Staying in the game

Kevin Keller looks at the packaging challenges when it comes to producing smaller power MOSFETs & Schottky diodes for the automotive sector

The global automotive electronics market is expected to be worth at least $240 billion by 2017 (according to research conducted by Strategy Analytics). Innovative integrated circuits (ICs) for powertrain, lighting and body electronics are helping car manufacturers to reduce emission levels, improve the fuel economy, and increase the safety of the vehicles they produce.

The number of electronics components inside the average vehicle has risen considerably over recent years and will continue to grow at an almost exponential rate (as Figure 1 suggests).

With the increasing proliferation of electric/hybrid vehicles, currents being used will become higher and this will require even greater electronics content. In addition, the emergence of x-by-wire technology (replacing much of the mechanical control linkages) will also have a notable impact.

As a result there is an ever growing need for more compact and high performance semiconductor devices for powering all this complex electronics hardware – offering greater efficiency levels and conserving battery life, while simultaneously taking up less room. Though semiconductor process technologies continue to adhere closely to Moore's Law, allowing smaller and smaller dimensions for IC dies, far larger technological challenges must be overcome if the packages in which they will be enclosed are to keep up with this progression.

As well as power ICs handling high currents and having a strong switching capability, major advances are called for so that the packaging technology they employ can deal with concerns such as ensuring adequate heat dissipation and robustness, as well maintaining overall cost effectiveness. In order to decrease the amount of board real estate taken up by these devices, a huge engineering effort must now be devoted to issues such as minimising interconnect resistance and curbing lead inductance, while still delivering sufficient thermal management to ensure the long term reliability of these devices.

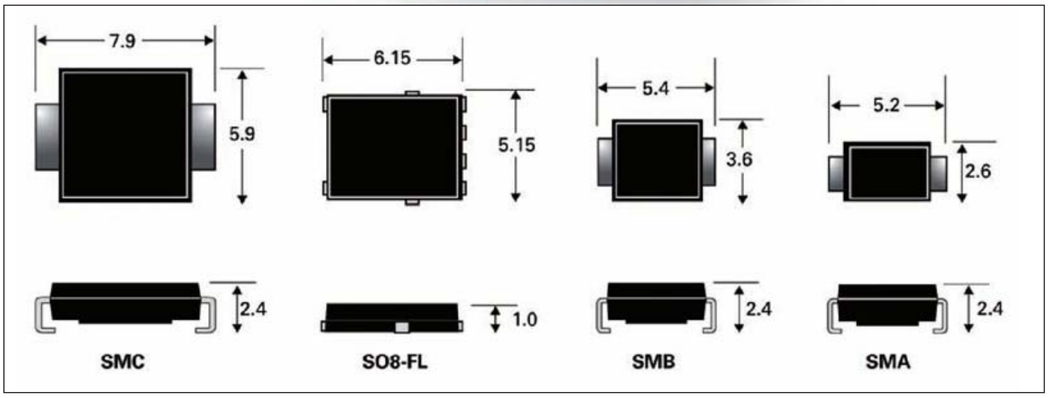

Figure 2: *Comparison of SO-8 FL with other package formats*

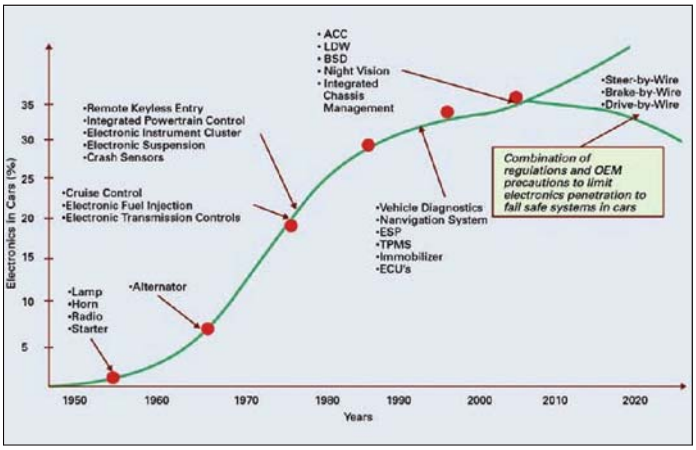

Figure 1: *Growth of Vehicle Electronics Content in Europe between 1950 and 2020*
(source Frost & Sullivan)

All the components used in automotive designs have to offer extensive lifespans and extremely high reliability as any failure of such items will have serious effects. Recalling many thousands of a particular car model can be incredibly costly for the manufacturer, and even worse can impact very heavily on the brand image. The risk of having to do this for the sake of one relatively cheap power IC unable to cope with the task it was specified for due to poor packaging design is simply too great.

IC packaging technology

Packages types used in the automotive electronics sector usually have far longer life cycles than those found in other areas (such as portable consumer, white goods, home entertainment etc). In some vehicle designs metal case components have only recently been phased out. Generally speaking over the course of the last ten years SMB, SMC and DPAK options have increasingly been favoured, however, the exacting demands now being placed on car manufacturers to add even more functionality into their latest models is accelerating migration to advanced packaging technologies. In response to this, semiconductor research and development is starting to focus heavily on enabling the power, savings and cost savings to bring better power MOSFET and Schottky diode solutions to the automotive industry. A new breed of surface mount packaging technologies is now emerging that possesses the necessary attributes to fight this cause.

Fuel injection systems

How the delivery of fuel into the car's engine is carried out has changed over the last few decades, with the supporting electronics now controlling the timing of the injection and the quantity of fuel introduced needing to have a considerably greater degree of ruggedness than previous generations. For both the Schottky diodes and MOSFET devices being specified by automotive manufacturers for this application, the operating temperature

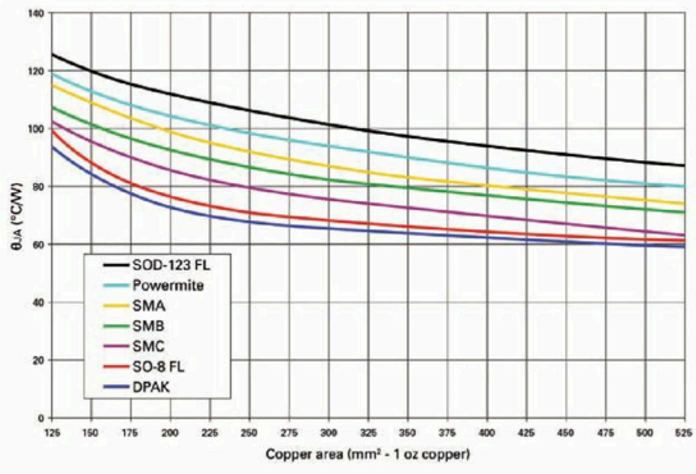

Figure 3: *Comparison of thermal performance characteristics for SO-8 FL and other package technologies*

range now needs to have an upper limit of at least 175°C, with 200°C becoming increasingly common. They must be very compact and slim-line, as space is particularly limited here, thereby raising power densities, and in turn amplifying the problem of dissipating heat away quickly enough.

HID automotive lighting

High intensity discharge (HID) lamps are now being incorporated into automotive lighting systems, replacing traditional halogen based lamps, as they greatly increase the driver's visibility range and thereby improve road safety. The EU has passed legislation making daytime running lights (LED-based headlights that are on whenever the engine is running) mandatory for every vehicle produced from 2011 onwards, in an attempt to reduce the frequency of accidents. Solid state lighting systems such as these need more sophisticated driver electronics. Once again smaller components are desirable, due to the space constrained nature of the modules employed. Though not generally located in such stressful environments as those needed for fuel injection, the components (ultra fast diodes and MOSFETs) still face difficulties - being exposed to electromagnetic interference (EMI) and large voltage spikes.

Elsewhere within automotive design, again and again we see the same elemental forces in action. Whether it is for antilock braking systems, instrumentation clusters, or transmission systems, the need to deal with extreme levels of heat and use up as little board space as possible are both constantly recurring.

Package Type	SMC	SO8-FL	SMB	SMA
Power Dissipation	750 mW	900 mW	550 mW	500 mW

Figure 4: *Comparison of power dissipation levels for SO-8 FL and other package technologies*

The flat lead imperative

The SO8FL small outline flat lead package was created to allow larger semiconductor dies to fit into a standard SO8 IC footprint. It uses a lead frame design from which the leads stick out beyond the moulded body size. This feature means the solder fillet can be seen fully, thereby making the visual inspection process more effective. In addition, this package format has greater thermal dissipation levels and reduced electrical parasitics. Its profile is considerably slimmer than DPAK, SMA, SMB, SMC, Powermite, or SOD-123 alternatives. Furthermore it accepts a wider variety of die types.

The SO-8 FL has markedly better thermal resistance than SOD-123 FL, Powermite, SMA, SMB, or SMC packages types (as shown in Figure 3). This is thanks to the shorter thermal path that it offers, with the die in contact with a copper pad.

So what does the future hold? Moving forward it looks likely that still greater pressure will be placed on semiconductor vendors to supply even more compact and thermally efficient ICs. The underlying trend is heading towards selling bare dies (particularly for employment in areas such as vehicles' powertrain or gearbox systems) as these will be easier for the car brands' integration partners to incorporate into their modules.

This, however, will be highly problematic for chip firms serving the automotive industry in terms of ensuring reliability of product and complicating the whole delivery process. The stakes are being raised all the time and it will take more imaginative pioneering approaches to stay in the game.

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Kevin Keller is Applications Engineer Manager at ONSemiconductor