# **APPLICATION NOTE** Comparison of shear test and BAMFIT results as part of a wire bonding parameter investigation\*

**s part of** an orienting experiment, 300 µm thick wires were bonded with two bond parameter settings. Subsequently, shear tests and BAMFIT-Tests were carried out. The scope of the investigation for the orienting experiment was initially limited to 10 bond sites to be tested. The bonding and test parameters summarized in the grey box were used.

In the shear test, the force [cN] is determined which is necessary to destroy the bond contact. In the BAMFIT test, the time until the contact is detached is measured and converted into the number of mechanical oscillation cycles (LoadCycles) on the basis of the applied excitation frequency. Both variables, shear force and LoadCycles, quantify the mechanical load capacity of the bond contacts close to the interface zone.

Figure 1 shows the achieved shear test results (top) and the achieved BAMFIT results (bottom) - both for both bond parameter settings. In addition to the absolute mean values of the measured values, Table 1 and Table 2 also show the change in the respective measured value between the two bond parameter settings in [%].

The shear force hardly changes between the two bond parameter settings (see Table 1). The percentage difference is only about 1%. In the context of a process optimization, a decision as to which of the two bond parameters is the "better" one would not be appropriate only on the basis of the shear force. It is therefore very likely that the decision would be made on the basis of visual criteria, e.g. bond contact deformation, damage to the surface of the bond contact, etc.. The BAMFIT test, on the other hand, shows a difference in the achieved mean load cycles between the two bond parameter settings of approx. factor 3.5 or approx. 350 % (see Table 2). Bond parameter setting B requires significantly more mechanical load cycles, until the interfacial crack has completely penetrated the contact. Such a significant difference makes it possible to evaluate a bond contact only on the basis of this mechanical test with regard to its fatigue behavior and thus with regard to its service life under e.g. thermo-mechanical alternating loading.

### Table 1: Shear test results

	av. shear force [cN]	s [cN]	s [%]	Difference A to B
Parameter A (US=110 digits)	1154	23,8	2,1	- ca.1%
Parameter B (US=160 digits)	1165	44,2	3,8	



#### Bonding- and testing parameters

Touchdown force: 200 cN Bonding time: 120 ms Bonding force: 600 cN US-power (varied): 110 digits (A) and 160 digits (B) Default force: 260 cN Wire bonder: F&S Bondtec 5850 Bonding wire: Heraeus Al-H11 300 μm, BL 318 cN, EL 22,7% Bonding frequency: 58 KHz Shear test: F&S Bondtec 5600 Shear tool: width 1,2 mm Shear height: 10 μm BAMFIT-Tester: F&S Bondtec (58 kHz) BAMFIT US-setting: 70 digits BAMFIT pre-load: 40 cN BAMFIT clamping-height: 30 μm (10% wire diameter)



Figure 1: Results after shear test (top) and BAMFIT (bottom)

#### Table 2: BAMFIT results

	av. LoadCycles	s [cN]	s [%]	Difference A to B
Parameter A (US=110 digits)	37577	9610	25,6	- ca. 350 %
Parameter B (US=160 digits)	141158	26341	18,7	

\*The BAMFIT method has been developed by TU-Vienna. Patent number: DE102016107028A1

Figure 2 shows three shear test fracture patterns each for parameter A and B. The higher US power (US 160 digits) for parameter B has clearly led to a higher bond deformation. The interface shape at parameter B is clearly "rounder" compared to the slim interface shape at parameter A. With both parameter settings, the shear chisel cuts approx. 40-50% of the wire material (a little bit more for parameter B) and then the break continues in a region close to the interface. Due to the smearing of the wire material in the shear area caused by the shear test, it is difficult to determine unconnected regions in the interface.

The fracture patterns according to the BAMFIT test are shown in Figure 3. The difference in the deformation of the bond contacts between parameters A and B is also clearly visible. In addition, the BAMFIT fracture images show the different shape of the interface much more clearly. At parameter A, where a lower ultrasonic power was set, the interface is elliptically shaped. The connection zones (aluminium adhesions) cover a large area of the contact surface. At parameter B the connection formation is concentrated at approx. 70% of the center of the actual contact surface. On the left and right side, approximately 15% of the surface is not covered with aluminium (grey areas).

Therefore, in these areas no sufficiently good connection has formed. As a result, the connecting zone at parameter B has a rather round shape. The area of the connected regions is about the same for both parameter settings. In contrast to the fracture pattern in the shear test, the unconnected regions are clearly recognizable in the BAMFIT fracture patterns. There is no significant difference between parameters A and B here.



**PARAMETER A** 

Figure 2: Shear test fracture patterns



**PARAMETER A** 

Figure 3: BAMFIT fracture patterns

Interesting is the fact that, despite very similar connection areas in the interface, such large differences between the two test procedures (shear test and BAMFIT) are observed. The shear test shows no significant change between the two parameter settings. This is understandable as the shear force is determined not only by the strength of the sheared material but also by the area of the sheared region. The resulting strength of the interface, which is largely determined by the bond parameter settings, is probably very comparable for both bonding parameters. The bonded interface area is very similar in both parameter settings, as shown by visual evaluation of the fracture patterns. Consequently, the shear forces, as shown by the shear test, are very comparable between the two bond parameter settings.

In the BAMFIT test, the crack that forms also passes through the very comparable interface surfaces of both parameter settings, but is much more strongly influenced by the structure of the wire and can also move upwards (into the wire material) or downwards (into areas close to the interface) in the z-direction. This results in a much more complex behavior during the test and, presumably, a significantly higher sensitivity of the test to the material properties within the bond contact. A closer look at the fracture patterns in Figure 3 shows that the crack at parameter A is close to the interface and runs at a very constant height. With parameter B, on the other hand, the crack plane is higher within the outer regions of the bonded interface. The image is slightly defocused in this area because the crack plane is higher and thus outside the focal plane. In the center, on the other hand, the crack pattern and height is comparable to that of parameter A.

Thus, if there are bond contacts with the same interface area and the crack in the BAMFIT test runs through other regions of these bond contacts (in the z-direction), this probably already explains the difference in the determined LoadCycles between both bond parameter sets. To what extent these differences in the lifetime under temperature cycling are reflected in the BAMFIT test (e.g. in Active Power Cycling of bond contacts on power semiconductors) can now be investigated by selected lifetime experiments and correlated to the test results.

#### Summary:

In an orientation experiment, 300 µm thick wires were bonded with two bond parameter sets. Subsequent tests by the BAMFIT method demonstrate a difference between the two bond parameter sets, while no significant difference can be found from the shear force alone. The reason for the pronouncedly different behavior in the BAMFIT test is probably due to the fact that the crack generated in the BAMFIT test interacts much more strongly with the recrystallized microstructure of the wire during bonding and thus better reflects the material properties. Without further material scientific investigations, many of the statements made remain speculative – however, the potential of the BAMFIT method can already be illustrated by this experiment.

The SpeedCycle project will evaluate the BAMFIT method for industrial use and extensively investigate the correlation between shear test and BAMFIT result.

#### Information about the SpeedCycle project:

www.bond-iq.de/speedcycle-english

### Seminars about wire bonding, everything about process optimization and technology at:

www.bond-iq.de

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