Sintering instead of soldering

Sintering is becoming an increasingly important bonding technology for **POWER SEMICONDUCTORS**, offering higher efficiency and performance than soldering. Assembly is performed by reliable systems with controllable processes.

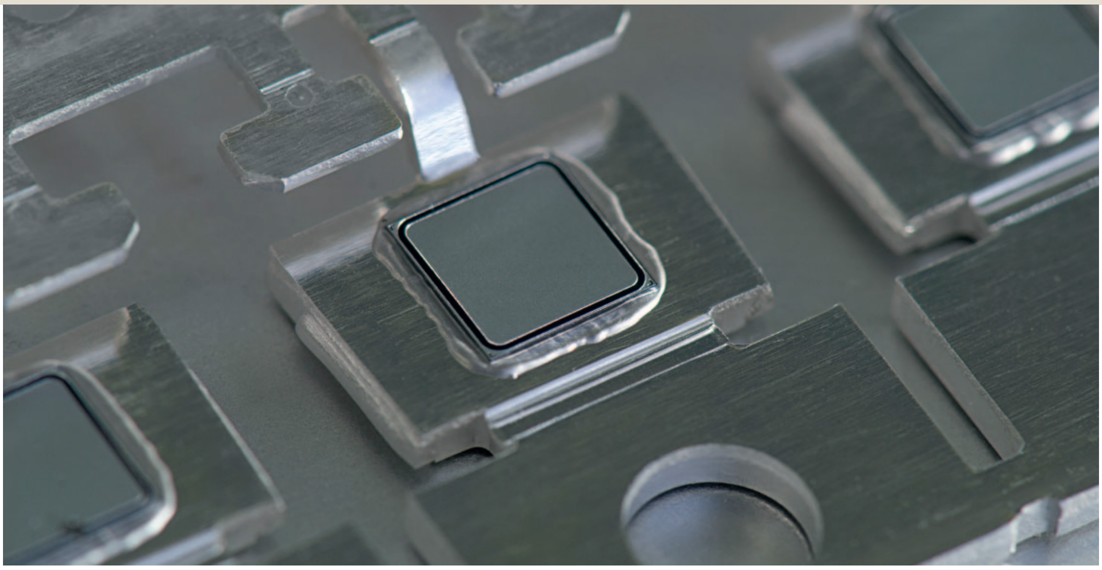

Figure 1. The power semiconductor is bonded to the lead frame by sintering, rather than soldering, to enable higher performance and efficiency in operation

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The efficient use of electrical energy is becoming increasingly important in the light of the energy transition and, in particular, the current energy shortage. In the context of renewable energy and electromobility, energy conversion plays a key role. Whether converting electricity from solar power plants or powering electric vehicles, when electricity is converted into another form, it should be done with as little loss as possible.

In the quest for greater efficiency in converting electrical energy, silicon carbide (SiC) power transistors are increasingly being used instead of silicon (Si). These offer higher efficiency and power density because they can operate at much higher temperatures than conventional silicon transistors. This increases performance. However, the solder joint, with its limited temperature resistance, is a bottleneck that limits maximum performance.

The low liquidus temperature, which is advantageous for the soldering process, is a limiting factor when operating at maximum currents. Prolonged operating temperatures close to the melting point lead to embrittlement of the solder joint. The associated faster material fatigue can lead to defects or failure of electronic components.

Sintering as an alternative

To exploit the full potential of power electronics, it is recommended to use a connecting material with a significantly higher melting point. This allows its homologous temperature, i.e. the temperature relative to the melting temperature, to be kept low during operation. This means that soldering is no longer suitable as a bonding technique, as significantly higher process temperatures would be required to reach the corresponding liquidus temperature of the solder material.

Sintering offers a good alternative: instead of a solder paste or preform, a thin layer of nano- to micro-

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Figures: Infotech

Figure 2. The pick-&-place head laminates a semiconductor die by briefly pressing it into a sinter film directly before placement

silver particles is introduced between the printed circuit board and the semiconductor chip **(Figure 1)**. In contrast to the soldering process, the bonding material is never transferred to the liquid phase during the joining process, but is pressed together at an elevated temperature of 240 to 280 °C – this process is known as sintering. By minimising the surface energy, the silver particles grow together at the atomic level by aligning their crystal structures against each other. A stable layer is formed, creating a permanent electrical and mechanical bond between the semiconductor die and the substrate.

Silver offers advantages

Silver as an bonding material has a high melting temperature of 961 °C and a low sintering temperature of less than 300 °C, which means that the sintering process is well tolerated by the components used. Due to its excellent electrical conductivity, silver also helps to minimise the electrical resistance in the bonding layer and thus the power dissipation. In addition, its excellent thermal conductivity promotes rapid removal of heat from the semiconductor die.

Unlike soldered interconnects, sintered interconnects remain in significantly lower homologous temperature ranges, making them mechanically more stable and preventing embrittlement. In addition to improved efficiency and higher performance, the reliability of sintered components is also a key factor. This is why the fast-growing electromobility sector in particular is relying more and more on this technology.

Preparatory processes pave the way to success

While the actual sintering process takes place in special sintering presses, the preparatory processes are crucial to the success of this bonding technique. Depending on the application, there are different ways to achieve this. The sintering layer can be applied by printing or dosing sintering paste onto the substrate or by wetting the semiconductor contact surface in a lamination process **(Figure 2)**. The semiconductor die is then mounted onto the substrate in a pick-&-place machine. This is called tacking, which is the placement and temporary bonding of the semiconductor to the substrate. For most common products, heat and some contact pressure are required to create this bond.

Therefore, in addition to precise placement of the semiconductor die, accurate force and temperature control – of both the substrate and the semiconductor – are critical for reliable tacking.

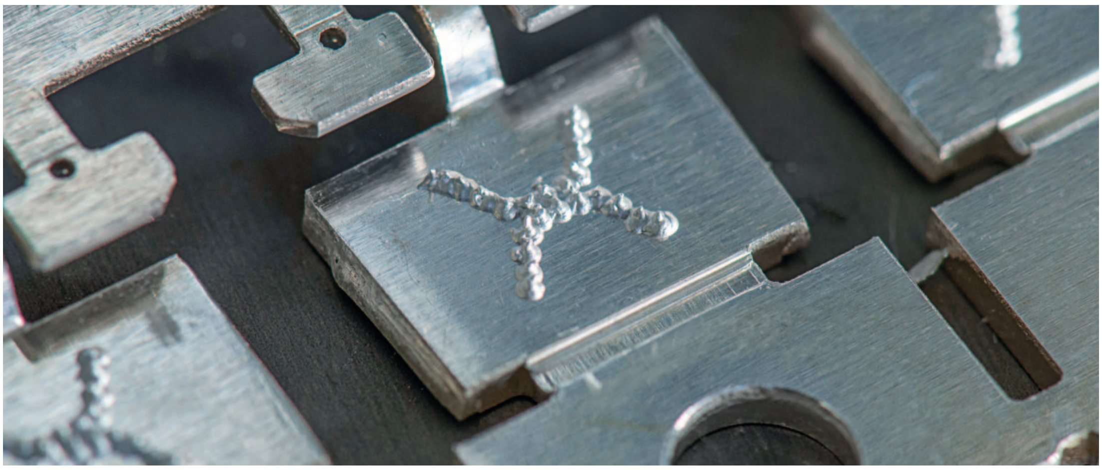

Figure 3. The sinter paste is dispensed directly onto the substrate

Figure 4. The compact desktop systems provide all the necessary components for the assembly of sintered products for development, prototyping and low-volume production

Customised solutions for sintering applications

The Swiss company Infotech from Solothurn develops sinter bonder systems for the fully automated assembly of sintered components. These offer a wide range of possibilities: from tacking the dies onto pre-printed sinter layers, to dosing the sinter layer directly on the system **(Figure 3)**, to laminating the dies with sinter film. The semiconductor devices can be fed on different systems: from wafer feeders, tape-and-reel or directly from the wafer. In addition to proper die handling, precisely controllable parameters such as speed, force and process temperature ensure high process stability. In addition to customised placement systems, Infotech offers process know-how and supports users in optimising processes on the system. Close cooperation with sintering press manufacturers and sintering material suppliers ensures that technology and know-how are kept up to date.

Figure 5. For larger series, production can be scaled directly through highly dynamic production cells that utilize the same basic design

From laboratory system to production line

The systems are based on many years of experience in handling and processing semiconductor and DBC boards in a wide variety of processes. The core element of each system is the Cartesian pick-&-place robot. Supported by intelligent vision systems, it enables high-precision and dynamic assembly processes. The pick-&-place robot can be supplemented with various additional modules from the extensive ›Component Matrix‹.

The cleanroom and ESD safe systems range from small desktop systems **(Figure 4)** – optimised for development and laboratory applications – to manufacturing cells **(Figure 5)** for high-volume production and complete production lines. Seamless scaling of production is guaranteed thanks to a uniform basic design and corresponding software. ■

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Figures: Infotech