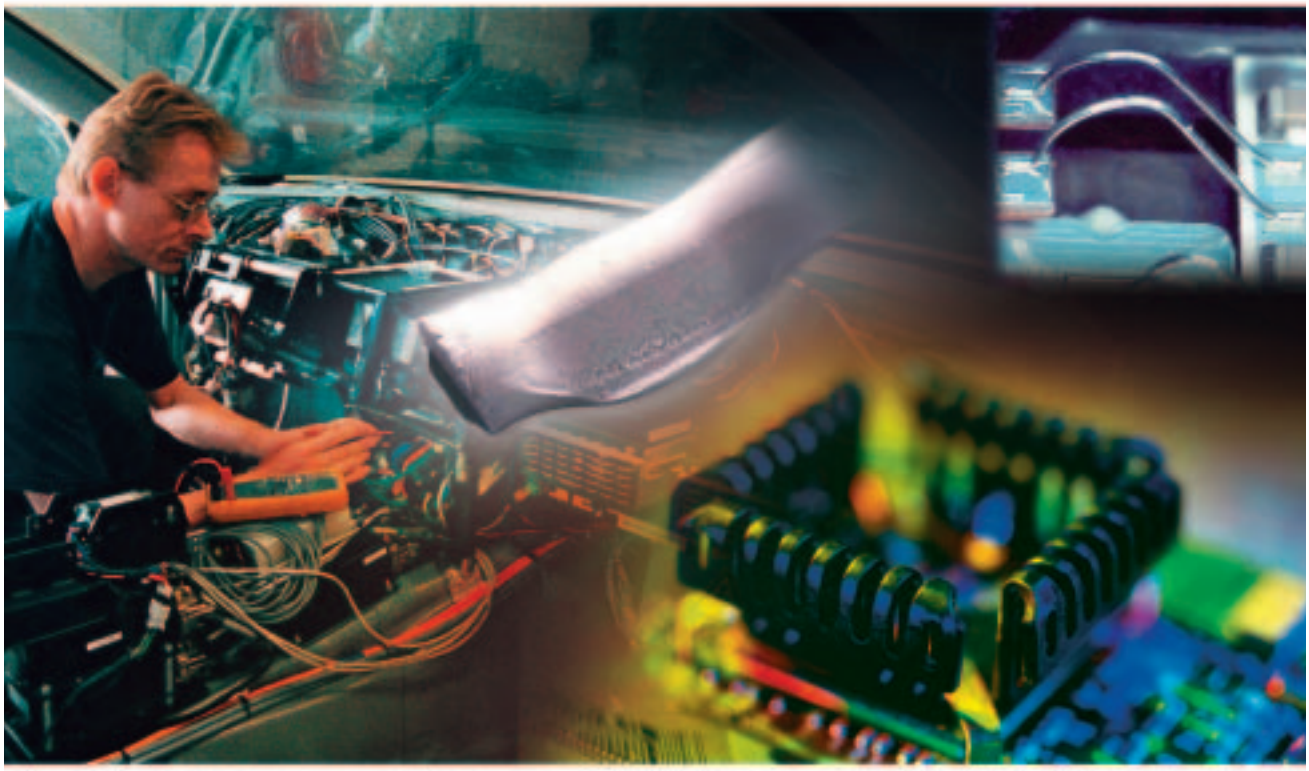
Laser Vibrometry *for a Good Connection*



Using Fiber-Optic Vibrometers for Quality Assurance in heavy Wire Bonds

Thick aluminum wire bonds are widely used to make contact with power semiconductors in the automotive industry. Reliable bond integrity under adverse environmental conditions is critical to maintaining vehicle performance, enhancing quality and lowering costs. Laser vibrometers provide an in situ examination of the bonding process and an important aid in identifying and solving quality defects.

Areas of Application

Automotive power modules are integrated devices that combine low current electronics with high current power electronics to provide control and power to vehicle systems. These devices are becoming more critical as hybrid and electric vehicles enter the market. To make electrical contact with the internal power electronics, thick wire bonding is used. These electrical contacts are produced by ultrasonic friction welding using aluminum wires with diameters ranging from 100 to 600 µm (figure 1). Another thick wire bonding application involves making electrical contact

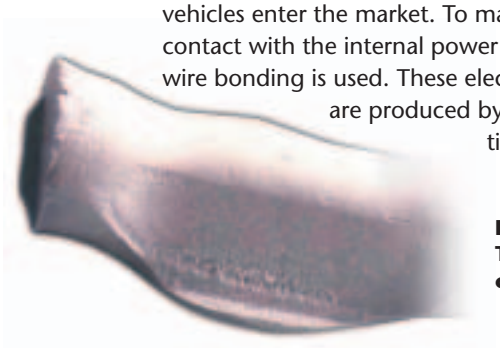


Figure 1:
Thick wire bond contact

Figure 2:
Connection of substrate to housing path

Source: Polytec LM INFO Special Issue 1/2004

between substrate holders and plastic injection molded copper parts (figure 2) which in the automotive industry form complex housings with plug-in contacts or copper conductors.

Challenges

There are numerous effects which occur with bonding and can have an impact later when the components are under load. The semiconductors can be damaged mechanically by the bonding tools („Cratering"). Contamination or too much roughness on the bonding surface can produce a poor weld. Reliability problems can occur with unfavorable wire loop geometries. A deleterious effect of plastic injection molded pressed aluminum plated copper parts is that the copper pads can vibrate during the bonding process.

The Bonding Process

Ultrasonic thick wire bonding is realized by pressing the wire onto the pad and introducing ultrasound into the connection zone. The ultrasound is introduced by the bonding tool as it moves the wire at a frequency of 60 kHz with a vibration amplitude of about 5 µm. Initially a strong relative movement between the wire and the substrate surface is essential to break up the oxide layers on the aluminum surface, transport them partially away from the contact zone and allow intimate elemental contact between the aluminum of wire and pad metallisation.

Use of Laser Doppler Vibrometry

With laser Doppler vibrometry the pad vibrations during the bonding process can be monitored. Laser vibrometry provides non-contact displacement measurement with excellent time and spatial resolution. Because there is zero mass loading, there is no effect on the vibration characteristics of the object under investigation.

Vibration measurements using a Polytec OFV-511 fiber-optic vibrometer (figure 3) have been compared with conventional mechanical tests (shearing test) for quality assurance during wire bonding. A significant correlation was found between the vibration amplitude of the bond pad and the quality of the connection.
This correlation substantiates the use of the OFV-511 as a testing device for improved pad design and for production quality bonds.

In addition, with the use of multi-channel or scanning laser vibrometers, it is possible to get important information on bond quality from the vibrations along both the other spatial axes. By providing an additional measurement channel to directly monitor the ultrasonic transducer on the bonding device, it is possible to determine the complete transfer function for the ultrasonic signal.

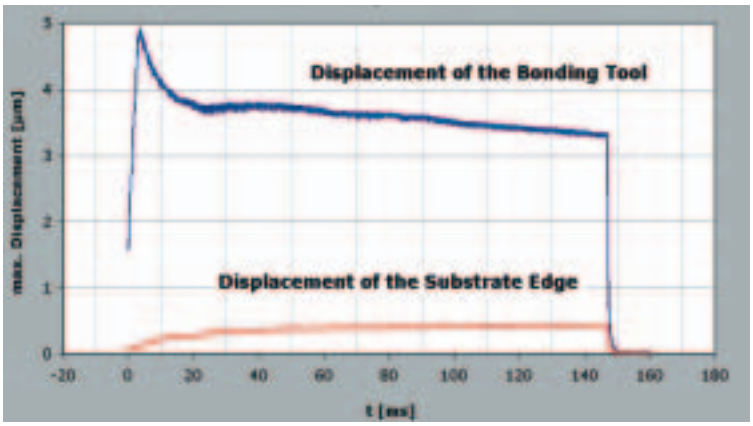


Figure 3: Progression of vibrations during the bonding process

Results and Outlook

Vibrometers can be used to characterize many other types of bonding processes besides the ultrasonic bonding of aluminum to aluminum plated copper in plastic/copper composite housings. One such process is the qualification of clamping systems on lead frames where a large number of bare copper "fingers" must be securely fixed by a hold-down clamp. Another interesting application is the quantitative evaluation of "soft" glues, for stress-free MEMS component mounting where vibrations with micron sized amplitudes are allowed due to the glue's flexible character.

THE AUTHOR

Dr.-Ing. Martin Schneider-Ramelow

Fraunhofer Institute for Reliability and Microintegration (IZM)

Phone +49 (0) 30 46403 172
E-Mail martin.schneiderramelow @izm.fraunhofer.de

www.izm.fhg.de

Source: Polytec LM INFO Special Issue 1/2004