Addressing the changing landscape of automotive electronic designs:

Improving performance and robustness through proper material choice

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Abstract
The automotive industry is experiencing significant change in design and performance expectations as it moves to the future. Synonymous with high reliability in harsh conditions, today the automotive industry is also being linked to advanced electronics. The market is learning how to incorporate function originally created for other industries such as high speed, high processing power and even the use of radio frequencies into a robust vehicle.

Current automotive mega trends require the use of electronics, many of which are sophisticated in design and function. This includes hardware to support Connectivity, Autonomy, Shared ride services, and Electrification (CASE). Certain performance characteristics have been adopted from consumer, telecommunications and aerospace markets which include a wide range of performance characteristics and design considerations. The automotive industry once used less complex electronic systems now must adopt this wide range to be successful. The semiconductor packages, circuit boards, and assembly techniques will support traditional systems, established for automotive decades ago through those currently used in the handheld and telecommunications markets. Understanding material performance, durability and consistency has become extremely important.

The IPC has taken steps to specify test requirements specific to the automotive industry through the IPC 6012DA Automotive Addendum. In addition, material suppliers and fabricators understand that the use of established, proven processes is important to the automotive supply chain. There are a host of process considerations and performance characteristics to investigate on the path to creating vehicles of the future.

When looking at the wide range of performance expected from the four mega trends, it is easy to understand that the required electronics and the expectations from those designs will also span a significant range. This paper will investigate all aspects of the electronic build. It starts with how increased performance influences the semiconductor packages, how that then affects design for PCB fabrication and finally the influence on assembly materials to join all pieces together.

Specifically, it will explore how, as more processing and performance is required of the package, the need for highly robust interconnect features to deal with miniaturization, signal routing, and increased thermal dissipation becomes greater. It will propose one chemical process set for the filling of blind vias that includes capabilities from large via sizes for robust construction and will also satisfy high density construction as designs shrink. Lastly, it will illustrate how solder alloy type and flux chemistry will provide robust reliable solder connections for the full range of automotive needs.

Introduction
Around 2015, the automotive industry introduced the acronym CASE to explain the direction of their future. It stands for four mega trends simply stated as Connected, Autonomous, Shared and Electrified [1]. To expand on these abbreviations; connected would not only bring connectivity to the occupants of the vehicle (which enables a more entertaining ride) without the need to physically drive the vehicle. The car itself would be connected to other vehicles and infrastructure to support safety, information transfer and ride share service when necessary.

Autonomous or assisted driving is the path described by the Society of Automotive Engineers as 5 levels to a fully autonomous vehicle. One that can drive itself without the intervention of a human. Regardless of the timing on a fully autonomous vehicle, the average consumer sees enhanced safety features being introduced daily in all new models. Even if an individual is not yet ready to turn all driving responsibility over to a machine, they are benefiting from alerts and additional safety features in the car to support the comfort of their traveling experience. Shared rides or car sharing is the consumer's desire to move away from owning a vehicle and instead have a subscription model. This allows for more flexibility of vehicle type, time of use and required use [2]. Lastly, electrified powertrains as an effort to reduce emissions of the vehicles on a path to a more sustainable environment and improving public health [3].

Car makers, start-up companies and the tier ones that support automotive are working towards one or multiple aspects of CASE to be the selling point of their technology. The resounding necessity to support these mega trends is a shift in the electronic hardware and software used in their creation. Electronics have been in the vehicle for over 50 years, starting with car radios. Until recently, quantity and sophistication of automotive electronics were not a main selling point. That has completely changed.

The CASE trends require everything from high speed, high frequency, increased processing power, thermal management, and power management to be successful. Therefore, the automotive industry must adopt all aspects of every market segment within the electronics industry to create a successful product.

This paper will focus on how increased performance expectations affect material requirements for the electronic designs, specifically the semiconductor packages and the printed circuit board to support advanced packages. It will also investigate the pressure this puts on the joining materials used in board level assembly when the semiconductor package is joined to the printed circuit board. It will illustrate material improvements to the fabrication at each step that is required for automotive robustness.

The change in automotive electronic hardware

There is a potential of even more change that the above-mentioned mega trends will bring to the car. As consumers, we are pressured with choices of what type of powertrain is best for me, how much advanced safety can I afford and how much of the driving responsibility am I willing to turn over to a machine? The list of considerations is long but exciting for many of us.

As designers and technologists, the pressures of the new trends require much different considerations. One of the most appealing design aspects to the consumer is affordable differentiation. Car makers and the supporting supply chain need to understand what aspects of their product will separate them from the rest. In most instances, this translates to performance, but dependability is always a consideration for car brands' reputation. As mentioned earlier, the more function put into a vehicle, the more advanced electronics it will require. The function is supported by hardware and software of the system. This work will focus solely on electronic hardware and offer materials and process considerations to deliver enhanced reliability.

The desired function and performance of an electronic system starts at the semiconductor package. It houses the silicon die and is responsible for, "signal and power transmission, heat dissipation, electromagnetic interference shielding and protection from environmental factors" [4]. The package provides a connection from the die to the printed circuit board. It can contain as few as two leads for connection but as the function of the die increases, so do the required connections. Semiconductor packages used in the automotive industry span a wide range of complexity depending on required performance. Electronic systems contribute to more than 90% of automotive innovation today, so close attention is paid to the reliability of these devices and the overall system.

Semiconductor packaging for automotive applications

The two main mega trends driving innovation that specifically affect electronics are increased Advanced Driver Assisted Systems (ADAS) and electric powertrains. The performance requirements, speed and overall power required for these trends are promoting greater use of advanced semiconductor packaging. The IC Substrate serves two main functions; to protect the die and to redistribute the input and output to a manageable pitch [5].

Two major challenges are realized for packages in automotive applications. First, they do not have the same life expectancy as their originally intended applications. Second, the automotive environment is much more aggressive, having high temperature exposure and vibration [6]. Also, localized heat generated during device operation must be managed. Designers and manufacturers are investigating material sets that can remove heat from the die to extend the characteristic life of the package. The automotive market has challenged the packaging suppliers with a "zero defect" product. Safety is a main concern of the automotive industry and this business segment has tighter control over process and quality than other market segments [5].

In a typical electronic packaging process, semiconductor chips (die) are attached to substrates and electrically-connected before they are encapsulated for protection. The die-attachment and electrical interconnections provide the chip with flow of electrical signals, mechanical support and heat removal. Die attach materials used in the packaging require some degree of thermal conductivity. As package performance gets more complex such as having RF capabilities or power semiconductors and systems are working at higher operating temperatures, the thermal dissipation needs to increase. For example, high-performance power semiconductors require much higher thermal conductivity than packages for other applications. Lead-based solders, eutectic gold-tin, Transient Liquid Phase Sintering (TLPS) pastes and nano-silver sintering technologies are typical materials used for die attach of power semiconductors and generally require processing temperatures in excess of 200°C [7]. This paper will introduce a new Hybrid Silver Sintering Technology (HSST) die attach material which enables relatively low temperature (< 200°C) curing, coupled with a very high thermal conductivity. This material promotes less stress in the manufacture process but still fits into a standard high-volume semiconductor assembly process [8].

Traditionally, solder alloys have been used as a die attach material in power semiconductor packages. They have high thermal conductivity and create a reliable joint under high power and high current operations [9, 10, 11]. With the transition away from lead containing alloys, poor fatigue resistance can be experienced. Also, gold-containing solders are very high cost. The alternatives to solders are Transient Liquid Phase Sintering pastes and silver-sintering technology materials.

Transient Liquid Phase Sintering pastes combine solder alloys and reactive metal particles to create a thermoset which is executed under the same reflow temperatures as solder. Silver sintering materials have become an attractive alternative for high power devices due to their high thermal conductivity. Their applications are normally for operation above 150°C. The process does require pressure in addition to heat to create the sintering mechanism of this material. The high-pressure requirements and complex processing can be viewed as a disadvantage. The following is an exploration of Hybrid Silver Sintering Technology (HSST) which maintains high thermal conductivity without the pressure requirements of conventional sintering.

In hybrid silver sintering technology, the pastes are comprised of micron-size silver flakes in an organic medium. Compared to nano-silver sintering systems, the unique inorganic and polymer composition of HSST adhesives facilitates silver sintering at relatively low temperatures, without the application of pressure, and provides very high thermal conductivity. The polymer enables adhesion to a variety of surfaces; bare silicon, gold- and silver-metallized die and silver and copper leadframes. The viscosity of these adhesives is similar to standard epoxy die attach pastes and their application processing is virtually identical to such conventional die attach pastes [12]. It is considered a “drop in" replacement.

High reliability board level joining materials

A second area of consideration to enhance automotive design reliability is the assembly material used at board level. This provides an electrical pathway from semiconductor package to the printed circuit board. In the early 2000s after a transition away from lead containing solder to a leadfree tin/silver/copper (SAC) alloy, car makers and their supply chain sought to develop a solder which could operate reliably above 120°C. This was a key characteristic required for on-engine and on-transmission electronic modules where temperatures often exceed 120°C.

Today, concerns surrounding product life and reliability extend beyond high temperature applications to many advanced safety systems. The challenges are directly connected to the environmental and use conditions, high-performance processing, power conversion and function required for life critical applications. As a result, there is a mass adoption underway for high reliability alloys in advanced safety systems.

This paper tests a six-part alloy initially based on tin/silver/copper with additions to alter the solder microstructure. The resultant microstructure combines multiple metallurgical techniques to deliver a more complex grain structure beyond the Ag_3Sn eutectic phase formed in traditional SAC alloys. The introduction of grain refinement strategies enables a stronger joint with enhanced thermomechanical stress resistance. This is illustrated by the reduction of crack propagation in high reliability alloys relative to the conventional SAC alloy. The high reliability alloy, melts in the same range as SAC (~220°C) but maintains greater structural integrity under stress after extended thermal cycling.

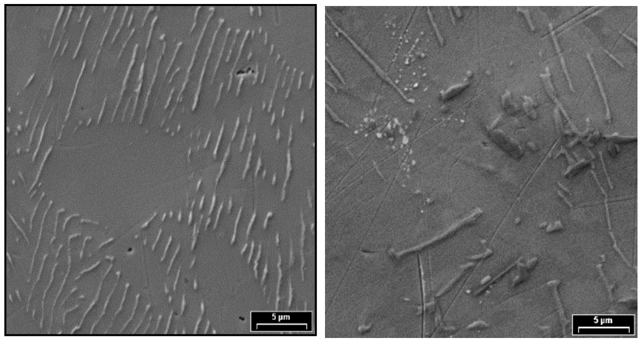

Figure 1: SEM of solder alloy crystal structure a) SAC and b) High Reliability

A second consideration for solder paste material and its intrinsic reliability, especially as the industry moves to miniaturized designs with low profiles is electrochemical resistance. This work will investigate both surface insulation resistance and damp heat testing.

Microvia reliability in circuit designs

In the printed circuit board design, blind vias fulfill the need for layer specific vertical interconnects for increased routing density, shortened signal paths for higher speed processing, and can be used for thermal dissipation. All these characteristics are used for automotive electronics today. The copper filling of these design features provides increased thermal conductivity, keeping heat away from other parts of the board and allowing it to pass straight through the metal. This can result in longer board life [14]. Copper filling is enabled by specific electrolytic copper plating processes.

Much of the electronics industry is focused on microvia reliability. As the quantity of high density designs increase in all market segments and there is a clear intention to continue that growth (figure 2), microvia reliability is becoming a bigger concern [15].

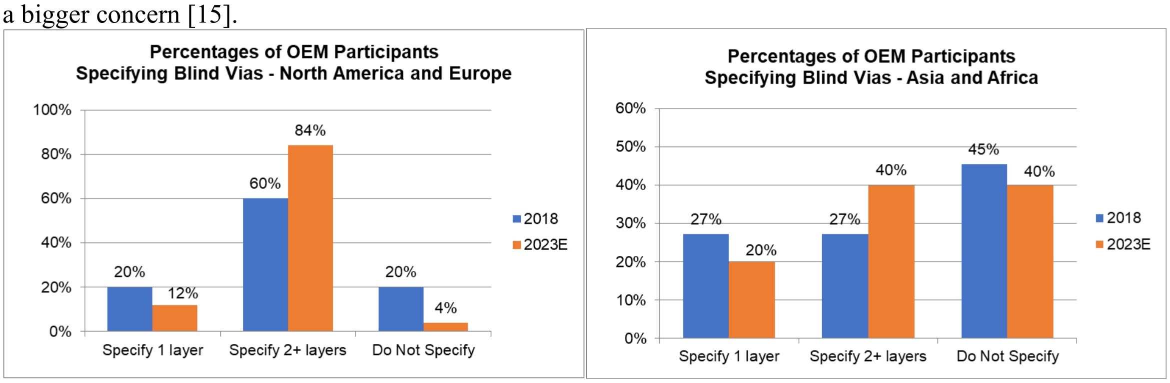

Figure 2: Expected growth of blind microvia usage from OEMs a) North American and Europe b) Asia and Africa

The main concern is a connection defect which results as a separation or open within the microvia caused by thermal expansion. More specifically, the separation is typically at the target pad interface between the metallization layers including electroless copper and electrolytic copper. During assembly, reflow temperatures ranging from 230 to 260°C put pressure on the design and cause expansion of the printed circuit board materials. The challenge is that the PCB contains many different materials which heat and expand at different rates. This is known as the coefficient of thermal expansion or CTE mismatch. The greatest difference occurs between copper and the substrate material. Copper's CTE is 16-17 ppm/°C and the epoxy laminate can range from 250-350 ppm/°C. When the circuit board goes through assembly of the components, the temperature exposure causes the glass transition (Tg) of the laminate to increase upwards of 5-10 times. This puts greater stress on the microvia. It could exceed the microvia's ability to withstand the movement, especially in conditions of suboptimal adhesion. The dramatic difference in CTE between the two materials create stresses greater than the design can withstand.

During heating, the epoxy resin within the laminate expands causing enough pressure to lift the plated copper from the target pad. Upon cooling, the resin shrinks and brings the copper back into electrical connection. In field applications, this can reveal itself as intermittent failures. The system experiences electrical opens upon heating but no issue when cooled as the connection has been made again. High reliability manufactures and OEMs are concerned about the hidden reliability threat of a weak interface between the target pad and electrolytic copper fill. Failure typically occurs during assembly. So electrical testing at the PCB manufacture site results in a pass and the defect goes undetected. In operation, one can get intermittent failure as the panel heats and the expansion separates electrical connection with the target pad. When the panel cools, electrical connection is remade as the structure contracts back together.

Prediction of design reliability starts at the bare board level. After much debate over proper testing, the IPC TM650 2.6.27 has added consideration for resistance measurements to be taken both during heating and cooling. There are many factors that go into board level microvia reliability but as a starting point, this paper will investigate pad geometries for proper plating execution. It will test the target pad ratio influence on pull strength and will also investigate performance of these sets in Current Induced Thermal Cycle (CITC) testing.

Experimentation and Results

Thermally conductive die attach

Various Hybrid Silver Sinter Technology (HSST) paste formulations were prepared by mixing different ratios of silver, thermoset resins and solvents to determine the best concentrations for thermal conductivity and adhesion after low temperature sintering. In all samples, a micron-sized silver flake was used at 82 or 85% concentration by weight as shown in Table 1. The silver flakes are specially designed to sinter at relatively low temperatures such as 175°C in contrast to the conventional nano-silver.

Table 1: hybrid silver sintering technology formulations tested

ID	Silver (%)	Resin (%)	Solvent (%)
Control	82	8	10
A2	85	5	10
B5	85	7	8
E1	82	8	10
F1	82	6	12

All samples were cured with a temperature profile using 175°C peak temperature for 3 hours dwell time in a box oven. The samples were ramped from room temperature to 175°C in approximately 30 minutes and, after curing, were cooled to room temperature which also took approximately 30 minutes. Control samples were cured using the same cure profile, however with a peak temperature of 200°C.

Adhesion was assessed through die shear strength using a Dage 4000 bond tester equipped with a heater block. Figure 3 shows the measurement set-up. The paste was first dispensed onto a copper leadframe, then the 1.2 mm x 1.2 mm x 100 µm gold-plated silicon die was placed onto the dispensed paste to achieve 100% filleting. The die attach samples were cured in a box oven and the final (cured) bond line thickness was 25 ± 3 µm. Parts were tested using a test speed of 300.0 µm/s and a land speed of 1000.0 µm/s. The shear height was between 25-75µm based on part to the tested. For the 1.2mm x 1.2mm sample, the desired shear force was $0.5 kg/mm^2$.

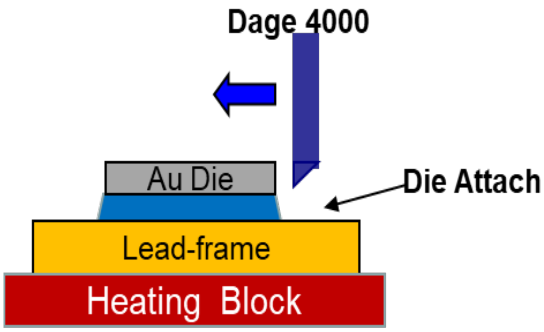

Figure 3: Dage set up for shear testing

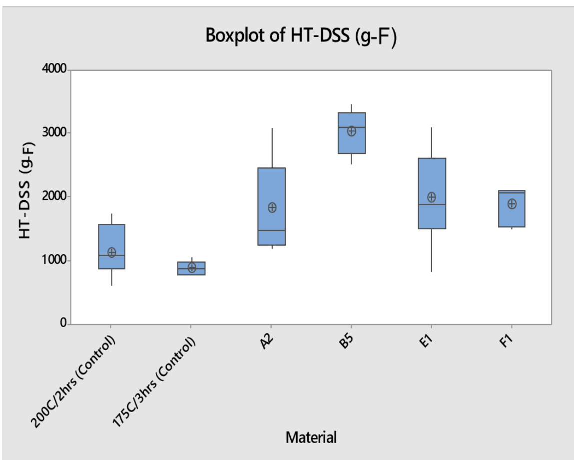

Figure 4: Table 1 formulations with varied silver and resin content tested for adhesion measured as shear strength in grams-force

In all cases, the shear strength was above the required 0.5kg/mm^2 for this test. The control sample run at 175°C (second bar) displayed the lowest shear force. It was improved when tested at its suggested sure temperature of 200°C (first bar). All hybrid silver sinter paste formulations show improved shear strength compared to the control. This indicates that increased silver content or increased resin content contributes to the shear strength improvement. The top performer was B, 85% silver and 7% resin, with an average shear of over 3kg/mm^2 (figure 4).

In most applications, bulk thermal conductivity of die attach pastes does not correlate with in-package thermal resistance. It only represents the thermal conductivity of the die attach material itself and does not consider the interfacial resistances between die /adhesive and leadframe /adhesive. To obtain more information about the effect of this interfacial, or contact resistance, a test method was developed internally to determine the "effective" thermal conductivity, termed K_{eff}. This accounts for loss of thermal conductivity due to die attach-to-substrate and die attach-to-die resistances. The test set up consists of a 'sandwich sample' where the die attach paste is printed between two gold-metalized silicon die as shown in Figure 5. Bulk thermal conductivity was measured using a Netzsch LFA 447N Nanoflash instrument.

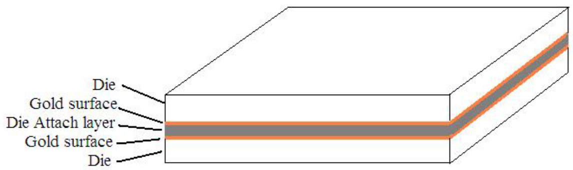

Figure 5: Test set up for "effective" thermal conductivity

Table 2:

Sample	**Control**	**A**	**B**	**E**	**F**
Bulk (W/m-K)	70	123	138	162	177
K_{eff} (W/m-K)	38	79	84	92	80

The hybrid silver sintering materials show significantly higher bulk and effective thermal conductivity (table 2). The results indicate greater sintering of the silver flakes. The effective values are lower than the bulk values, due to interfacial resistances mentioned previously. The highest thermal conductivity values are shown by materials B and E.

Enhanced Solder Alloy

To test the endurance of vehicle electronics, the automotive industry relies heavily on thermal cycle testing to measure an assembly alloy's ability to resistance long term creep failure. Vehicles encounter various temperature fluctuations throughout their life [13]. These temperature fluctuations are also experienced by the electronic hardware but in addition those builds also experience heat as a result of device function. To show the thermomechanical resistance of the high reliability alloy, two types of BGA components were subjected to thermal cycling from -40 to 125°C at 30 minutes for each temperature dwell.

Thermal cycling air to air -40 to 125°C

- Average temperature recorded with 2 external thermocouples connected to the PCB, on the back of the component.
- Dwell time: duration for which temperature on board is maintained at the two extremes of the profile.
- Transition time: duration required for board to automatically transit from one extreme temperature to the other.

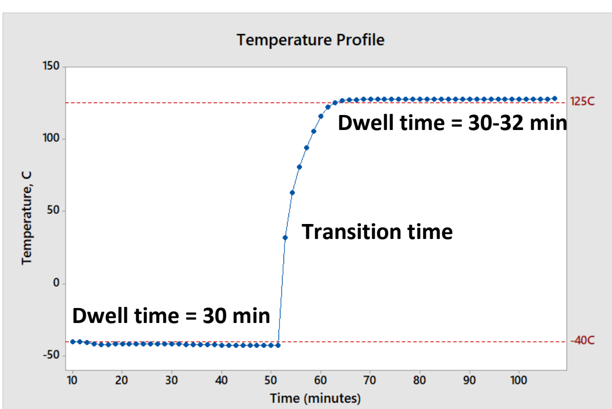

Figure 6: Thermal cycle profile

Table 3: a) BGA 228 details b) BGA 256 details

Body Size	12 x 12 mm
I/O's	228
Solder Ball Diameter	10 mil
Solder Ball Pitch	0.5 mm
Type of Array	Perimeter

Body Size	17 x 17 mm
I/O's	256
Solder Ball Diameter	0.5mm
Solder Ball Pitch	1 mm
Type of Array	Full Array

With failure defined as a 20% increase in nominal resistance for 5 consecutive reading scans per IPC9701-A, the active test vehicles were measured for resistance changes and/or loss in continuity over 3000 thermal cycles.

The testing indicates that the size of the package, the pitch and the overall input/output (I/O) count does influence the characteristic life of the solder joint as observed by the characteristic life of the package. In both cases, the alloy increased the solder joint reliability by a defined percentage when compared to the traditional SAC alloy. In the case of the BGA228 package, the increase is 39.5% and 16.3% with the BGA256 package.

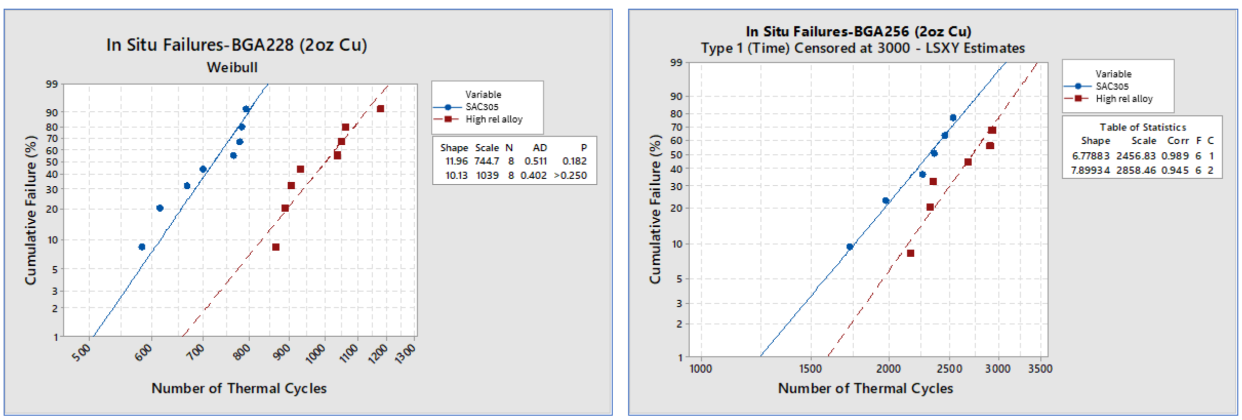

Figure 7: Percent failure after thermal cycling a) BGA 228 and b) BGA 256

Solder Flux Reliability

Increased power densities from shrinking package sizes require flux chemistry enhancement. As packages move to finer pitch construction with lower profiles, attention to surface insulation resistance performance increases. This has always been an area of focus for the automotive industry which follows more stringent cleanliness than other market segments. The electrochemical performance testing for this study was executed according to IPC TM 650 2.6.3.7 Surface Insulation Resistance at 85°C/85% RH 10V (20-minute measure) on a B-24 test coupon with a 360 pin BGA package (0.400mm pitch with 0.200mm spacing). It was also tested under damp heat conditions with and without conformal coatings to assess performance when subjected to a saturated environment.

Automotive damp heat cycle on IPC-B-24 coupons with and without a conformal coating

- Solder paste was hand printed for SIR testing, using a DEK Horizon 03iX.
- Coupons were reflowed in a BTU Pyramax 125N.
- Coupons were conditioned during testing using an Espec ESL 2CA temperature humidity chamber.
    - SIR measurements were made using a Gen3 AutoSIR datalogger with bias at 50V (1-hour measure)
- BGA360 SIR**,** small BGA360 dummies connected for SIR testing, 100µm stencil

Table 4: Damp heat chamber program

Step #	Time (hours)	Temperature (°C)	Relative humidity (%)	Type
1	1:00	25	92	Soak
2	3:00	55	96	Ramp
3	9:30	55	96	Soak
4	1:30	40	94	Ramp
5	4:00	25	92	Ramp
6	6:00	25	92	Soak

Steps 2-6 repeat 5 additional times.

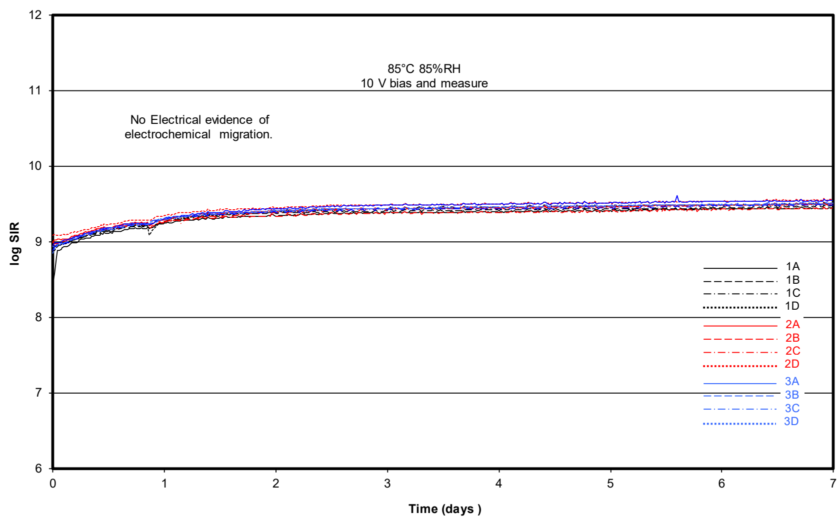

Figure 8: SIR 85°C 85%RH 10V for BGA 360 design

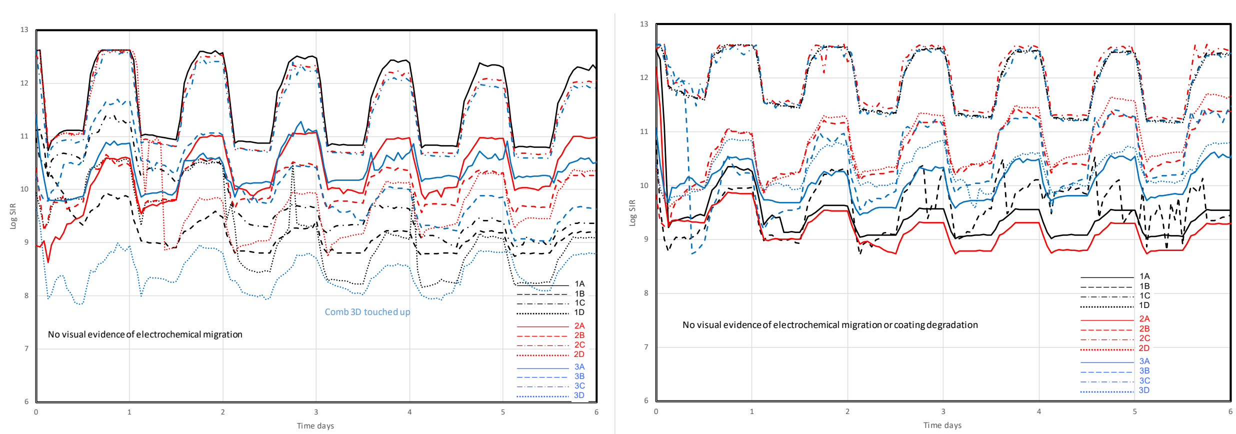

Figure 9: Damp Heat Testing a) uncoated and b) conformal coated

For SIR testing, no failures were observed according to J-STD-004B requirement log SIR > 8 after 7 days [16]. All samples also passed visual inspection as none displayed evidence of electromigration (figure 8). Additionally, when exposed to a saturated environment that promotes electrochemical migration. There was no visual evidence of electrochemical migration or conformal coating degradation for the entirety of the test cycle. The log SIR stayed within the required measurement criteria of log SIR >8 (figure 9). Flux chemistry design plays an important role in the product performance as automotive converges to finer pitched covered component packages subjected to harsh operating conditions.

Microvia reliability

There are many aspects that affect microvia reliability including design, number of stacked layers, and pitch. In addition, considerations during board fabrication include laser drilling, target pad cleaning, metallization and electroplating. Consistent processing is one of the best methods to ensure a reliable build. The details of which have been presented previously at the IPC Reliability Forum in Baltimore, Maryland, USA in 2018. This work will only briefly mention some considerations for proper processing and focus on testing how the size and shape of the target pad effects pull strength.

To start, via geometry greatly influences the effectiveness of the copper filling. The geometry effects the potential of the plating solution which could limit throwing power or solution transfer in the holes. Either can compromise the plating quality and completeness of filling and overall flatness of the plated microvia. In an extreme case it could cause premature sealing of the top of the via leaving a cavity in the microvia.

Smaller microvias present challenges for proper cleaning, activation, and plating. The small dimension makes solution exchange to the critical target pad surface more difficult. Improper target pad preparation results in poor adhesion of via fill copper to the target pad and this could compromise reliability. Assuming proper cleaning and solution exchange, pad size will influence the overall resultant pull strength. An industry accepted "quick test" to determine reliability is the pull test. After a microvia has been filled, electrolytic copper is used to plate several additional mils of copper. This additional copper allows one to peel the copper from the substrate using an Instron pull tester. Failure mode is evaluated to determine the integrity of the metal-to-metal bond at the copper plating to capture pad interface. A brittle fracture along a specific interface is unfavorable. Pull test failure mechanisms can be observed in figure 10.

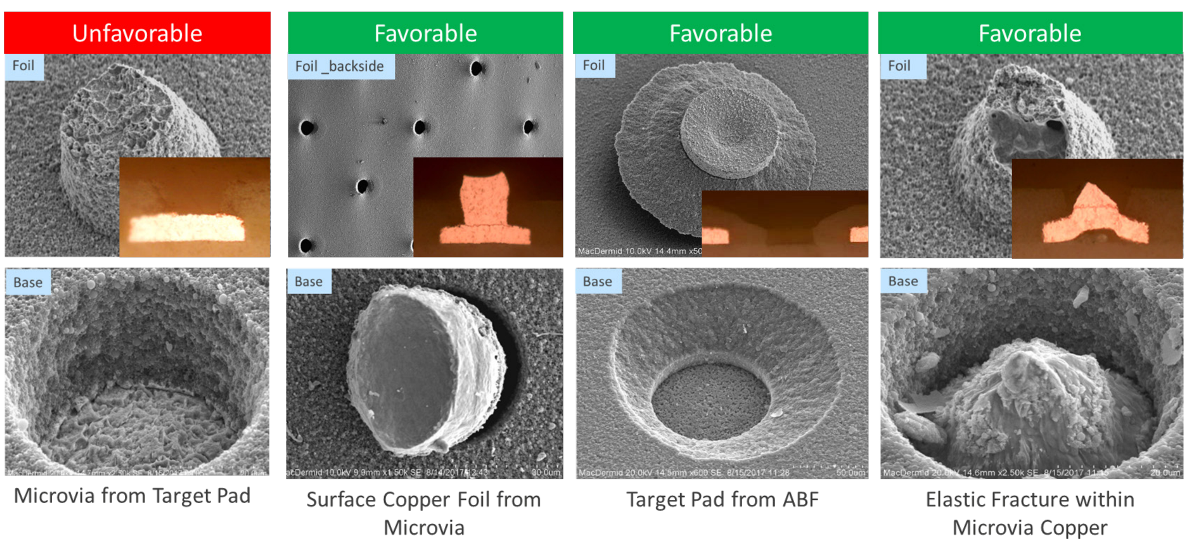

Figure 10: Modes of pull test failures

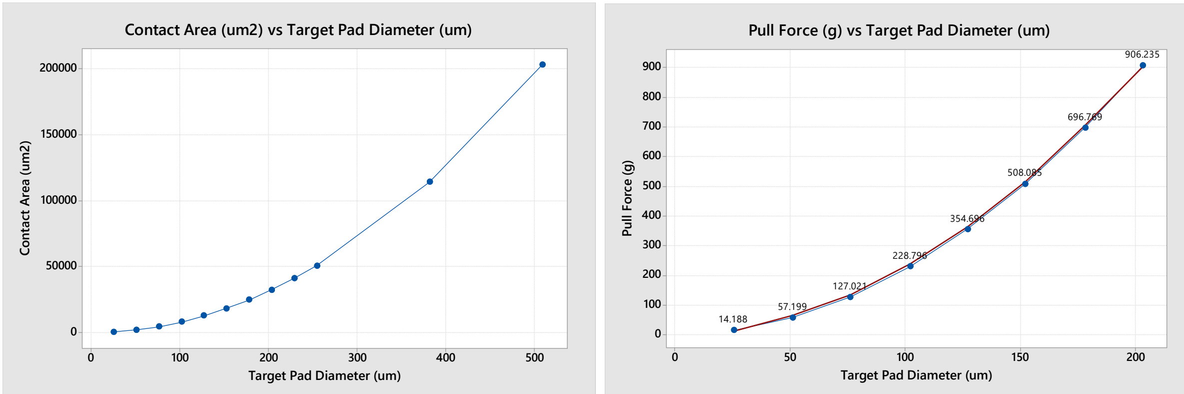

Figure 11: a) Contact are vs target pad diameter b) Target pad diameter effect on pull force

Figure 11 shows that as the contact area is reduced, the absolute possible resultant pull force is decreased. The smaller the absolute bond area, the lower the bond strength.

To determine survivability and reliability of the design with various pad diameters, it was decided to use a newer test method which would allow for *in situ* resistance testing. The test was originally introduced by IBM but was recently added to IPC TM 650 2.6.26A. It is called Current Induced Temperature Cycling (CITC). The test coupon contains a connector and current induced heat, similar to the Interconnect Stress Test (IST) method, is used to elevate the board temperature. Microvias were tested to 190°C and assessed as a pass if the percent change in resistance was less than 10 for 250 cycles. Survivability Testing was done by heating to 260°C, with the desired result < 10% resistance change for 10 cycles.

A set of test vehicles containing three different microvia size diameters 0.075, 0.100 and 0.150mm diameter (figure 12), were exposed to CITC testing under the test conditions can be found in Table 5.

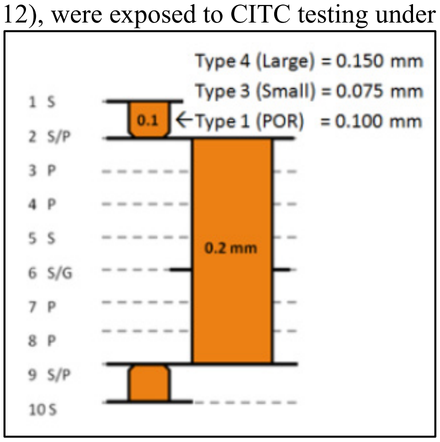

Figure 12: Cross section schematic of test coupon design for CITC testing

Table 5: CITC test conditions

Parameters	Value
Thermal Coefficient of Resistance	Determined on sacrificial coupons
Temp Range	23 – 245°C

Ramp Rate	3°C/sec, 40sec dwell, fan cool
Cycles	To Failure or 100 Cycles
Specification	IPC-TM-650 2.6.26

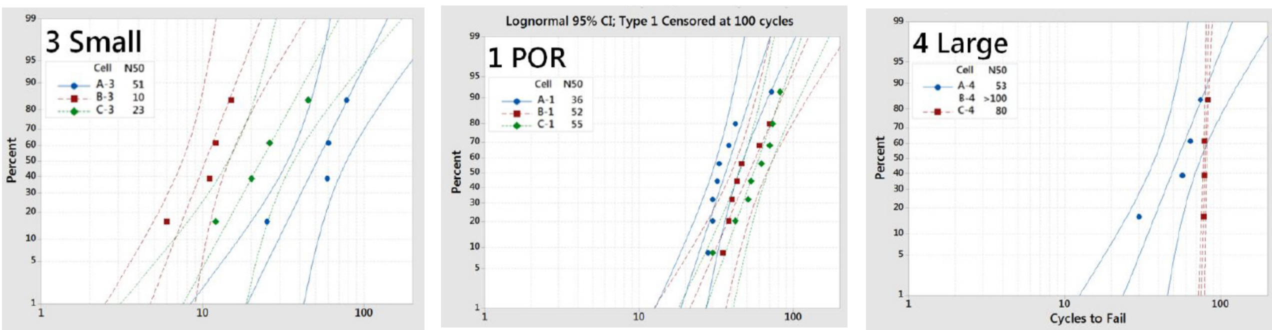

Figure 13: Probability plots for varying target pad diameters a) 0.075mm b) 1.0mm and c) 1.5mm

CITC testing showed that as the microvia increased in size reliability increased. This is due to the larger microvias having greater target pad areas with increased absolute bond strength to withstand thermal stressing. It could also be attributed to the larger microvia allowing greater ease of activation and rinsing during the plating process.

Conclusions

Reliability has always been a cornerstone of the automotive industry. As car makers, tier ones and the entire supply base continue to support this market in a rapidly changing landscape, reliability and the ability to enhance it where possible is a consideration for all. There are so many aspects of design, manufacture and performance expectations that contribute to the overall characteristic life of an electronic system. End users must pay attention to the individual components as well as the entire build to fully understand reliability. Attention to process detail and consistency will have a significant effect on reliability; and the proper choice of materials can enhance robustness.

Material and design enhancements at each step of the electronic build will support automotive electronic advances. Hybrid Silver Sintering Technology offers lower stress fabrication and extended product life through enhanced thermal dissipation from the die. Though the size of the package, the pitch and the overall I/O count does influence the characteristic life of a solder joint, the high reliability alloy increases solder joint reliability compared to the traditional SAC alloy. Flux chemistry design plays an important role in product performance as automotive converges to finer pitched covered component packages subjected to harsh operating conditions. Finally, larger microvias have greater absolute bond strength to withstand thermal stressing. They also allow for greater ease of activation and rinsing during the plating process. With attention to design and material choice, the automotive industry can succeed in extending the characteristic life of their electronic hardware.

Acknowledgements

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Reference

[1] https://www.digitalistmag.com/digital-economy/2019/01/02/4-ways-of-case-in-automotive-industry-06195360/

[2] https://www.automotiveworld.com/articles/c-s-e-future-industry/

[3] https://www.energy.gov/eere/electricvehicles/electric-vehicle-benefits

[4] https://www.sciencedirect.com/topics/engineering/electronics-packaging

[5] https://www.mclpcb.com/ic-packaging-information/

[6] https://semiengineering.com/packaging-chips-for-cars/

[7] https://www.powerelectronics.com/technologies/dc-dc-converters/article/21858906/selecting-die-attach-technology-for-highpower-applications

[8] Kanagavel, S. "A Low Temperature Curing Hybrid Silver Sintering Die Attach Paste for High Reliability Power Semiconductor Applications." MiNaPAD Conference Grenoble, France 2018.

[9] Catherine Gallagher, Goran Matijasevic, and James McGuire, "Transient Liquid-Phase Sintering Conductive Adhesives as Solder Replacements", 47th IEEE Electronic Components and Technology Conference (ECTC), San Jose, May 19, 1997.

[10] Pei, L. S., Pan, B., Zhang, H., Ng, W., Wu, B., Siow, K. S., Tsuriya, M., "High-Temperature Pb-Free Die Attach Material Project Phase 1: Survey Result", 2017 International Conference on Electronics Packaging, ICEP 2017, pp. 51-56.

[11] M. Hutter, C. Weber, C. Ehrhardt and K. D. Lang, "Comparison of Different Technologies for the Die Attach of Power Semiconductor Devices Conducting Active Power Cycling", 9th International Conference on Integrated Power Electronics Systems (CIPS), Nuremberg, Germany, 2016, pp. 1-7.

[12] Howard Jin, "Novel Conductive Paste Using Hybrid Silver Sintering Technology for High Reliability Power Semiconductor Packaging", IEEE Electronic Components and Technology Conference (ECTC), June 1–4, 2010, pp. 1790–1795.

[13] https://www.sigmatest.org/automotive-life-cycle-testing

[14] https://www.mclpcb.com/copper-filling-blind-microvias/

[15] IPC Market Research. „PCB Technology Trends 2018." January 2019.

[16] www.ipc.org

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