SiC Devices are Moving towards Standard Products

Material defects are reduced and wafer sizes are growing

Silicon carbide (SiC) has been talked about for a while. Historically, silicon carbide was known for its hardness and used as a grinding material. Its potential for semiconductor’s has been known since the middle of the last century, but unfortunately large scale quality substrates have not been available until recently.

By Bodo Arlt, publishing editor Bodo’s Power Systems

Rectifier and switch production in SiC started on relatively small wafer sizes, as compared to silicon. Technology has developed over the last decade – now much larger lower defect wafers are reducing cost. And it is not only the device cost that is significant, the whole solution changes with SiC. With higher current density in SiC semiconductors, the chip size can be smaller. Switching losses are mostly eliminated. Passive components can be smaller as frequency can be increased. Smaller capacitors and coil sizes have a significant impact. The device can operate at much higher temperature, so cooling is easier. Critical space and transportation applications benefit from reduced weight.

All areas of application show improved performance from the excellent switching behavior of SiC devices... Modules using SiC diodes paired with silicon switches (for example, IGBT’s) show a remarkable improvement in system performance. At the ROHM SiC Forum in December, Dr. Ino presented a comparison of losses at 125°C junction temperature, showing a reduction of about 75% in losses in a module equipped with SiC devices (Figure 1).

SiC switches in different variations are now being introduced to the market, and a modular approach makes good sense immediately. To utilize higher switching frequency in most applications creates problems in Electro Magnetic Interference (EMI), so reduced spacing between switching devices is a requirement. Short internal wire length between semiconductor elements is perfectly achieved in well-designed modules.

A challenge remains to get to higher temperature packaging materials to fully utilize the SiC temperature capabilities. Articles in my publication during the last years have addressed the packaging opportunity.

Figure 1: Estimation of Module Power Loss versus Standard IGBT in Silicon (Source ROHM; Dr. Ino)

Figure 2: The Micropipe Density of SiC wafers (Source SiCrystal; Dr. Eckstein)

Figure 3: The Timeline Upscaling and Quality improvement (Source SiCrystal, Dr. Eckstein)
Also, the practical use of SiC and GaN has been widely covered.

Conventional wisdom of the past has been that wafer cost and size would always dictate against volume applications. At the ROHM SiC Forum, Dr. Robert Eckstein from SiCrystal AG presented a significant update and outlook. Micropipe density (MPD), shown in Figure 2 from SiCrystal, shows remarkable improvement.

In parallel, the wafer size for SiC is growing over the years. Processing here is different to what we know from silicon, but as the crystal structure is the basis for the semiconductor elements, it is the basis of product improvement. Figure 3 and 4 draws a clear picture of what has been achieved in the last 10 years.

Figure 4: Micropipe Mappings: 3 inch, 100mm & 150mm as of today (Source SiCrystal, Dr. Eckstein)

So we are looking forward to seeing wide band gap semiconductors moving more and more into volume designs. Not only SiC devices at higher voltages, but GaN devices are now available for line voltage applications. It will be great to see at upcoming power conferences this year, starting with APEC in Fort Worth, what to expect as the norm in semiconductors. Technology has moved from tubes to mercury-arc, to Germanium, then to Silicon bipolar and MOS devices, and now to Silicon Carbide. That all happened within the last 60 Years – a continual improvement in capability.

What will be next?

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