APPLICATION NOTE

Cracks on Molded Power Inductors

ANP020 BY RANJITH BRAMANPALLI

1. Introduction

This document helps understanding the influence of visual asymmetry around the core which may occur during the manufacturing process of WE-LHMI series inductors.

WE-LHMI series inductors have an optimized molding technology, especially designed for low profile high current applications like laptops, tablets, battery operated devices, etc. where the need for high current, high stability Point of Load devices are increasing. The advantages of WE-LHMI series products are high saturation current which exhibits soft saturation characteristic, low core losses, high operating temperature, and a small footprint.

Unlike most of the power inductor cores, WE-LHMI core is not a ferrite, it is a mixture of iron powder and resin binder which is pressed around the inductor coil. The resin binder creates a distributed gap and greatly enhances the electrical characteristics of an inductor. After pressing, the mixture is cured along with the inductor coil in an oven to increase the bonding strength between resin binders and iron powder. Unlike other manufacturers, WE-LHMI series products are coated with varnish to avoid oxidation around the core which can affect electrical properties of an inductor in the long run.

2. Visual Appearance & Effects

It is desirable to have a good visual appearance, but due to the manufacturing process involved in the molding process, the process and the core material have limitations in maintaining perfect visual appearance and this application note further explains the affects that can be seen.

WE-LHMI series products with and without visual imperfections have passed all industry standard tests like thermal shock, mechanical shock, terminal strengths, vibration, humidity, moisture resistance, operational life, etc. These imperfections also do not affect the reliability or performance of WE-LHMI series products.

2.1. Hairline Crack: Side View

Cracks around the core are nearly impossible to eliminate as the molding process involves curing the resin binder and iron powder together. During this process small cracks are caused by wall friction when ejecting the component. Unlike in ferrite powder inductors, minor to moderate and major cracks may occur and they do not affect the performance of WE-LHMI series. In order to ensure best quality, Würth Elektronik eiSos has set up standards for production department to control the intensity of cracks before release.

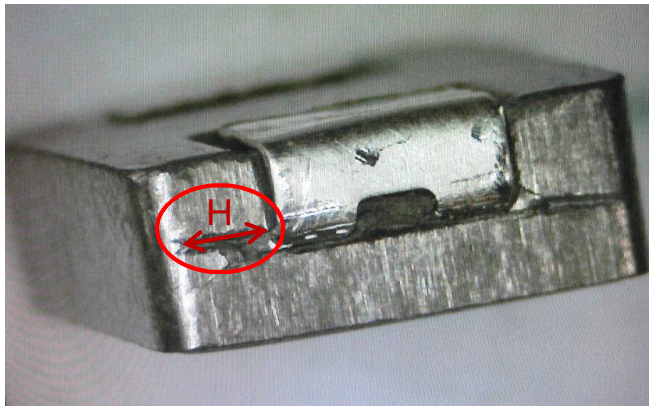

Figure 1: Hairline crack and definition of H

The length of the hairline crack should be less than one third of the H on its left and right side of the terminal otherwise they are deemed as rejected parts at production. H is defined in figure 1.

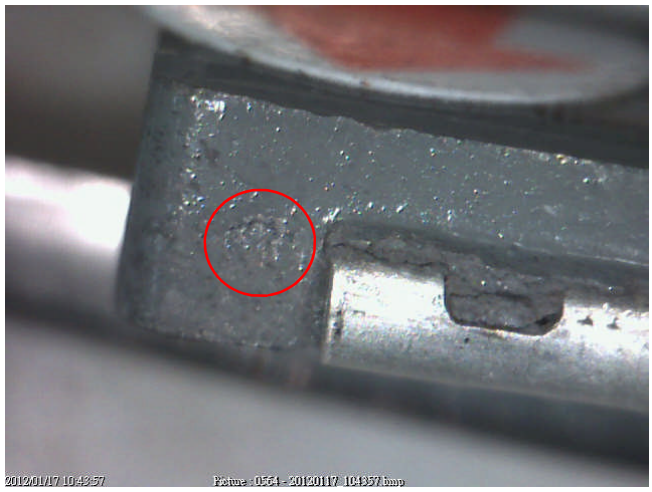

Figure 2: Acceptable minor crack on left side of terminal

APPLICATION NOTE

Cracks on Molded Power Inductors

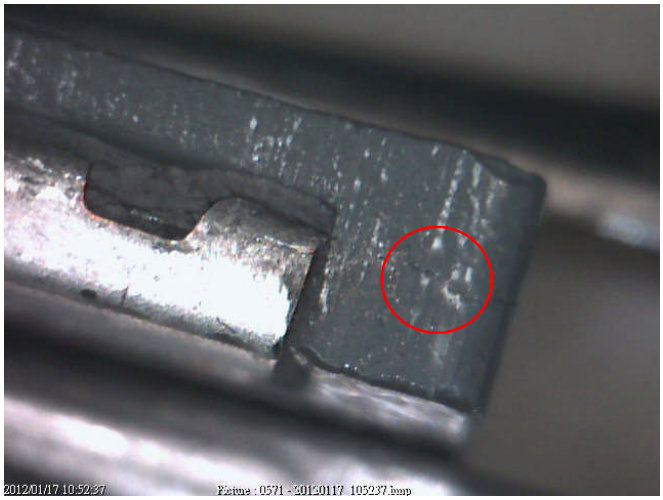

Figure 3: Acceptable moderate crack on right side of terminal

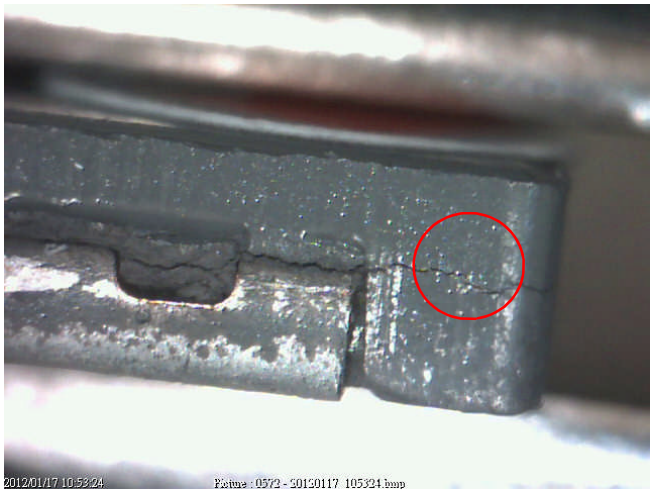

Figure 4: Acceptable major crack on right side of terminal

Visual inspection takes place during the manufacturing process. This is generally done under magnifying glass, CCD camera or 10x optical inspection. This gives an accurate measurement of any imperfections. As shown in figures 2 and 3, there is evidence of visual cracking but as this is within specification these are perfectly useable as the crack is less than 1/3 of height H., whereas figures 1 and 4 show rejected parts at production line.

All other cracks must be less than the height H to be accepted.

2.1.1. Surface with Marking (Crack)

As shown in figure 5, any crack occurring on surface is deemed as not acceptable.

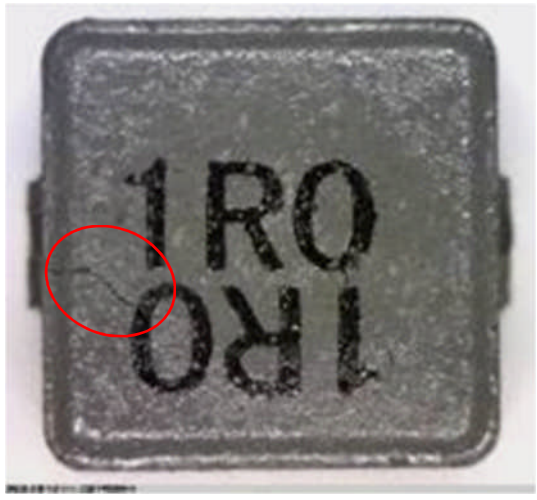

Figure 5: Crack line on surface not acceptable

2.1.2. Pad Surface (Crack)

Cracks can also occur at bottom side near the pad surface. If the crack length is less than 2 mm, the components are deemed as acceptable.

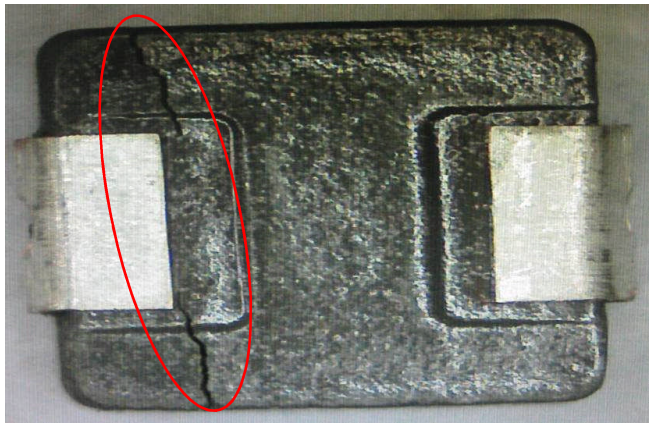

Figure 6: Crack at the bottom, >2mm not acceptable

2.2. Oxidation

Since WE-LHMI series products contain iron, oxidation may occur in worst case scenario, which will not be deemed as accepted. Unlike other manufacturers of molded inductors, WE-LHMI components are coated, so oxidation may not occur around the core at all.

In case of any oxidation around the core, as shown in figure 7, the component is deemed as unacceptable during production process.

APPLICATION NOTE

Cracks on Molded Power Inductors

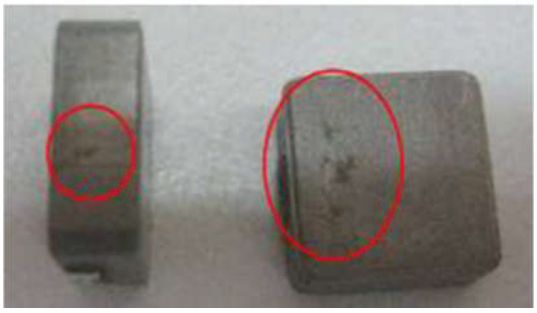

Figure 7: Oxidation on the core, rejected

Also oxidation can be avoided from the customer side by storing components away from heat and humidity in sealed package until mounting on PCB.

2.3. Chip off

Chip off can occur during the manufacturing process of LHMI products. Even though the amount of chipping does not have any affect until the coil is exposed or broken, Würth Elektronik eiSos has set up standards to facilitate customer concerns and visual appearance. Chipping typically occurs on the edges, surface and corners of the inductor as shown below.

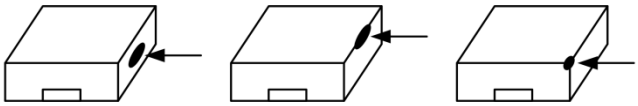

Figure 8: Chip off at various locations

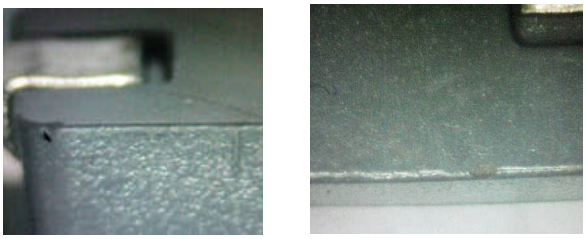

Figure 9: Acceptable chip off at surface junction

WE-LHMI parts are only accepted during production if the chipping on the surface is less than 1 mm, alternatively the chipping at two surface junctions is less than 1,2 mm and the chipping at surface of three junctions is less than 1,5 mm.

Figure 10: Rejected chip off at three surface junctions

2.4. Electrical Performance

Several electrical and reliability tests have been done on WE-LHMI products with visual irregularities and have proven that there is no effect on the performance or reliability. As major chip off is the worst case condition to happen to the inductor, comparison of electrical performance is made with and without chipping.

A synchronous step down switching regulator is implemented using an LTC3810 controller and WE-LHMI's 744 373 680 68 inductor. The DC-DC converter is designed to handle 60 W of power, switching at 250 kHz. The DC-DC converter is designed with an input of 24 V input and output of 12 V at 5 A.

The perfect WE-LHMI 6.8 µH inductor without any visual difference is used in the testing and the resulting values are 11.78 V, 5.02 A with 93 % efficiency. The same test is repeated with 15 % chipping of the original inductor and the same results are exhibited. In figures 12 and 13 waveforms are shown for the inductors with and without chipping.

Figure 11: Chip off on WE-LHMI 744 373 680 68

APPLICATION NOTE

Cracks on Molded Power Inductors

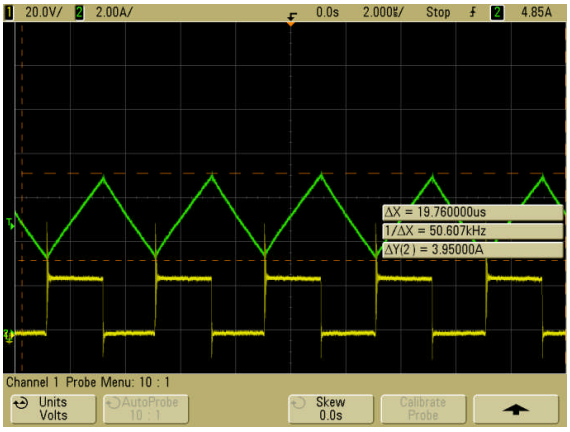

Figure 12: Inductor current and switching voltage with no irregularities on the inductor body

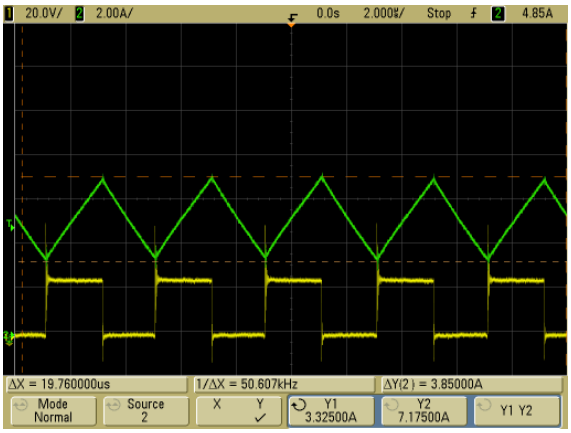

Figure 13: Inductor current and switching Voltage with 15% chipping on the Inductor body

The waveform in green is the current measured through the inductor using Hall effect probe and waveform in yellow is the Voltage measured at the Drain of MOSFET.

3. Summary

The WE-LHMI core is not a solid core, instead it is an iron powder molded around the winding. To match the requirements of modern electronic load demands it is important to look at inductor technology which gives stable inductance into high currents while maintaining a compact design. The molding technology gives us many advantages but in the process can give some minor imperfections. While many of these imperfections are only on the surface and do not affect the reliability or performance of the product. It is still required that Würth Elektronik eiSos continues to develop to minimize these

Also Würth Elektronik eiSos's quality control is constantly setting up standards during manufacturing process to ensure better reliability and performance.

4. Bill of Materials

Index	Description	Package	Electrical Specification	Order Code
L	WE-LHMI SMD Power Inductor	1040	6,8 µH,	744 373 680 68
IC	Switching Controller	28-Pin SSOP	60 W, 250 kHz, 24 v to 12 V, 5 A	LTC3810

APPLICATION NOTE

Cracks on Molded Power Inductors

IMPORTANT NOTICE

The Application Note is based on our knowledge and experience of typical requirements concerning these areas. It serves as general guidance and should not be construed as a commitment for the suitability for customer applications by Würth Elektronik eiSos GmbH & Co. KG. The information in the Application Note is subject to change without notice. This document and parts thereof must not be reproduced or copied without written permission, and contents thereof must not be imparted to a third party nor be used for any unauthorized purpose.

Würth Elektronik eiSos GmbH & Co. KG and its subsidiaries and affiliates (WE) are not liable for application assistance of any kind. Customers may use WE's assistance and product recommendations for their applications and design. The responsibility for the applicability and use of WE Products in a particular customer design is always solely within the authority of the customer. Due to this fact it is up to the customer to evaluate and investigate, where appropriate, and decide whether the device with the specific product characteristics described in the product specification is valid and suitable for the respective customer application or not.

The technical specifications are stated in the current data sheet of the products. Therefore the customers shall use the data sheets and are cautioned to verify that data sheets are current. The current data sheets can be downloaded at www.we-online.com. Customers shall strictly observe any product-specific notes, cautions and warnings. WE reserves the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services.

WE DOES NOT WARRANT OR REPRESENT THAT ANY LICENSE, EITHER EXPRESS OR IMPLIED, IS GRANTED UNDER ANY PATENT RIGHT, COPYRIGHT, MASK WORK RIGHT, OR OTHER INTELLECTUAL PROPERTY RIGHT RELATING TO ANY COMBINATION, MACHINE, OR PROCESS IN WHICH WE PRODUCTS OR SERVICES ARE USED. INFORMATION PUBLISHED BY WE REGARDING THIRD-PARTY PRODUCTS OR SERVICES DOES NOT CONSTITUTE A LICENSE FROM WE TO USE SUCH PRODUCTS OR SERVICES OR A WARRANTY OR ENDORSEMENT THEREOF.

WE products are not authorized for use in safety-critical applications, or where a failure of the product is reasonably expected to cause severe personal injury or death. Moreover, WE products are neither designed nor intended for use in areas such as military, aerospace, aviation, nuclear control, submarine, transportation (automotive control, train control, ship control), transportation signal, disaster prevention, medical, public information network etc. Customers shall inform WE about the intent of such usage before design-in stage. In certain customer applications requiring a very high level of safety and in which the malfunction or failure of an electronic component could endanger human life or health, customers must ensure that they have all necessary expertise in the safety and regulatory ramifications of their applications. Customers acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of WE products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by WE. CUSTOMERS SHALL INDEMNIFY WE AGAINST ANY DAMAGES ARISING OUT OF THE USE OF WE PRODUCTS IN SUCH SAFETY-CRITICAL APPLICATIONS.

USEFUL LINKS

Application Notes:
http://www.we-online.com/app-notes

REDEXPERT Design Tool:
http://www.we-online.com/redexpert

Toolbox:
http://www.we-online.com/toolbox

Product Catalog:
http://katalog.we-online.de/en/

CONTACT INFORMATION

Würth Elektronik eiSos GmbH & Co. KG
Max-Eyth-Str. 1, 74638 Waldenburg, Germany
Tel.: +49 (0) 7942 / 945 – 0
Email: appnotes@we-online.de
Web: http://www.we-online.com