Silicon Carbide, fueling the EV revolution

In the global pursuit of decreasing the environmental impact of the fossil fueled vehicle industry, the ongoing advancements in electrical vehicle technology are imperative. As of now, the vehicle industry is undergoing electrification. For the electrical vehicle to be competitive on the market, a high efficiency of the vehicle is essential. One component that affects the vehicle efficiency is the traction converter. Tirelessly striving for higher efficiency, pioneers have discovered the potential of new semiconductor materials, one of which is Silicon Carbide.

One of the main issues with electrical vehicles today is that the range does not come close to competing with its counterpart, the combustion car. Theoretically there's multiple ways to solve this issue, one is to go around the issue by improving the EV charging infrastructure. Another solution is increasing the energy density and reducing the cost of batteries, or to further improve the drivetrain efficiency of the vehicle. This study is investigating the possibilities of increasing the efficiency of the electric drivetrain specifically focusing on the traction inverter.

For the car to have high drive train efficiency it is important that all components within the drivetrain maintains a high efficiency. For a conventional car this means transforming the chemical energy in the fuel directly to mechanical energy through combustion. However for an electrical car this means transforming electrochemical energy from the traction battery to electrical energy before converting to mechanical.

The main components within the drivetrain to consider regarding electrical efficiency are: The traction battery, which supplies the car with energy, the three phase converter, that converts the DC-voltage of the battery to three phase AC, and the traction motor, transforming the electric energy to mechanical, allowing the vehicle to move.

Since the introduction of the electrical vehicle, the traction converters in the vehicle industry has been dominated by silicon (Si) technology. Recent advancements in the field has led to investigations on alternative semiconductor technologies. By replacing silicon with silicon carbide (SiC), even higher efficiency of the electric car can be reached.

In the design of electric vehicle drivetrains, component simulations are essential to reach a good drivetrain design. To size each component in the drivetrain, it is essential to have a good understanding of the component specific power losses. The battery heats up as a consequence of the chemical reactions within itself, the traction motor mainly heats up from the losses in the copper windings and steel laminations. The losses in the traction converter mostly consists of semiconductor losses. Semiconductor losses are the losses that can be significantly reduced by replacing silicon with silicon carbide, which increases the efficiency of the traction converter and therefor the complete drivetrain.

With SiC being a new player in the vehicle industry, the component selection is scarce. This makes it difficult for interested parties to investigate the possibility of a transition to SiC for their specific use case. The work done in this project has focused on filling this gap. By generalizing specific component characteristics, a seamless model for SiC power semiconductors is created, optimizing for semiconductor area and cost. The loss model for SiC converters is developed for pre-design of traction converters.

In a final comparison study between the performance of Si traction converters compared to SiC traction converters, the efficiency is higher of the SiC converter. It does however come at a higher price tag. With silicon being the senior technology in the vehicle industry a more aggressive price reduction is expected for SiC than for Si, shining a bright light on the future for SiC.