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Special Reports

In-Vehicle Platform Technologies Allowing Creation of Sophisticated Cars

Toward Realizing Society with Autonomous Car Systems
SERIZAWA Mutsumu

Trends in Autonomous Car Technologies and Toshiba's Approach
YOSHIKAWA Takashi / OKAMURA Atsushi
The movement toward the development and introduction of autonomous car systems has accelerated both in Japan and other countries, with the aim of reducing traffic accidents and improving driving efficiency. This has given rise to the need for the development of in-vehicle platform technologies capable of precisely understanding driving conditions and performing high-accuracy vehicle control, as well as the development of legal systems and improvement of transportation infrastructure.
The Toshiba Group has been promoting the research and development of various in-vehicle platform technologies with the objective of realizing an optimal autonomous car system applying the image recognition processor.

High-Accuracy Vehicle Periphery Recognition Technologies Using TMPV7608XBG Image Recognition Processor
NISHIYAMA Manabu / KUDO Yoshihide
In the field of driver assistance and automated driving systems for vehicles, technology using camera images to appropriately recognize the peripheral conditions including pedestrians and other vehicles is essential to improve the safety and quality of driving. As recognition accuracy depends on the image recognition algorithm, demand has been growing for accurate algorithms as well as robust algorithms applicable to a wide range of targets.
In response to these circumstances, Toshiba has developed a novel image feature descriptor necessary for pattern recognition, which makes it possible to improve the performance of nighttime pedestrian detection. We have also developed a three-dimensional (3D) reconstruction technique to detect arbitrary obstacles, such as objects that have fallen on the road, using 3D information inferred from time-series monocular camera images. The TMPV7608XBG, an advanced image recognition processor, provides such techniques with dedicated image processing accelerators that achieve real-time image processing with low power consumption.

Compact Automotive Camera Modules with Image Recognition Function
SAKAMOTO Hideki / FURUKAWA Kenji / TAKAGI Kenji
In line with the roadmap for advanced driving projects being promoted by the Japanese government, the development of autonomous car technologies has recently been progressing in the automobile industry aimed at practical realization. In particular, as sensing technologies are positioned as key technologies for the detection of other vehicles and pedestrians, a variety of products using cameras and millimeter-wave radars have been introduced on the market, leading to improved performance and reduced costs.
With these market trends as a background, Toshiba Alpine Automotive Technology Corporation has developed a platform for automotive camera modules with an image recognition function and released compact automotive camera modules based on this platform, with the objective of offering an optimal solution for autonomous car systems that will be accepted by the market. These products provide a low-cost sensing system that has high affinity with other on-vehicle modules as well as robustness to future changes in vehicle systems, thereby responding to various product deployment requirements.

Vehicle Security System to Enhance Driver Safety
KAWABATA Takeshi / KOMANO Yuichi / ISOZAKI Hiroshi
The development of increasingly sophisticated functional safety features for in-vehicle systems is progressing, aimed at realizing autonomous car systems and reducing the risk of hazards caused by malfunctional operations. However, the expansion of sophisticated in-vehicle systems in recent years has been accompanied by a higher risk of such systems being hijacked by cyberattacks targeting vulnerabilities in their functional safety features. To construct a vehicle security system that provides safety to both developers and drivers, protection from malicious hackers is necessary through supervision at the appropriate boundary and implementation of a secure functional area.
In response to this situation, Toshiba is developing a high-speed signature authentication technology to secure in-vehicle vehicle-to-X (V2X) systems at the boundary between the areas inside and outside the vehicle network and a security architecture to combine the required security components by appropriately dividing in-vehicle functional boundaries.

Feature Articles

Application of Connectivity Theory to Large-Scale Wireless Mesh Network Systems
DOI Yusuke / Orestis GEORGIOU
In recent years, a wireless mesh network technology that can facilitate the construction of a wireless network system through the interconnection of a number of devices, in which each device mutually relays data, has been attracting attention as a method to flexibly build a wireless network system at low cost using existing communication infrastructure. However, in a large-scale wireless mesh network consisting of many components, it is difficult to predict the behavior of the system because of the complex interactions among the components.
With this as a background, Toshiba has applied a connectivity theory based on a statistical physics approach to large-scale wireless mesh network systems in order to theoretically estimate interconnections among components while maintaining the connectivity probability so as to exceed a certain value. This technology makes it possible to predict the macroscopic behavior of a mesh network using statistical parameters including node density, thereby improving the design process for large-scale wireless mesh network systems.

Application of Random Telegraph Noise to Individual Authentication Technology Using Physical Unclonable Function (PUF)
CHEN Jiezhi / TANAMOTO Tetsufumi / MITANI Yuichiro
With the acceleration of downscaling technologies for transistors in recent years, random telegraph noise (RTN) has been attracting considerable attention due to its large impacts on transistor operating current fluctuations. The effects of RTN on the reliability of complementary metal-oxide semiconductor (CMOS) image sensors, flash memories, and three-dimensional transistors are a matter of concern.
Toshiba has been conducting studies on random variations in the time constants of traps that cause RTN and the dominant physical mechanisms of these variations through experiments, and confirmed that the time constants of RTN traps in individual chips are quite stable under electrical stressing. Focusing on highly stable and highly random characteristics of the time constants of RTN traps, we have applied RTN to a physical unclonable function (PUF) technology, one of the important security technologies for individual authentication. From the results of experiments using a newly developed algorithm, we have confirmed that the information of RTN traps can be successfully detected and that this RTN-based PUF technology can not only convert RTN into a chip ID in a sort time, but also achieve ID reading cycles of more than one million times by measuring the hamming distance (HD) as an index of stability.

High-Efficiency CIGS PV Cell with Homojunction Structure
NAKAGAWA Naoyuki / YAMAMOTO Kazushige
CIGS photovoltaic (PV) cells are fabricated by forming a thin film of copper indium gallium selenide ($Cu(In,Ga)Se_2$) on a glass substrate. In the PV market, CIGS PV cells are expected to reduce power generation costs due to the advantages of lower-cost film forming compared with the dominant crystalline silicon (Si) PV cells and high energy conversion efficiency despite the use of polycrystalline thin film.
Toshiba has been actively focusing on the development of a CIGS PV cell with a homojunction structure as an ideal device structure having fewer interface defects at the pn junction in comparison with conventional heterojunction structures. We have now succeeded in forming an n-type CIGS layer by applying our proprietary thin-film fabrication technologies. Experiments on a small prototype PV cell have confirmed that it achieves an energy conversion efficiency exceeding 20%, equivalent to that of a crystalline Si PV cell.

Chemical Dicing Technology Using Noble Metal Catalytic Etching to Simultaneously Process Entire Surface of Si Wafer
ASANO Yusaku / MATSUO Keiichiro / HIGUCHI Kazuhito
With the reductions in size of semiconductor devices, the deterioration of silicon (Si) wafer use efficiency, throughput, and production yield in the blade dicing process is becoming an increasingly critical issue.
To overcome these problems caused by the blade dicing process, Toshiba has developed a chemical dicing technology applying anisotropic wet etching of Si using noble metal catalysis that makes it possible to chemically process the entire surface of a Si wafer simultaneously with high accuracy and high productivity. In order to clarify the optimal conditions for forming deep vertical trenches, we have investigated the mechanism of mass transfer and side etching and confirmed that the trench shape can be controlled by varying the etchant composition. Experiments on prototypes have verified that this chemical dicing technology has the potential to process fine lines on a Si wafer of less than 10 μm in width under the optimal conditions.

Development of Remote Decontamination Technologies Improving Internal Environment of Reactor Buildings at Fukushima Daiichi Nuclear Power Station
HOTTA Koji / HAYASHI Hirotada / SAKAI Hitoshi
The reactor buildings at the Fukushima Daiichi Nuclear Power Station of Tokyo Electric Power Co., Inc., which was seriously damaged by the Great East Japan Earthquake of March 11, 2011, have been highly contaminated by radioactive materials. To safely and efficiently advance the processes related to the forthcoming decommissioning of the reactors, it is necessary to improve the hazardous environment inside the reactor buildings.
During the more than four years that have elapsed since the Great East Japan Earthquake, Toshiba has been implementing various measures to reduce the ambient dose rates inside the reactor buildings through decontamination work and participation in a national project for the development of remote decontamination technologies for reactor buildings. A variety of vehicles and technologies to support decontamination work have been developed through these activities, and are significantly contributing to improvement of the environment inside the reactor buildings.

Protection Relay for Loop Transmission Systems Using Ethernet(†)-based Communication
FUKUSHIMA Shota / MORI Takahiro / KURIYAMA Megumi / KOHIGA Seiichi
Protection relays, such as line current differential relays, support the stable operation of an electric power system by detecting faults that occur in the system due to a lightning strike, etc., and issuing a trip command to circuit breakers in order to isolate the part of the network in which the fault has taken place. The conventional type of system is capable of detecting whether a fault is an internal or external accident in the area covered by protection through differential calculations using current data from all of the terminals on the transmission line collected via a pulse code modulation (PCM) communication system.
Toshiba and Tokyo Electric Power Co., Inc. have now developed a protection relay for loop transmission systems adopting an Ethernet(†)-based universal communication system that makes it possible to share the differential calculation information as well as maintenance and operation information among equipment in the network. The newly developed protection relay is expected to contribute to reductions in overall system costs and enhanced sophistication of protection relay systems.

10 Ah-Class SCiB™ Lithium-Ion Battery for Idling Stop Systems and Micro Hybrid Vehicles
SARUWATARI Hidesato / YAMAMOTO Dai
Toshiba has been supplying two types of SCiB™ lithium-ion battery cells: a 20 Ah large-capacity type and a 2.9 Ah high-power type. The 2.9 Ah type cells are currently being mass produced for light vehicles.
We have now developed a 10 Ah-class SCiB™ cell for idling stop systems and micro hybrid vehicles (HVs) in response to the market demand for batteries with increased energy capacity to improve the fuel consumption of a wider range of vehicles. Lower resistance and higher reliability were achieved by reconsidering the cathode material. As a result, the 10 Ah-class SCiB™ cell offers a power density exceeding 4,000 W/kg for 10 seconds at a temperature of 25°C and a state of charge (SOC) of 50%. It also has superior lifetime characteristics, as demonstrated by its capacity fade rate of 3% and internal resistance increase rate of 15% after 8,000 cycles in a 5C high-rate cycle test at a temperature of 35°C. The application of the 10 Ah-class SCiB™ cell to 12 V and 48 V automotive power systems will contribute to a reduction of the environmental load of automobiles.

High-Velocity Solid Particulate Deposition Technology for Ceramic Coatings
HINO Takashi
Plasma processing, such as the dry etching process, is used in various processes during the manufacturing of electronic devices. Attention has therefore been focused on the application of ceramic coatings to the inner walls of manufacturing equipment in order to improve plasma resistance and corrosion resistance. Although the thermal spraying method, which has been widely used in recent years, can form a ceramic film by melting and quench-solidifying ceramic powder, the occurrence of defects including cracks and voids in the film is a critical issue.
To address this issue, Toshiba Materials Co., Ltd. has now developed a high-velocity solid particulate deposition technology capable of creating a fine ceramic film almost free from defects through the continuous deposition of ceramic powder without melting it. This technology is expected to contribute to lengthening of the lifetime of manufacturing equipment and stabilization of manufacturing processes by realizing improvements in both the quality of oxide ceramic films and the deposition of nitride ceramic films, which have been difficult to form using conventional methods.

Frontiers of Research & Development

Charge Curve Analysis Technology for Performance Degradation Evaluation and Effective Utilization of Lithium-Ion Batteries
Visualization of Values Resulting from Interoperation of Multiple Infrastructure Systems