Research and Design on a Product Data Definition System of Semiconductor Packaging Industry

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Research and Design on a Product Data Definition System of Semiconductor Packaging Industry

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Abstract. This paper develops a product data definition (PDD) system for a semiconductor packaging and testing company with independent intellectual property rights. The new PDD system can solve the problems such as, the effective control of production plans, the timely feedback of production processes, and the efficient schedule of resources. Firstly, this paper introduces the general requirements of the PDD system and depicts the operation flow and the data flow of the PDD system. Secondly, the overall design scheme of the PDD system is put forward. After that, the physical data model is developed using the Power Designer15.0 tool, and the database system is built. Finally, the function realization and running effects of the PDD system are analysed. The successful operation of the PDD system can realize the information flow among various production departments of the enterprise to meet the standard of the enterprise manufacturing integration and improve the efficiency of production management.

1. Introduction

The production process is complex in a semiconductor packaging and testing company, because the order quantity is large and the order also depends on the individual demand of different customs. Customized packaging requirements in the production-manufacturing process need a flexible MES system. Consequently, it is necessary for the semiconductor industry to develop, design, and research the MES system. Nowadays, many scholars study the relevant technologies of MES in semiconductor industry. For example, Hwa Gyoo Park et al [1] put forward an object-oriented simulator for manufacturing execution systems in the perspective of architecture, H. Wada [2] and B. Li [3] applied an autonomous agent approach in the computer for manufacturing execution control systems in modeling and Paul Valckenaers et al [4] presented schedule execution in autonomic manufacturing execution systems to expand the function module realization of MES. The PDD system is an important component of the MES. In order to solve problems in semiconductor packaging and testing, the authors used information integration and fusion theory to research and design a PDD system. The system could improve the management level and enhance the ability to cope with the challenge of globalization.

2. Design of the PDD system

The core of the semiconductor packaging industry demand is the special customization. The key to the research and design of the PDD system of MES is the component system layer. The mapping mechanism is applied to the semiconductor packaging industry, including materials, equipment, personnel, product characteristics, production process data, WIP, and finished goods status.
Consequently, it achieves the integration and fusion of information and knowledge based on the function construction, encapsulation, interface, and management. After that, basic information is integrated by database access technologies. Finally, component modeling, enterprise modeling support, and workflow management are used on the craftwork of customized products and the requirements of potential customers. The evolution and appreciation of information are achieved by using data warehouse, on-line analytical processing, and data mining technology [5].

2.1. General requirements of the system
The PDD system is mainly about using massive collected information, i.e., materials, equipment, personnel, product characteristics. The PDD system provides instructions on the back-end process of production. Requirement analysis of the PDD system is actually about investigating, summarizing, and clarifying the requirements of customers. The entire requirements of the PDD system consist of two major parts. One is maintenance on the Product Internal Device (referred to as PID); the other is maintenance on the Main Bill of Material (referred to as MBOM). The requirement analysis of the PDD system is listed in Figure 1.

![Figure 1: The requirement analysis of the PDD system.](image)

The maintenance of PID includes PID information maintenance, seal information maintenance, wafer information maintenance, package information maintenance, packaging batch rules identification, net weight maintenance, special seal information maintenance, process query, and PID history query. The maintenance of the MBOM includes modules such as MBOM information maintenance, MBOM material selection, material type maintenance, SMT station query, and MBOM history query. Through the analysis of the requirements, the overall package operation flow and data flow of the system are summarized as Figures 2 and 3, respectively.

The operation flow of the system is as follows, a wafer from the front-end process is cut into smaller wafers (Die) by dicing process. The cut wafers is then glued to the island of the corresponding basal laminas (lead frame). After that, through the use of ultrafine metal (gold, tin, copper and aluminium) wire or conductive resin, the Bond Pad of the wafer is connected to the corresponding Lead of the basal lamina. The required circuit is also formed. In the next step, plastic housing is used for encapsulation and protection of individual wafers. After the completion of the package, a series of operations called finished product tests are performed, including incoming, testing, and packaging.
The data flow of the PDD system is to edit the data from the web collection platform, and the data are transferred to the production line system after identification. In the first step, the data flow from the web collection platform to the PDD system. During that step, staffs edit and filter data from the web collection platform. The second step identifies the edited data of the PDD system. This step transfers data from the PDD system to the production line system. So far, the entire data from the outside flow into the production line through the PDD system, and guide the production packaging line.

2.2. Overall structure of the system
Compared with the old framework, this system adopts the three-layer framework model of Client/Server, which is more flexible and hierarchically arranged. The working principle is to reduce the system operating burden by assigning tasks to the client and server [6]. The development of client and server programs is different. The user program is generally in the client-side, which is used for completing the specific operation of users. The server side is to manage the database, and share information with users. The three-layer framework divides the whole business applications into three parts: interface layer, business logic layer, and data access layer, as shown in Figure 4.

2.3. Database Design of the System
The PDD system is connected with many modules, and its internal structure is complex. Therefore, the workload of database design is heavy. The Power Designer 15.0 tool is adopted to model and design the database, which can regulate the design task and shorten the design cycle. It provides strategies for standard database design and operational analysis for software development management by integrating several standard data modelling techniques and main-stream developing platform. It also provides users with the tools of selected model examples, which can help users to create the conceptual and physical models of the database.
Generally, there are two methods to design the conceptual structure of the database system, which are the centralized model method and the view integration method [7]. The view integration method is used in this paper. Firstly, the system is designed from the local to the whole. The PDD system is complex and has many branches. The database system is divided into separate modules for design, and then sharing among these modules is achieved. Through the analysis of the requirements, the Power Design15.0 tool is used to model the database and establish the E-R data model diagram.

The logical structure of the database system is designed, after the conceptual structure is identified, which turns the entity relation data model (E-R model) into a logical model identifiable to the database. The logical model could be expressed in many ways. The most popular and practical one is the relational scheme model. The detailed steps are as follows [8].

1. The relational model is established through conversion and mapping of entity classes in the E-R model.
2. Each link in the E-R model is converted. If the relationship is more than one pair, it is necessary to add a set of additional relational patterns.
3. The attributes in the E-R diagram can also be converted to the attributes of the relationship.

The design of physical data model of PDD system is to do SQL execution of the conceptual data model by the Power Designer. Then, the physical data model of the relation based list data structure is established in the Oracle database [9]. The physical data model that is designed for the relational database management system is abstract to users. There are two main goals of design: improving the performance of the database system and enhancing the database system storage space efficiency. After the internal characteristics of the backstage Oracle 11g database are fully understood, the physical design of the database system considers the following four aspects: anti-normalization processing, data storage structure design, data storage path, and storage location design. System configuration is optimized taking into account of time efficiency, space efficiency, and maintenance cost of the PDD system database [10]. The anti-normalization process is to return a number of tables that have been normalized to the last specification level to improve the efficiency of the PDD system. Three factors are taken into consideration while designing the data storage structure. They are access time, storage space utilization, and maintenance costs. There are inner restricted relationships among the three [10]. Data storage location design is to storing data files of system tables and user tables in different space on the disks drive in order to divide the storage of data and index. The data storage path usually creates an index to improve the searching speed for tables and aggregate data. As for system configuration optimization, the Oracle11g database allocates parameters for storage provided by the user which gives the reasonable default values. However, sometimes, certain parameters should be set according to the actual needs of the system and the specific environment.

3. Implementation of the PDD system

3.1. Implementation of functions of the system

The function of the PDD system is the same as its roles, which is to serve MES. The PDD system is designed for improving the adaptability and timelines of the production plan and increasing the information flow about the bottom control activities. It is also designed for filling the gaps between management plan and production control. The PDD system is designed based on the development of the MES system.

The function interface is about settings for PID maintenance. It sets the marking, packing, special note, and curing profile through PID. The interface can be divided into two parts. One is used as the browser of property of PID itself. The other is used for tabbing. Ways of paging include four parts: departs, marking, packing, special note and curing profile. Each page is set with the Edit button in the browse block respectively. Then the data is maintained by the pop-up editing interface. Among them, the state of PID could be “UnApproved”, “Active”, or “Frozen”. These states are specified manually in the PID
editing interface. When the state of the PID is designated as “Frozen”, information like marking, packing, special note, curing profile information cannot be edited. Meanwhile, when a PID is selected, related information or data will show up. Every time new PID information is queried, the data will be cleared first. Then corresponding results will show up according to the query. In addition, the states of PID are marked with different colors in the query results, such as “Frozen” (red), “Active” (green), “UnApproved” (yellow).

The function interface is mainly used to maintain BOM and sub BOMs. It also completes the job of adding, modifying, deleting, or querying BOM. BOMs have three kinds of state. After creation, with the default version of V1, the state is “Created”. Then you can modify and maintain BOM information. When released, the state is changed into “Active”. At this moment, all the BOM information is not allowed to modify. In addition, when released, among all versions of BOM, only one could be “Active”. That is, during the release, the current version turns into “Active” and the rest versions become “Frozen”.

3.2. Running effects of the system

The PDD system designed and developed in this paper has been already in stable operation in an enterprise. It not only improves the information level of the production department, but also greatly improves the work efficiency. The system can reduce the manual records and cut down errors in operation. In previous manual operation, disoperation often occurred after shifting, because the latter one has no idea whether the previous one has done certain operation or not. With this system, however, employees can query all the previous operations and then operate accordingly. The disoperation rate is reduced by more than 25%. Moreover, the utilization rate of the automation equipment of the enterprise is improved significantly. Employees can find unoccupied machines to realize reasonable allocation. The work efficiency is thus increased by 20% approximately.

4. Conclusion

The system orients to semiconductor packaging integration information of MES. With the development of computer technology and network communication technology in China, it uses advanced production management concept, especially the design of PDD system of MES. In this way, it realizes the integration, sharing, application, evolution and appreciation, of the information on management level and lower levels for producing. It also results in unifying of logistics, capital flow, and information flow. The practical application shows that the system contributes much to the integration, interaction, and sharing of information among different departments of the semiconductor packaging enterprises.

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