are needed to be removed to allow the head of the vacuum pen (or other handling materials) to reach the position of the WLCSP device.

To pick up the WLCSP device, it is recommended to use ESD safe plastic tweezers or an ESD safe vacuum pick-up pen. It is not recommended to use ceramic or metal tweezers during demounting due to the tendencies in damaging the device.

Figure 6 *Vacuum pen (left) and plastic tweezers (right)*

Before attempting any rework ensure that the assembly is moisture-free. This is to prevent moisture damage to the board or other components during rework. Under-board pre-heating is required at 100 °C to 125 °C for eutectic solder and 150 °C to 170 °C for Pb-free solder.

In case underfill is used, removable underfills are available for chip mount and CSP assemblies. Concentrated acids plus heat is applied to underfilled units in removing underfill. Another method is to use heat and light abrasion. After this, the CSP is then pulled off during heating. We recommend re-workable underfill.

4 Packing

Products must be packaged carefully. Each WLCSP device must be in its own anti-static plastic bag, which is properly marked to recognize the devices. The bags must be packed so that damage is impossible during transportation.

Note: If multiple WLCSPs are packed in the same bag damage will occur, so this is not recommended.

Placing of WLCSP devices on masking tapes or any other adhesive tape is not allowed. This will make the device removal difficult and prone to loss or damage and will also result in damage from ESD.

For temporary storage or for shipment of devices to Nordic, it is recommended to use ESD safe boxes or trays or to put each WLCSP device into one ESD safe bag to avoid them coming into contact with each other.

An alternative and cost effective way to pack devices is to re-use the original carrier tape when shipping back samples for analysis to Nordic. See ***Figure 7***.

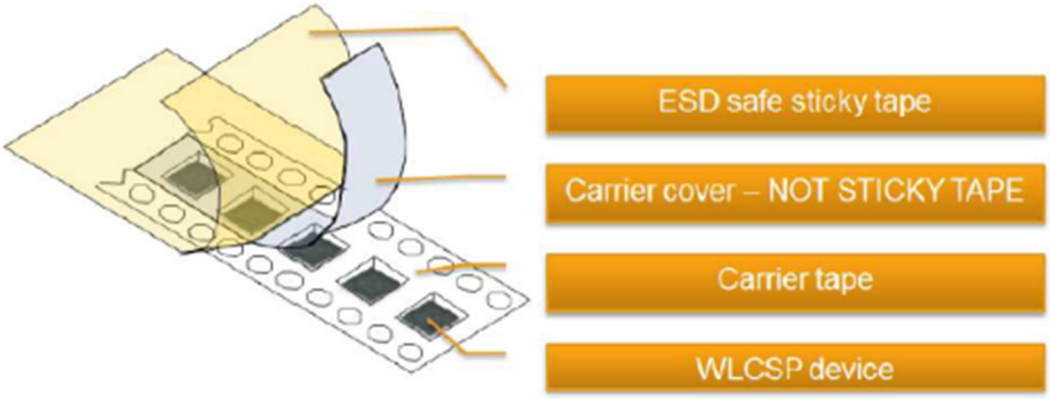

Figure 7 *Re-use of original carrier tape as an alternative to chip trays*

Below are important reminders:

1. Carefully place the WLCSP device inside the carrier pocket.
2. Use the transparent carrier cover to conceal the device.
3. DO NOT USE STICKY TAPE to cover the device as this will make the device removal difficult and prone to loss or damage.
4. Use an ESD safe tape to fully seal the device inside the carrier.
5. Properly identify the samples: Place a sticker to indicate it's device number.
6. Place the carrier inside an ESD safe plastic bag and place this inside a carton box with bubble wrap as additional protection.

5 References

- Deca Technologies WLCSP Assembly Guidelines.

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Revision History

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