

Semiconductor Packaging and Assembly Technologies Supporting Evolution of Various Devices

Continuously Evolving Toshiba Semiconductor Packaging and Assembly Technologies

MOMODOMI Masaki

Toshiba's Progress in Developing Semiconductor Packages and Approaches to Packaging Technologies

CHIDA Dajjo / HAPPOYA Akihiko

Toshiba has been continuously developing various types of semiconductor packages in response to the miniaturization of semiconductor devices supporting the advancement of electronic devices since the 1980s, including multi-die packages for memory devices to achieve larger capacity, compact packages with high reliability to meet the increasing demand for electronics in automobiles, and ultra-small packages for information and communication devices to achieve lighter weight, thinner profile, and smaller size. These packages are contributing to the enhancement of performance and downsizing of electronic devices according to their applications.

In line with the ongoing evolution of the information society, we are continuing our efforts to realize smaller and more sophisticated semiconductor packages applying our cutting-edge packaging technologies with the need for semiconductor miniaturization technologies as a leading company in this field.

EMC Design Evaluation and Simulation Technologies to Support Noise-Tolerant Semiconductor Product Design

OKANO Motochika / IMAIZUMI Yusuke / TSUJIMURA Toshihiro

With the expanding use of in-vehicle electronics in recent years, malfunctions of electrical equipment caused by electromagnetic noise have become a safety issue in the automotive field. In particular, electromagnetic compatibility (EMC) tolerance is an important evaluation item for electronic control unit (ECU) manufacturers when selecting semiconductor devices, in addition to performance, compactness, and cost.

In order to provide customers with information on the EMC tolerance of its semiconductor products at any time, Toshiba has constructed test environments complying with the IEC (International Electrotechnical Commission) 61967 series standards for electromagnetic interference (EMI) and IEC 62132 series standards for electromagnetic susceptibility (EMS). We have also established EMC simulation technologies to determine whether an abnormality is caused by our product or the printed circuit board (PCB) when the test result is unsatisfactory. In the event that a problem is identified in our semiconductor product by such simulation, we can immediately feed back the necessary countermeasures to the design. If a problem is identified in the peripheral circuit, on the other hand, we can provide customers with a specific solution based on the evaluation result. Our EMC design evaluation and simulation technologies can therefore not only strengthen semiconductor product development capabilities, but also contribute to the development of ECUs with high EMC tolerance.

Toshiba's DFM-Based Approach to Printed Circuit Boards for Storage Products

ISHIZAKI Kiyokazu / ISHII Norihiro / KAJI Keiko

There is a need for high-density mounting technologies for printed circuit boards (PCBs) installed in storage products such as solid-state drives (SSDs), hard disk drives (HDDs), and solid-state hybrid drives (SSHDS), in line with the increasing data storage capacity of such products. In particular, it is important to optimize the design specifications of large-scale controller chips and printed wiring boards (PWBs), which are the main components affecting manufacturing quality and productivity in the event, in order to eliminate costly and time-consuming design change processes in the event of a failure.

Toshiba has applied an approach based on design for manufacturability (DFM) to PCBs for storage products at the initial stage of design, taking manufacturing quality, productivity, and production costs into consideration. By conducting a variety of simulation experiments using this approach, we have succeeded in assuring quality, reducing costs, and improving the productivity of PCB manufacturing.

Technology to Form EMI-Shielding Film on Semiconductor Packages Using Sputter Deposition Process

YAMAZAKI Takashi / TAKANO Yusuke / HONMA Soichi

In order to achieve greater compactness and higher performance of mobile information communication terminals, improvement of the electromagnetic interference (EMI) performance of each electronic device mounted on the high-density printed circuit boards (PCBs) of such terminals is now attracting the attention of electronics manufacturers. The need has therefore arisen for an EMI shield forming process for semiconductor products that realizes high performance including low noise radiation and high noise resistance at low cost.

Toshiba has developed a mass-production technology for semiconductor packages with an EMI-shielding film on the surface, referred to as EMI-shielded packages, using a sputter deposition process capable of forming a metal thin film more stably compared with the screen printing process using a metal paste. Newly developed special tools are incorporated into the sputtering equipment generally used for the pretreatment process, so as to prevent overflow of the shielding film to the back of the package without the need for costly protective tape and thereby reduce costs. Experiments on a prototype EMI-shielded package produced by this sputter deposition process have verified that it is effective in suppressing radiation noise.

World's First 16-Die Stacked NAND Flash Memory Package Fabricated Using TSV Technology

MATSUDERA Katsuki / KAWASAKI Kazushige

NAND flash memory is now widely used in mobile terminals including notebook PCs, smartphones, and tablets, as well as various applications such as solid-state drives (SSDs) for high-end servers and data centers. Demand has been growing for higher speed, lower power consumption, and higher density accompanying the broadening of its areas of application.

To fulfill these requirements, Toshiba has introduced a through-silicon via (TSV) technology into NAND flash memory as a packaging technology using vertical vias to interconnect multiple silicon dies in a single package. In August 2015, we announced the development of the world's first 16-die stacked NAND flash memory package, which achieves more than double the data transfer rate and reduces power consumption by about half compared with those fabricated using conventional wire-bonding technologies. We are planning to apply this new technology to the development of a 32-die stacked package and the BiCS FLASH three-dimensional flash memory package.

TB9150FNG Opto-Isolated IGBT Gate Pre-Driver IC for In-Vehicle Inverters Offering Greater Compactness and Higher Insulation Performance

KISHI Hiroaki / HORI Masahiko

Accompanying the expansion of the hybrid electric vehicle (HEV) and electric vehicle (EV) markets, the roles of inverter systems used to drive electric motors have become diversified. This has led to demand for the miniaturization and multifunctionality of such inverter systems incorporating power modules equipped with motor driving devices including insulated-gate bipolar transistor (IGBTs), insulated devices, and IGBT driver circuits.

In response to this situation, Toshiba began shipping samples of the TB9150FNG opto-isolated IGBT gate pre-driver integrated circuit (IC) for in-vehicle inverter systems in April 2016. The TB9150FNG integrates photocouplers as insulated devices, a pre-driver as a controller for the IGBT driver circuit, and other devices into one package, making it possible to downsize inverter systems.

Small and Lightweight Packaging Technology for Four-Channel Power Amplifier ICs Applied to Car Audio Systems

SEKI Yoshiyuki / HOSOKAWA Atsushi / KOTOKAWA Yoshikatsu

A car audio system typically has four speakers located at the front, back, left, and right of the car interior. These speakers are separately activated by individual amplifier circuits in the car audio set. As a result, four-channel power amplifier integrated circuits (ICs), in which four amplifiers are embedded in one package, are the mainstream products in this field. Toshiba has been expanding its lineup of four-channel power amplifier ICs incorporating its proprietary advanced core technologies, and leads the market with a high share. In recent years, demand has been increasing for smaller, thinner profile, and lighter weight car audio sets to secure a wide interior space and improve fuel consumption.

To fulfill these requirements, we have developed a small and lightweight four-channel power amplifier IC applying a shrink small outline package with heat sink (HSSOP) with an exposed pad (e-pad) structure for the first time in the industry.

Technologies to Reduce Manufacturing Cost of Super-Small Package for Semiconductor Devices

IWAGAMI Yasuyuki / IIDA Akio / TAKEUCHI Osamu

With the increase in the number of parts installed in tablets and wearable devices accompanying the progress of telecommunication technologies and expanding multifunctionality, demand has been growing in recent years for higher density packages to reduce the size and thickness of such products. Toshiba released the SC2 super-small package for semiconductor devices, with dimensions of 0.62 mm in width, 0.32 mm in length, and 0.3 mm in height, in 2004 to cater to this demand.

Going to a step further, we developed the SL2 package, a new low-cost super-small package with the same dimensions as the SC2, in September 2014. Through the application of a stamped lead frame to the SL2 based on our accumulated technologies in addition to newly developed technologies, the SL2 package realizes a 33% reduction in manufacturing cost compared with the SC2.

"Environment Sensing Logger" Equipped with ApP Lite Processor Providing IoT Solution

TAKAYAMA Kazuyuki / IMAMURA Naofumi

In the logistics business field, demand has recently been increasing for improvement of transportation quality through the monitoring of freight transportation conditions, as well as for enhancement of product quality through the elucidation of product storage environments.

In response to these diverse requirements, Toshiba developed an "environment sensing logger" for business-to-business (B2B) services in June 2015. This environment sensing logger incorporates the following features: (1) an all-in-one sensor capable of sensing of five types of environmental data (temperature, humidity, pressure, illuminance, and shock); (2) the ApP Lite TZ1001 processor, which provides an Internet of Things (IoT) solution and realizes a long battery life allowing continuous operation for about two months on a full charge; and (3) a waterproof and dustproof construction compliant with the IP67 ratings for dust and water ingress stipulated by Japanese Industrial Standard (JIS) C 0920 and the U.S. military standard drop tolerance requirements (MIL-STD-810). These features make it possible to apply the environment sensing logger to a broad range of applications.

Flowganizer™ Dataflow Management Technology to Maintain High Service Quality in Complicated Networked Systems

ITO Toshio / KANEKO Yu / MAEGAWA Tomonori

The movement toward the introduction of information and communication technology (ICT) into factories, plants, and the social infrastructure field has accelerated in recent years. Although the configuration of systems incorporating ICT tends to become complicated in order to handle a wide variety of data flowing between various devices, high service quality is also required.

Toshiba has been developing a dataflow management technology called Flowganizer™ to maintain high service quality even in complicated networked systems by focusing on the dataflow in such systems. Flowganizer™ makes it possible to precisely measure and control the quality of the dataflow even in cases where the data are handled across multiple devices. We have applied a prototype of Flowganizer™ to an actual clustered building energy management system (BEMS) and confirmed that it can determine whether or not there is an abnormality in the system as well as identify an abnormal device by analyzing the processing delay times of dataflows related to power consumption data from individual buildings of the clustered BEMS.

Wearable Support System to Assist in Maintenance Inspection Work

NAKASU Toshiaki / IKE Tsukasa / YAMAUCHI Yasunobu

In maintenance inspection work for social infrastructure products such as power control panels, a worker must carry out the necessary tasks by pressing buttons or switching control switches on the panel while referring to the operating procedures in the related manual. The process of referring to the operating procedures requires the worker to shift their line of sight from the panel to the manual and to turn the pages of the manual over by hand, interrupting the work and leading to decreased efficiency.

With the aim of supporting maintenance inspection work without the use of paper-based operating procedures, Toshiba has developed a wearable support system that allows workers to smoothly perform maintenance inspection work while referring to the corresponding page of operating procedures displayed on an eyeglasses type device by controlling the display using finger gestures such as tilting and tapping. To permit workers to easily operate and confirm operating procedures, we have developed a gesture control interface capable of suppressing malfunctions during operation as well as a gesture recognition technology using a finger-ring type accelerometer that enables workers to confirm and control a procedure manual through a series of finger gestures. We have confirmed through demonstration tests that this system can contribute to improved work efficiency by allowing workers to concentrate on tasks without the need to shift their line of sight.

SIC Power Module Achieving High-Speed Switching Operation through Significant Reduction of Parasitic Inductance

TAKAO Kazuto / KYOGOKU Shinya

Silicon carbide (SiC) power devices are a focus of high expectations as a next-generation power device providing lower loss and higher speed switching characteristics compared with conventional Si power devices. In order to improve the performance of power converter circuits by maximizing the features of high-speed SiC power devices, there is a need for further reduction of parasitic inductance in the circuits.

In response to this need, Toshiba has developed a technology for SiC power modules that significantly reduces parasitic inductance by means of a unique circuit structure. Experiments on a prototype SiC power module have verified that it achieves a reduction in parasitic inductance of approximately 85% and reduction in switching loss of approximately 47% compared with our conventional SiC power modules. Our newly developed ultralow-inductance SiC power module is expected to contribute to the realization of power converters with improved energy conservation, compact dimensions, and light weight.

Position-Sensorless Control Technology for PMSMs in Low-Speed Region Using PWM Waveforms Generated by Symmetrical Carriers

MAEKAWA Sani / SHIBANO Yusuke / HASEGAWA Yukihisa

In line with the widespread dissemination of permanent magnet synchronous motors (PMSMs) with higher efficiency compared with induction motors (IMs) in a variety of applications, demand has arisen for a position-sensorless control technology to drive PMSMs in the low-speed region while estimating the magnetic pole position without a rotor position sensor in order to achieve compactness and reduce costs. The indirect flux detection by online reactance measurement (INFORM) method, one of the position-sensorless control methods under consideration for this purpose, can estimate the magnetic pole position by detecting three-phase currents when applying a test voltage. However, the audible noise generated by the application of the test voltage is a serious issue.

To rectify this situation, Toshiba has developed a position-sensorless control technology for PMSMs in the low-speed region that eliminates the need to apply a test voltage. This technology makes it possible to estimate a magnetic pole position using novel pulse-width modulation (PWM) waveforms generated by symmetrical carriers. Experiments on this technology have confirmed that it achieves improved control performance in the low-speed region and a reduction of audible noise.

Component Manufacturing Technologies Enhanced by Supplier Control Taking QCDS into Consideration

KARASAWA Jun / NISHIKAWA Shoichi / OHMURA Mio

Toshiba has been actively promoting the sophistication of technologies and improvement of productivity for basic components of electronic devices and systems, including molded parts, sheet-metal stamped parts, and printed circuit boards (PCBs), applying technologies cultivated through its experience in product manufacturing. However, a strong need exists for the reduction of component costs through collaboration with overseas suppliers, particularly those in China and Southeast Asian countries. For the management of such suppliers, it is important to ensure appropriate quality, cost, delivery, and service (QCDS) so as to achieve a balance between the suppliers' technology levels and labor costs as well as fluctuations in exchange rates.

We have responded to this situation by making efforts to enhance in-house and overseas manufacturing technologies for components while keeping the Chinese market in mind, through efficient supplier sourcing based on the technical know-how that we have accumulated from past development results.

Development of Tools to Autonomously Improve Issues at Manufacturing Sites

NISHIMURA Keisuke

Attention has been increasingly focused on the introduction of new technology concepts, including the Internet of Things (IoT), into manufacturing sites. However, common issues exist in terms of the continuous accumulation of information on manufacturing progress and the visualization of production management.

To address these issues, Toshiba has developed a number of tools that are contributing to the advancement of improvement activities at its manufacturing sites. These tools include a time analysis tool to reduce the burden of time analysis investigations and a manufacturing information gathering tool, both of which are designed to facilitate the accumulation of information related to manufacturing, as well as a Makigami analysis support tool and a work process evaluation tool, which are designed to facilitate the analysis of work processes. These tools meet the various requirements of manufacturing sites, including low initial cost and standalone operation for stepwise introduction and trials. Through the extraction of issues at manufacturing sites by means of these tools, autonomous improvement of such issues can be expected.

Completion of Dredging and Reclamation Work for Jimah East Coal-Fired Power Plant, Malaysia

YOGO Yuji

Under an engineering, procurement, and construction (EPC) contract, Toshiba is engaged in not only the manufacturing of ultra-supercritical steam turbine generators, their auxiliary equipment, and power transformation systems but also marine civil engineering operations including dredging and reclamation work at the Jimah East Coal-Fired Power Plant (1,000 MW x 2 units) in Malaysia. This site is located near the sea and the plant is being constructed on a reclaimed area created using sea sand obtained by dredging of the offshore seabed. We performed the dredging and reclamation work using a trailing suction hopper dredger (TSHD) over a period of five months, as well as dewatering work by pumping up groundwater at the site during the same period.

After completion of the dredging and reclamation work in December 2015, the site was settled and consolidated for about three months to satisfy the required specifications. As a result, we were able to transfer the main plant area to Hyundai Engineering Co., Ltd. and Hyundai Engineering & Construction Co., Ltd., which are in charge of the onshore civil engineering work, in April 2016, two weeks ahead of schedule, thereby leaving time available in the construction schedule.

Power Supply and Demand Management System for Power Producers and Suppliers

OKAYAMA Hitoshi / TOYOSHIMA Ichiro / WADA Kosuke

The Japanese retail electricity market, including that for low-voltage consumers, was fully liberalized in April 2016. In addition to conventional power producers and suppliers (PPS) and general electricity utilities, various companies are entering the retail electricity market. There has been a growing need for systems for such PPS to support planned power balancing, as well as to perform demand forecasting for the increasing number of new low-voltage consumers.

With these market trends as a background, Toshiba has developed a power supply and demand management system for PPS after the full liberalization of electricity retailing based on its know-how cultivated through the development of electricity supply and demand control technologies. This system incorporates the following functions: a demand forecasting function for new low-voltage consumers, a photovoltaic (PV) power generation forecasting function, various planning and scheduling functions including a demand procurement schedule, and a balancing monitoring function. It also supports a demand response (DR) function as an advanced control measure for the suppression of electricity demand.

Integrated Letter Sorting System for PE Post of Serbia

SEKINE Hiroyoshi / IRIE Bunpei / KANAMORI Kazuya

Toshiba has developed a new integrated letter sorting system and delivered its constituent equipment to three mail sorting centers of the PE post of Serbia under a turnkey project. The system commenced operation in December 2015. This system incorporates four letter sorting machines (LSMs), a mixed mail sorter (MMS), a unified optical character recognition and video coding (OCRV) system for integrated management of optical character reader (OCR) and barcode reader (BCR) recognition processing and video coding systems (VCSs), information technology (IT) systems for operation planning and management, and revenue protection systems for verification of the validity of charges based on the measured number of mail items. Since this is the first deployment of such a letter sorting system in Serbia, we carefully prepared the operational plan and organizational framework at the conceptual design stage in cooperation with PE Post of Serbia. We have confirmed that, through the application of the latest OCR technology using deep learning, the system achieves an address recognition rate of more than 92% as stipulated in the target specifications. Centralized management of the equipment installed at the three mail sorting centers has also been realized using the unified OCRV system installed at one mail sorting center connected to the other centers via a wide area network (WAN).

TOSNIC™-S1400 Uninterruptible Power System Using SiC Power Devices

SUEYOSHI Akira / MATSUOKA Kazumasa

The stable operation of information and communication systems including network services and communication equipment has become essential in people's daily lives in recent years. The introduction of an uninterruptible power system (UPS) as key electrical equipment in such systems has therefore become increasingly important to prevent unforeseen situations, such as unexpected disruptions of operations, that could have a serious social impact. In addition to enhancing the reliability of the power supply, a UPS must have high efficiency and high maintainability to minimize its life-cycle cost and be compact and lightweight to achieve space saving.

To fulfill these market requirements, Toshiba has developed and released the TOSNIC™-S1400 UPS offering high-reliability power supply and high added value by applying silicon carbide (SiC) next-generation power devices to the converter and inverter.

Technology to Evaluate Ball Disappearance Phenomenon at Baseball Stadiums with LED Lighting

HIGASHI Hirokuni / SASAKI Jun / HATA Yuki

In the field of lighting fixtures at baseball stadiums, the replacement of conventional high-intensity discharge (HID) floodlights by light-emitting diode (LED) floodlights, which offer both high luminous efficiency and high light density, has been progressing in recent years. In stadiums with LED lighting, however, the phenomenon of ball disappearance sometimes occurs when a ball's trajectory overlaps with the light-emission zone of the LED floodlights.

To address the concerns of players and personnel over the possible occurrence of this phenomenon at stadiums with LED lighting, Toshiba Lighting & Technology Corporation has conducted studies to clarify the factors of lighting that cause ball disappearance through experiments including field tests at baseball stadiums and indoor tests under a controlled lighting environment, and developed a technology to evaluate this phenomenon. This technology is expected to contribute to lighting design to reduce the phenomenon of ball disappearance at baseball stadiums illuminated by LED lighting.