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A Computer-aided Mold Design for Transfer Molding Process in Semiconductor Packaging Industry

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Abstract

This article presents a novel method for the development of a computer-aided mold design for transfer molding process in semiconductor packaging industry. The method developed will standardize mold design process and reduce lead time and costs significantly. In this method, highly robust 3D parametric templates for mold shot for different types of packages are created and stored to constitute a library for computer-aided mold design process. Mold design terms and all related design rules are standardized and streamlined for each mold shot. The mold shot is used to cut out mold parts during the next design stage. Leadframe configurations, customer input as well as technical specifications and design inputs are standardized to create the robust mold shot. Some critical features of mold parts like clamping area, location, and gate dimensions are calculated on mold shot. The mold shot is used as a positive cut-out for the top and bottom cavities as well as cull and sleeve strips. After completion of the cut-out process based on mold shot, air venting for packages and runners, clamping areas, shutoff areas, side-rail areas, relief areas, locating pins holes and their relief, misalignment pins holes and their relief are created by the rules and thumbs and mathematical formulae incorporated into the program. Finally ejection pins, support plugs, springs and other parts are created using parametric parts library and database. A prototype system "PMOLD" is developed based on is new method. This research would make a significant contribution in transfer molding and semiconductor packaging industries.

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Keywords: CAD, Transfer molding, Semiconductor packaging mold, Mold shot

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1.0 Introduction

In today's global economy and changing manufacturing environment the ability to introduce quality products in the shortest possible time is a decisive factor to capture market share [1]. The increasing competitiveness, innovation speed and faster time to market demand in the manufacturing sector has led to the development of different computer-aided design and manufacturing systems and automation of various planning functions [2]. The mold design process is a critical step for the development of a new product. Conventionally, mold design has always been a much 'mystified' art; requiring years of experience before one can be relatively proficient on it [3, 4]. Due to the initial difficulty in learning this art, fewer people are benefiting from experience and knowledge of the experts in this field. To change current situation, one way is to use computer-aided mold design. However, currently most CAD systems provide only the geometric modeling functions that facilitate the drafting operations of mold design, and do not provide mold designers with the necessary knowledge (design rules) to design the molds.

2.0 State of the Art - Mold Design and Basic Component

In semiconductor packaging, transfer molding is used to encapsulate package to protect fragile IC assemblies with their fine interconnection wires and to maintain high electrical insulation between conductor, interconnections, components and other electrical parts. Due to the high accuracy of transfer molding tooling and low cycle time of the process, transfer molding is used in semiconductor package encapsulation [5]. Transfer molding is a process where thermosetting plastic is placed in a heated chamber. After material reaches the proper temperature, it is injected into closed molds [6]. Mold is placed in the mold housing of the transfer molding machine. The molding material in the form of pellet is preheated and loaded into a chamber using loading mechanism. A plunger is then used to force the material from the chamber through channels known as a sleeve, cull, runner and gate system into the mold cavities. The mold remains closed as the molding material is transferred to cavities and molding is taken place and is opened to release the part from the cull and runner after molding is completed. The mold material is heated to a temperature above the melting point and this allows a faster transfer of material through the cavities. A typical transfer molding process used in industries is illustrated in Fig 1. Like plastic injection mold, packaging mold consists of cavities, different plates, standard components, different types of pins, springs etc. The mold is divided into two parts: the top mold chase and the bottom mold chase. Fig. 2 shows the layout of the bottom mold chase of a typical transfer mold used in industries. The main components are cavity strips, cull strip, sleeve strip, unit block, end bar, ejector plate, mount plate, ejector holder and a large number of pins, support plugs and springs. The cavities are created in cavity strips. There are usually two cavity strips for a mold, one for top mold chase and the other for bottom mold chase. However, some packages do not need bottom cavity strip. Culls are created in cull strip (i.e. several culls are designed in one cull strip) which belongs to the top mold. Holes are created in sleeve strip and holes in sleeve strip and culls are axially aligned.

The mold is preheated and its temperature is controlled to achieve better result. Clamping force is required to be calculated in an appropriate way. The control of preheat, mold temperature, clamp force and packing pressure are done by the molding machine. However, appropriate calculations must be done before setting these parameters. Thermal factors (i.e. preheat temperature, molding temperature), mechanical factors (i.e. clamping force, packing pressure), time factors (i.e. transfer time, preheat time, curing time) and velocity factor (transfer speed) need to be considered properly for better results.

Epoxy resin is commonly used in transfer molding process. Hardener (i.e. phenol novolak), catalyst (phosphorous type or amine type), filler (silicon di-oxide), demolding agent (fatty acid), reforming agent (silicon flexiblizer) and flame retardant are usually used with epoxy resin to create epoxy molding compound (EMC). EMC shows small shrinkage (less than 4 percent) compared to other resins and reduces tendency to crack and allows small dimensional tolerance. It has excellent adhesive property, good resistance to extreme environment, excellent insulating properties and curing reaction is not inhibited by metal, air etc. and can be accomplished at room temperature.

Semiconductor packaging mold design involves extensive heuristic knowledge about the structure and functions of the components of the mold. Generally, thermal expansion and shrinkage need to be considered in order to ensure