PressFIT for Solderless Assembly of Power Modules

Power module contact technology has to meet the requirements for load-, driver- and sense currents. PressFIT technology is one possibility for lead-free solderless mounting of power modules according to the RoHS directive. **M. Buschkühle, T. Stolze, and M. Thoben, Infineon Technologies AG, Warstein, Germany**

PressFIT technology is used in automotive applications for medium currents. In this area of application, high vibration loads and thermal cycling occur. In telecommunication applications, pin grid connectors with PressFIT technology are used for signal currents [1, 2]. Therefore, PressFIT technology is an attractive, reliable contacting technology for power modules with pin grid connectors. A module with pin grid arranged compliant pins used for this mounting technology is shown in Figure 1.

As shown in Figure 2, special shaped contacts are used to realise the connection between the PCB and the power module. Different plating materials have been tested, and pure tin as a favourable metallisation was identified for lower signal currents. Pure tin has also shown good results for high current loads in lead-free solderless mounted power modules like EconoPIM und EconoPACK with PressFIT contacts [1].

Figure 1: EasyPIM 2B power module without a baseplate equipped with PressFIT compliant pins

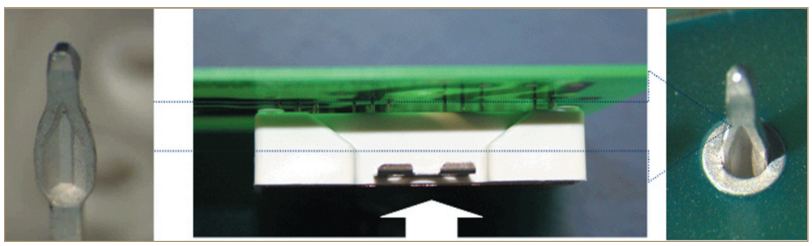

Figure 2: Assembly of PressFIT module

Pin geometry and forces

The large number of contacts makes it necessary to constrain the press-in forces, whereas push-out forces have to be high. The shape of the PressFIT contact strongly influences the forces. Therefore, different geometries have been considered in combination with varying materials. Two of the investigated geometries are shown in Figure 3. Both geometries, A and B, have similar length of the PressFIT section. The geometries differ in the cross-sections. Geometry A (left) is symmetrical in two directions and the press-in procedure results in a compression of the small cross-piece. Geometry B is symmetrical only in one direction and the press-in procedure results in a bending of the cross section.

Different materials can be utilised to produce the different PressFIT geometries. Besides the mechanical properties, the electrical and thermal properties of the materials are influencing the electrical resistance, losses and temperature under high current conditions. The electrical conductivity of

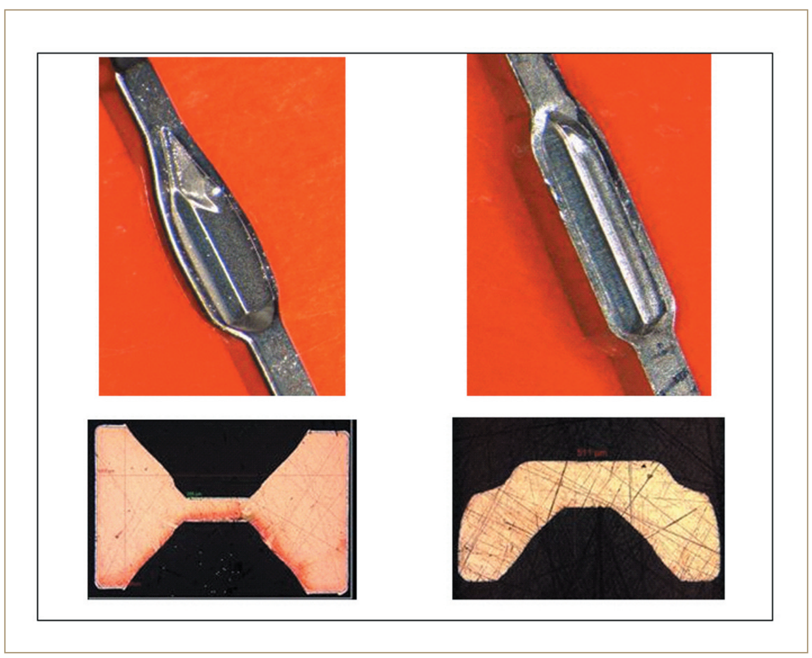

Figure 3: Pin geometry A (left) and B

VARIANT	ELECTRICAL CONDUCTIVITY [m/(Ωmm²)]
Material (A)	12
Material (B)	24
Material (C)	37

Table 1: Electrical conductivity of investigated materials

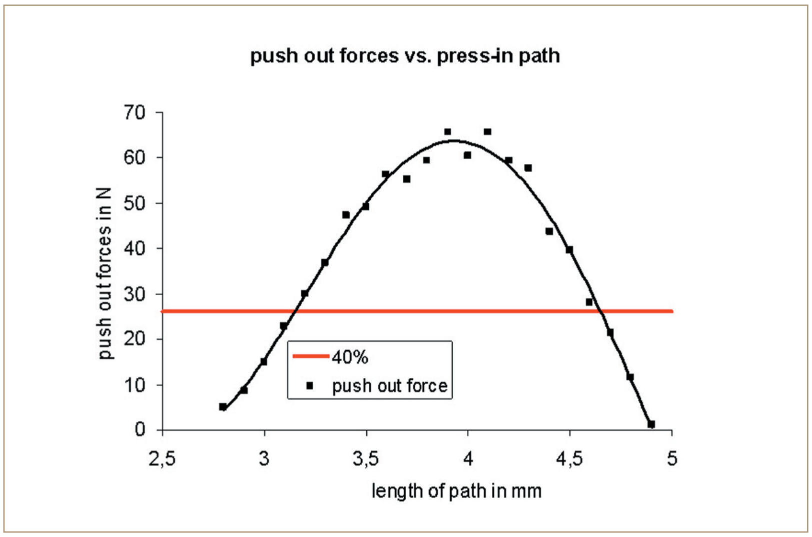

Figure 4: Push-out forces for varying press-in paths

the investigated materials is listed in Table 1.

The press-in and push-out forces of PressFIT pins with different geometries and materials have been investigated. In all cases tests with geometry A result in much higher press-in forces in comparison to geometry B. Tests with geometry B always generate press-in forces lower than 100N. Press-in forces of approximately 70N were achieved. The resulting push-out forces of combination geometry B/material (A) are in the range of 50N and approximately 70% of the press-in forces. Therefore, geometry B with moderate press-in forces and adequate push-out forces was

$$R_{contact} \approx 140 \cdot \rho_{Sn} \cdot \sqrt{\frac{H_{Sn}}{P_{contact}}}; \quad H_{Sn}: hardness\ of\ tin; \quad \rho_{Sn}: resistivity\ of\ tin$$

$$= 140 * 1.1 \cdot 10^{-5}\,\Omega cm \cdot \sqrt{\frac{3 \cdot 10^{4}\,\frac{N}{cm^{2}}}{25\,N}} = 0.055\,m\Omega$$

selected to realise the PressFIT contact of the power module. A further advantage of the contact geometry is the long experience for signal currents in telecommunication, where it has been used over a period of 20 years.

To investigate tolerances during the press-in procedure, tests have been performed with varying press-in path lengths. Consequently, the push-out forces also vary with different press-in path lengths.

As shown in Figure 4, in these tests a path length variation of 1.4mm results in push-out forces higher than 25N. Assuming a coefficient of friction of 1, this value is also the minimum contact force. The following simple equation can be used to estimate the resulting contact resistance [3, 4]:

Even a contact force of only 25N results in a very low contact resistance of 0.055mΩ.

Thermal-electrical behaviour

In a test, the terminals have been shorted inside the module. PressFIT Pins were used for the interconnection to the PCB. The purpose of the test was to investigate the thermal and electrical behaviour at different case temperatures, and measurements have been done with infrared thermography and thermal couple. Figure 5 shows the temperature distribution of two different load conditions. A current of 30A and a case temperature of 80°C, respectively room temperature. No temperature maximum in the contact point can be observed. In accordance with the contact resistance calculation, no relevant losses are generated by the contact.

Further tests were done with different materials for the PressFIT pin; the current was varied to reach a maximum temperature of 105°C in the contact area. Material C with the highest electrical conductivity allows a current of 37A to reach the temperature of 105°C in the measurement set-up, whilst material A with the lowest electrical conductivity allows a current of only 25 A. Therefore, the current carrying capability is mainly limited by the selected pin material.

By measuring the voltage drop during the high current tests, the distribution of the losses can be identified. The total

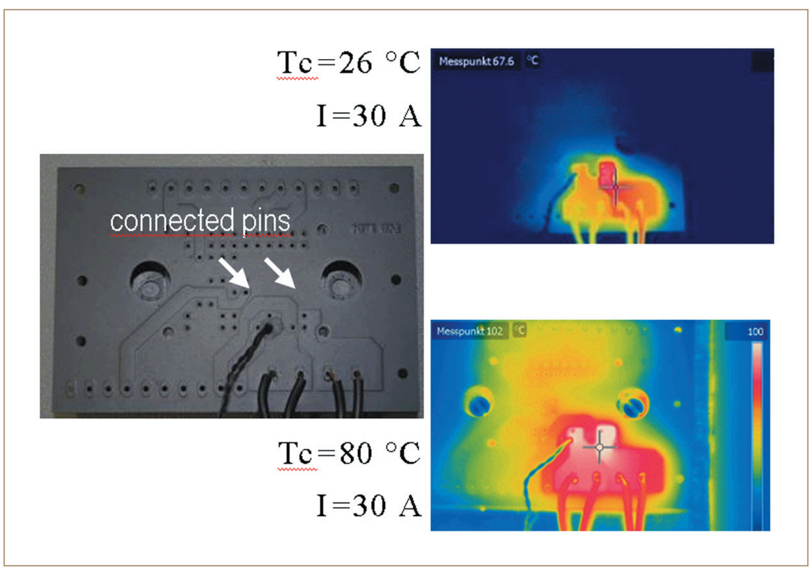

Figure 5: Infrared thermography for 30A per pin at room and 80°C case temperature

resistance can be devided into several parts such as resistance of the PCB track, the Pin, the DCB, bond wires and the PressFIT contact itself. The total resistance is dominated by the pin and wire bonds. The portion of contact resistance is lower than 3%. Therefore, the current carrying capability is not limited by the PressFIT contact resistance.

Assembly procedure

In addition to investigations of the technology, possibilities to ease the storage and mounting process for the user of power modules with PressFIT technology have to be considered. The assembly time can be reduced to a few seconds compared to minutes using selective soldering techniques.

The assembly can be realised by using automated hydropneumatic presses or toggle lever presses. Both processes can be controlled by measurement of forces over the path. Figure 6 shows the set-up exemplary proposed for mounting of the power modules.

The set-up consists of a toggle lever press with Path sensor and Force sensor to control the PressFIT procedure. The PCB will be placed in the lower PressFIT tool first. After inserting the power module, the force will be applied by the upper PressFIT tool.

The integrated force limiting unit can be modified to vary the maximum force during the press-in process. The disassembly of the power module can be realised by a similar tool.

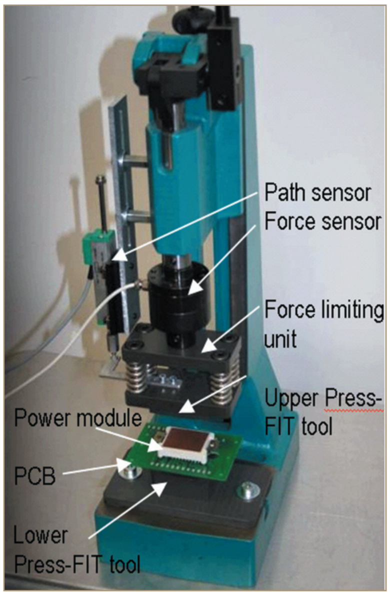

Figure 6: Tools for assembly of PressFIT power modules

Conclusion

PressFIT technology offers the possibility of solderless mounting of power modules, meeting the demands of lead-free technology. No special surface plating is needed.

The extremely low FIT value for PressFIT contacts offers the possibility to increase system reliability under harsh conditions [5]. In comparison to wave soldering, PressFIT technology offers the possibility of mounting the power module on the component and solder side of the PCB. This increases the design flexibility. The low electrical resistance enables the use of the contact for a wide range of signal-, sense-, and load currents.

References

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