Advanced Power Electronics Project

Vision and Background:

Reaching the greenhouse gas reduction goals of the Kyoto protocol signed in 2005 as the global warming countermeasures is of great importance to us. In 2006, the Kanagawa Prefectural Government has established "The Kanagawa EV (Electric Vehicle) Promotion Council" in order to advance the vehicle technologies with low impact on the environment.

Power Electronics is the technology associated with electric energy conversion, control and conditioning from its available input form into the desired electrical output form. This technology is extremely important in pushing forward the development of an energy efficient household electrical appliances as well as the EV.

In the advanced power electronics project we intend to build a small EV with high energy efficiency. Developing new implementation technologies and highly reliable power devices with improved resistance to heat becomes essential for targeted high power density.

We also intent to establish a public experimental manufacture laboratory. The goal of this facility is to offer a sustainable technical support for medium and small sized businesses in the prefecture.

Research Activities:

We set two following research themes.

Research Theme I: Suggestion and realisation of eco-future model EV

Leader: Atsuo. Kawamura (YNU)

The goal of this research theme is to build a highly efficient eco-future model EV. The main research topic is highly efficient and high power density power electronics technology implemented in the vehicle power management. The goal is to minimise losses in the electric energy conversion as well as in the propulsion system. The technology will be implemented in a four passenger small sized urban EV with easy charging capability. We envision this vehicle to be the [*]electric mileage world's best eco car.

[*] Electric mileage – Mileage of 1 kWh converted into body mass of 1t (km/kWh/t)

Research Theme II: Development of packaging technology for high integrated power devices

Leader: Akio Takahashi (YNU)

Our final goal is to develop a key power device packaging technology for the urban EV with the goals of improved lifetime and high efficiency. The target is high current density and high heat resistance technology for improving the state of the art Si and SiC devices.

Application 1: Development of high heat-resistant resin for encapsulation materials.

LabLeader: Akio Takahashi (YNU)

The use of power devices based on SiC material enables highly efficient operation at high temperatures up to 300C. However, conventional isolation / sealing technologies are unable to cope with such high operating temperatures and therefore new advanced materials are necessary. Our aim is to develop a material which is able to operate at the high operating temperatures close to 300C. The main research topic is the in-situ polymerization of a thermally stable modifier with a high heat-resistant matrix resin newly molecular-designed during the curing process.

Application 2: Development of new reliability assessment method for high power densities

LabLeader: Qiang Yu (YNU)

The power module reliability research will be targeted through trial manufacture of power modules and establishing module simulation technology. We intend to reproduce series of real-world failures related to electrical/thermal/structural stress. This will help us to understand the failure mechanisms involved in the joints of semiconductor chips which will serve as the basis for the consequent reliability research. In addition to developing the new joining materials such as nanoparticles and tininess of the joint, we intend to establish a high precision non-contact evaluation technology of material characteristics of the micron zygospore.

Application 3: Material system design technology for next generation power modules

Lab Leader: Toshiro Shinohara (KITC)

The aim of this research is a development of high heat-resistant bonding technology for Silicon Carbide power modules. We improve bonding pastes within nano-size metal particles for die attachment. The characteristic of the pastes and bonding processes are studied to achieve high bonding strength and reliability under 300 degrees C. In addition, we would obtain the evaluation technique of the high heat-resistant bonding system through these studies.