SGS-THOMSON MICROELECTRONICS

APPLICATION NOTE

MIXED WIRE BONDING TECHNOLOGY FOR AUTOMOTIVE SMART POWER ICs

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By using a mixture of gold and aluminum bonding wires in the same IC, SGS-THOMSON has found a reliable way to correct very high current ICs that avoids wasting die area.

One of the essential prerequisites for the large-scale introduction of multiplex wiring systems for vehicles is the availability of high power integrated circuits (ICs) capable of replacing relays, driving directly lamps, motors and solenoids. These ICs must be rugged and highly reliable yet inexpensive. Many power ICs suitable for this market are already available but a gap was left at the high current — roughly 4A+ — end of the range; ICs delivering 20A or more are needed for loads like windowlift motors.

One of the main problems in high current IC design lies in the thin wires that connect the silicon chip itself to the external connections of the IC package. These bonding wires are typically fine gold wires (up to 50um thick) which cannot carry more than a few amperes of current.

Increasing the thickness of the gold wires is ruled out partly because of cost, and also because they are too rigid to weld to the surface of the chip without damaging it. It is possible in theory to use two or more gold wires in parallel for each connection but this solution is generally impractical because the large number of bonding pads waste space on the chip (the cost of a silicon chip is proportional to its area), the cost of the wire is excessive and because testing each bond is difficult.

Figure 1: Part of an almost completed strip of integrated circuits utilizing the new mixed bonding technology. The gold and aluminum wires connecting the silicon chip — the small gray rectangle — with the gold-plated external connections can be clearly seen.

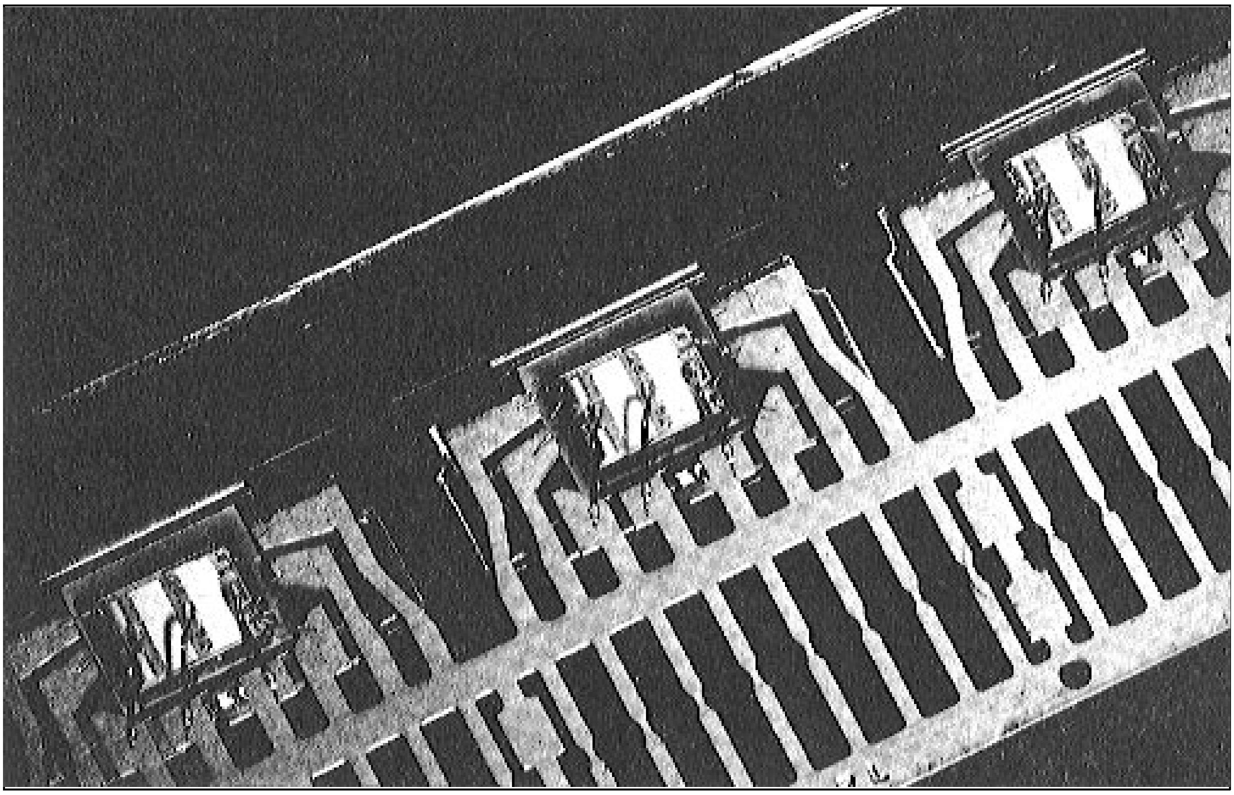
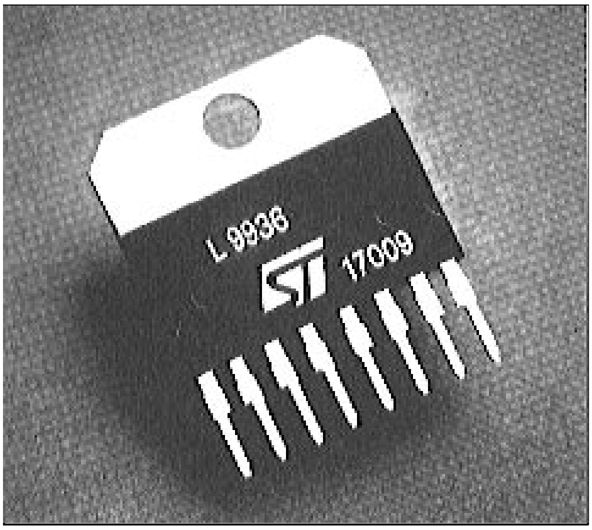


Figure 2: After the wire bonding operation the completed frame assembly is encapsulated in black plastic resin and the parts of the metal frame that served as a mechanical support are removed. The finished parts are then tested and marked with the type number and lot tracing information.

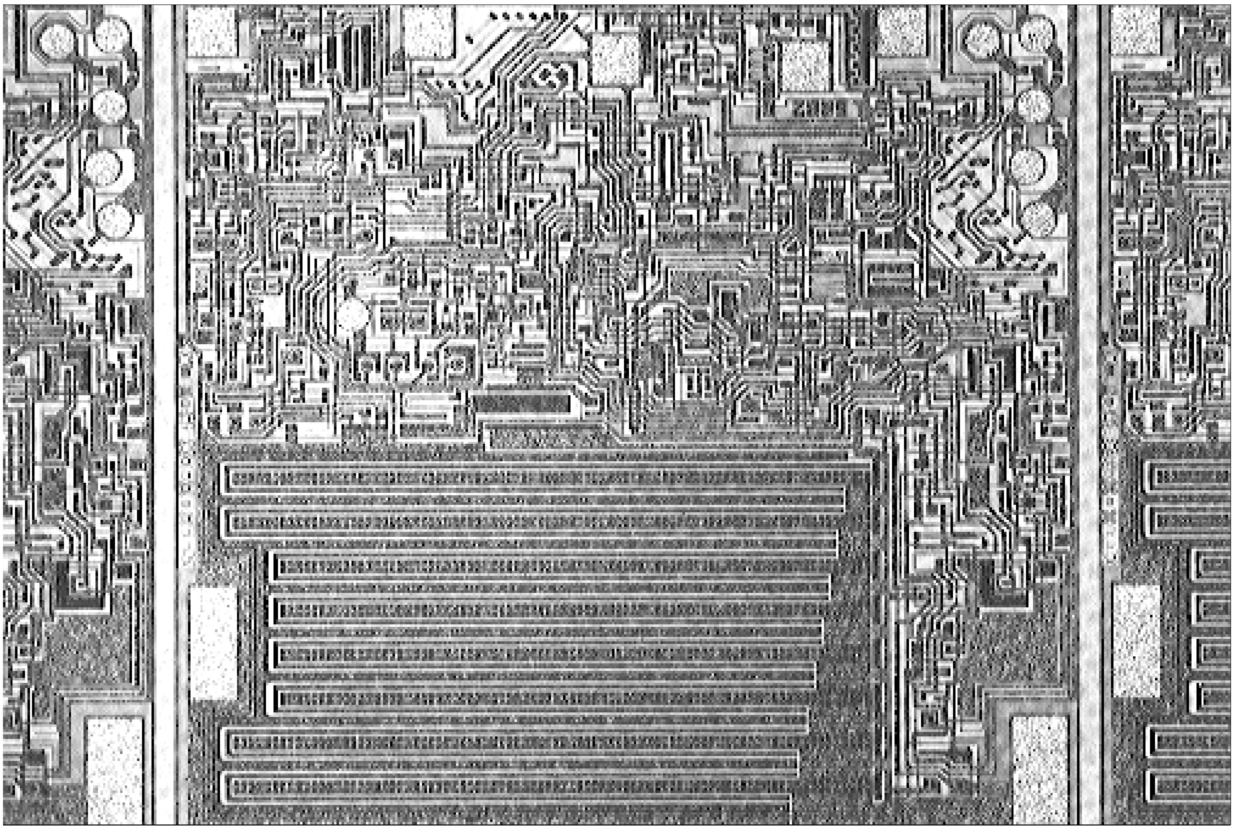


One alternative, widely used in simple power ICs, is to use thick (250um) aluminum wires. However, a thick aluminum bonding wire needs a large bonding pad on the die. In a simple device like a 3-terminal voltage regulator this is not a problem because there are few such pads, but for more complex ICs with eight or more connections the wasted silicon area would be excessive.

SGS-THOMSON has developed and industrialized an effective and efficient solution to this problem: a mixed bonding technology where thin gold wires are used for low current connections and thick aluminum wires used for power connections. Figure 1 shows a bonded frame of a 20A windowlift motor driver that uses this method; the two types of bonding wire can be clearly seen. Figure 2 shows the same IC after encapsulation with black molding resin and removal of the support elements of the frame.

Because of the use of aluminum bonding wires a selective gold alloy plating of the leadframe is necessary; gold is one of the few metals that will weld reliably to aluminum. Apart from reasons of cost, gold plating is used selectively — rather than the simpler overall plating — because of gold were used on the external lead part of the frame it would contaminate the circuit board soldering bath, leading to possible reliability problems.

Figure 3.



Different bonding techniques are used to weld the two types of wire to the surface of the silicon chip. For the thin gold wires the thermosonic method is used where an electric discharge first creates a small ball on the free end of the wire, this ball is then pressed on to the bonding pad and vibrated rapidly (in the ultrasonic range), causing the gold ball and silicon surface to weld together.

The thicker aluminum wires are bonded using the simpler ultrasonic method, where the wire is simply pressed onto the surface of the chip then vibrated rapidly to weld the wire to the pad. Because more vigorous vibrations are used in this technique the aluminum wires are bonded first, followed by the gold wires. On the production lines two separate machines are used in tandem.

Reliability is an important consideration in automotive ICs therefore it is essential that wire bonds be secure throughout the lifetime of the circuit. To ensure that bonds are correctly executed some parts are subjected to a pull test, where the wires are pulled to determine their breaking strength. Gold wires must resist a force of at least 15g; the thicker aluminum wires must resist a pull of 130g. In both cases the wire must break; the bonds must not detach.

These pull tests are also repeated on statistical samples after accelerated life testing where parts are subjected to humidity, thermal cycling, and other stresses.

Mixed bonding technology can be used in various different power IC packages, though the photos here show the Multiwatt-8 package. This type has eight leads in line at 0.1" centers — wider than is usual — to suit high current circuits where wide circuit board tracks are used. The metal frame design of such packages reflects the care taken to ensure reliability in line with the needs of the auto market. For example, the die-mounting zone of the frame is isolated mechanically by notches and groove from the external mounting tab area. This ensures that deformation caused by overtightening the mounting screw will not subject to stress that could adversely affect reliability.