Application of Silicon Carbide Semiconductors in Hybrid Electric Vehicles

During last years, a discussion has started on environmental issues and ways to reverse climate changes. One of the most important matters is the greenhouse effect, where car emissions is a main causes. A worldwide effort is made by automobile industries to produce vehicles consuming less fuel and therefore lowering emissions. This is how the idea of a hybrid car was born. The use of an electric motor with high efficiency (over 90%) and no emissions would limit the non-efficient (around 30%) combustion engine's use and hence the fuel consumption.

Using two motors, an electric and a combustion engine, of similar power and a high capacity battery, however, increases the cost of such a vehicle too much. The solution is to find the best compromise between initial cost and hybridization level. An electric machine of 5 kW power proves to be cheap enough and sufficient for a fuel consumption reduction up to 30%. Apart from the battery and the electric machine, there are some electronics needed for the energy conversion between the battery and the electric machine. The aim is to lower as much as possible the cost of these electronics in order to build a cost efficient vehicle.

The idea is to put the converter under the hood in order to get it as close as possible to the electric machine and save space somewhere else in the car for other use. The problem is that today's electronics cannot operate in temperatures higher than 100^{o}C reliably, which is a common temperature under a car's hood. The solution came from the innovative technology of transistors in silicon carbide. This new material proves to have many advantages compared to silicon that is commonly used today in electronic applications, but is in experimental stage yet. The first products are expected to enter the market in 2008.

This matter does not prevent us from designing and evaluating a power converter based on silicon carbide semiconductors to prove if it is worth continuing the research on this area. We came with two different designs, for a low (112 V) and a high (300 V) voltage battery. They both proved to be more efficient than the corresponding converters based on silicon components and also proved to be able to withstand the temperature conditions under a car's hood, even under the most severe circumstances. We concluded that the combustion engine's cooling system was sufficient to cool the electronics as well.

We compared the two designs in terms of power losses and efficiency. It seemed that silicon carbide operates more efficiently in higher voltages, as the losses were significantly lower for the 300 V design. Apart from the losses, in the high voltage design, we used 1/3 of the semiconductors needed for the 112 V design that can lead into an even greater cost reduction and of course better reliability, as the components used are less.

To conclude, this study proved the great potential of silicon carbide semiconductors in hybrid electric vehicle applications by evaluating a power converter. SiC has better performance than silicon and this performance improves as the voltage rises. The higher the battery voltage, the lower the cost becomes to build the converter. As a result, for a cost efficient mild hybrid car, we have to turn into silicon carbide and high voltage batteries, regardless of the electric machine's low power.

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