Project profile

CATRENE
Cluster for Application and Technology Research in Europe on NanoElectronics

CT315 | Embedment technology benefits power-drive electronics in electric vehicles [EmPower]

Based on chip-embedding technology for thin insulated-gate bipolar transistors (IGBTs) and diodes, and an innovative double-sided wafer plating process and equipment for thin wafers, the EmPower project is developing an innovative packaging concept of high-power modules for e-mobility and industrial applications, especially in automotive. An important project objective is to drastically improve heat dissipation and thermal impedance of embedded power cores by deploying double-sided cooling and vertical current and heat flow.

Current packaging solutions, based on expensive copper-coated ceramic, increase production costs (due to an increase in size and weight), which make these products unattractive, especially for use in the automotive industry. EmPower (a contraction of ‘embedded power’) will therefore develop an innovative packaging concept for the power-drive electronics of engines in electric vehicles (EVs) which are adapted for operating in harsh conditions. It is primarily targeted at inverters for drive motors, battery chargers and electronic power controllers in auxiliaries (such as power-steering and brake systems).

Key technical activities

EmPower’s approach is based on the concept of embedding power-drive components (IGBTs, MOSFETs and diodes) as thinned chips into a glass-fibre reinforced epoxy-resin layer. This creates large-area interconnections on both sides by direct copper plating the dice to form a conductor structure with the lowest possible electrical impedance, and to achieve an optimum heat removal. In this way a compact, small-sized core is formed, referred to as the embedded component package (ECP) power core.

EmPower will also develop embedding technologies for logic controller components (usually provided as packages with solder balls or SMD terminations). Conventionally, such logic packages have a higher thickness than power dies, and are consequently embedded in a separate module (other than the power module) called the logic module. The development of logic-embedded modules creates an additional set of challenging technical goals for EmPower since heterogeneous pre-packaged components have to be first assembled using various techniques (depending on termination), and then embedded, taking into account the difference in package thicknesses.

Furthermore, the EmPower project will develop a cost-effective and optimised thermal-management concept. To this end, it will develop a sinter interconnection technology for the ECP power core and logic module, using insulated metal substrate (IMS) heat sinks for heat removal from both sides of the modules over the shortest possible heat conduction paths, and creating the ECP power module. This compact module can be easily attached directly to the electric motor housing, thus reducing the number of connectors and length of copper cables.

The results of the EmPower project (and the know-how gained) will be published in scientific journals and presented to the scientific community and industry at international conferences and trade shows.

PROJECT CONTRIBUTES TO

Communication	✓
Automotive and transport	✓
Health and aging society	
Safety and security	
Energy efficiency	✓
Digital lifestyle	✓
Design technology	
Sensors and actuators	
Process development	
Manufacturing science	
More than Moore	
More Moore	
Technology node	

Partners:

AT&S
Atotech
Conti
STMicroelectronics
ILFA
Institute TU Berlin
University TU Wien

Project leader:

Johannes Stahr
AT&S

Key project dates:

Start:	May 2013
End:	August 2016

Countries involved:

Austria
Germany
France

Project website:

http://catrene-empower.ats.net/

Well-resourced consortium

EmPower's project consortium is finely balanced between industry and academia. In addition, its seven project partners bring to the project their reputation, expertise and key resources needed to ensure success. Partners range, for instance, from a leading European supplier of high-quality PCBs and associated services (primarily to the telecommunications, measurement and control technology and the computer and automotive industries); a company involved in strategically important application fields of plating and wafer metallisation; and a leading global automotive supplier of systems and components for powertrains and chasses; to a medium-sized enterprise supporting innovative solutions in very fine conductor technology for over 30 years; as well as technical universities with expertise and experience essential to EmPower, such as advanced microelectronic packaging and reliability, optimising new packaging concepts and interconnection techniques.

Impacting the all-important automotive market

EmPower will generate several key technical benefits. It will, for example, enable a drive to be mounted directly on the motor to form a single unit with the motor housing, and also provide a wider switching-frequency range and high power-efficiency. EmPower technology also promises to reduce the volume of an electrical control unit (ECU) of the drive inverter found in EVs and hybrid electrical vehicles (HEVs). In mobile applications, the package density, weight, and power losses, which have to be considered in the cooling system, are the most design-critical boundary conditions. Notably, EmPower is expected to produce improvements in all these three design targets.

EmPower will also impact two core technical aspects: double-sided cooling and the conductivity of semiconductor switches without the use of bond wires. The former will lead to a lower power resistivity; and the latter to a lower resistivity and inductance of the power switch. It is expected to impact 10% of the overall car production of EVs and HEVs by 2035.

On the ecology side, a key success factor will be to develop power-efficient energy converters in order to maximise CO_2 reduction in the face of increased individual mobility. This will be seen as a (significant) win in the sustainability battle.

Commercially, the innovative packaging of power-drive electronics of engines in electric vehicles (and in some cases consumer applications) will result in lower costs, higher reliability and lower space requirements, thus securing a competitive edge in the European automotive industry.

Analysing the value-chain of existing power modules underscores future importance and ubiquity of the power module developed in the EmPower project. Roughly 25% of the value-chain will benefit from the new power-module concept. EmPower's main potential market is for EV's, whose registration is expected to rise from 500,000 in 2015 to 1.1m in 2020. Notably, power modules are not only limited to electro- mobility; power semiconductors, excitation designs and mechatronic integration are also needed for industry and the consumer market.

And the general health of the automotive business, the main beneficiary of EmPower, is also crucial to the success of the EmPower project. Encouragingly, we see that automotive has the second-highest compounded average annual growth rate (CCAAGR), 14% in 2016, after renewable-energy applications (wind power, for example) with a CAAGR of 22% in 2016.

CATRENE (Σ! 4140), the EUREKA **C**luster for **A**pplication and **T**echnology **R**esearch in **E**urope on **N**ano**E**lectronics, will bring about technological leadership for a competitive European information and communications technology industry.

CATRENE focuses on delivering nano-/microelectronic solutions that respond to the needs of society at large, improving the economic prosperity of Europe and reinforcing the ability of its industry to be at the forefront of the global competition.

CATRENE Office
9 Avenue René Coty - F-75014 Paris - France
T. +33 1 40 64 45 60
E. catrene@catrene.org
www.catrene.org