Sophisticated 3D systems realized by the combination of 3D-MID (3D Molded Interconnect Devices) and PCB (Printed Circuit Boards)

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1 Introduction

The continuous technological progress leads to an increase of electronic systems in almost all industries including medical technology in diagnostics for mobile monitoring or endoscopic surgery as well as automotive industry for driver assistance systems or electrical drive mobility. The necessary miniaturization and functionality to open up new and decentralized installation spaces requires innovative solutions. Conventional printed circuit boards (PCB) and flexible printed circuit boards (FPC) are the focus to meet the development of system integration on substrate and component level. But in addition to the high integration density of electronic functions, the direct imaging of mechanical, fluidic, thermal and even optical features is also required. In this context, conventional electronic systems are limited and the use of spatial mechatronic systems is necessary. In particular, 3D molded interconnect devices (3D-MID) enable multifunctional 3D packages. Two innovative solutions are presented in this paper: a lighting module for a sensor-based security system and a sensor carrier for a large-format camera. [1]

2 Specific advantages of 3D-MID and PCB

MID components are injection molded thermoplastic parts with an integrated conductive pattern structure. One of the strengths of a 3D-MID is the high design flexibility, achievable miniaturization and the associated weight reduction. Furthermore, various functions such as 3D circuit structures, antennas, switches, connectors or sensors can be integrated. By eliminating mechanical parts the amount of system components and electrical interfaces is reduced which results in a simplified assembly, shorter process chain, higher reliability and lower system cost. [2]

There are several ways to manufacture 3D-MID components. The most important manufacturing processes are laser direct structuring (LDS) and two-component injection molding (Fig. 1). Today more than 90 % of all MID applications are done in LDS. Laser direct structuring is based on thermoplastics that contain a specific organometallic additive as active component. The laser beam vaporizes the upper

layer of the polymer and activates the underlying metallization nuclei of the active component. This is followed by a chemical metallization of the activated surface. Two-component injection molding is a process by which assemblies are molded with two different plastic types. One of them can be metallized and forms the conductor lines. The other one serves as isolator. For both technologies, the assembly of electronic components is the final step.

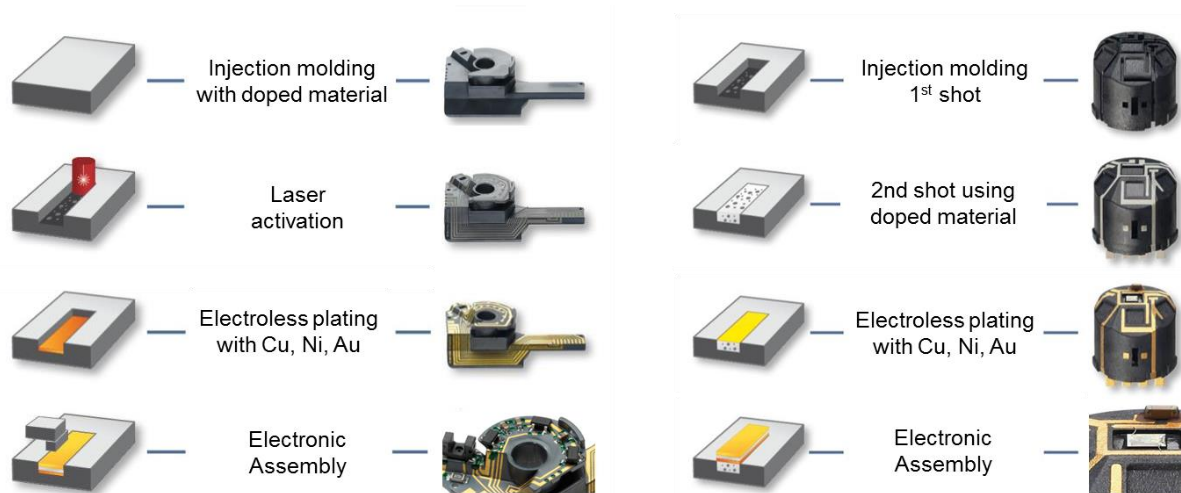

Fig. 1: Process chain laser direct structuring (left side) and process chain two-component injection molding (right side)

The advantages of PCB or FPC are mainly in the production due to efficient assembly machines for processing planar substrates. On the other side multilayer and fine-pitch applications are possible. Accordingly, PCB or FPC enable streamlined production and products compared to MID for smallest SMD components and higher integration if non-spatial solutions are required.

Both technologies offer specific advantages to fit needs by either the product or the manufacturing process. The combination of 3D-MID and PCB leads to highly integrated 3D packages. However combining two technologies means managing interface techniques between sub-assemblies.

3 Interconnection of 3D-MID and PCB

Interfaces for data and energy transmission are an important factor in the use of 3D-MID technology. With only a few exceptions (RFID being one), information is transferred by an electrical connection and concepts for the connection to the peripherals (PCB, FPC, connectors, cables etc.) are necessary.

3D-MID can be assembled similar to SMD components on the PCB with processes like soldering or conductive adhesive bonding. On the other hand, a PCB can also be integrated in a 3D-MID package. Fig. 2 shows two examples of mass production applications with 3D-MID and PCB, a lighting module for a sensor-based security system and a sensor carrier for a large-format camera.

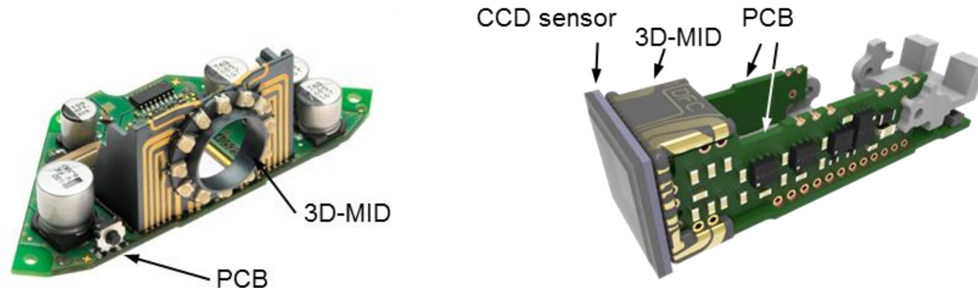

Fig. 2: Lighting module for a sensor-based security system (left side) and sensor carrier for a large-format camera (right side)

3.1 Sensor-based lighting module for security system

Sensor-based security systems (Fig. 2, left side; Fig. 3) are used to monitor automatically defined areas such as engagement openings on machines. For visual monitoring non-visible light is emitted by LEDs. This is reflected by a reflector tape into the monitoring field of the camera. In this way, the detection of interference is possible. Application areas for the camera system are in the electronics industry, robotics, packaging and pharmaceutical industry.

The 3D-MID aligns exactly the individual LEDs to ensure a complete illumination of the critical area. The mechanical and electrical interconnection to the PCB is already integrated in the MID solution and thus the assembly costs are reduced dramatically – compared to a conventional solution with just PCB or FPC.

Fig. 3: 3D-MID lighting module (left side) and integrated in the camera system (right side)

The structuring of the injection molded component (Vectra E 840i LDS) is done by LDS technology. The electroless plating consists of Cu, Ni, and Au, which is a typical plating system for MID. For the laser process and the assembly of electrical components an expansion of plant technology was required: four sides of the MID are laser-structured, the assembly of the LEDs is carried out in many different angles.

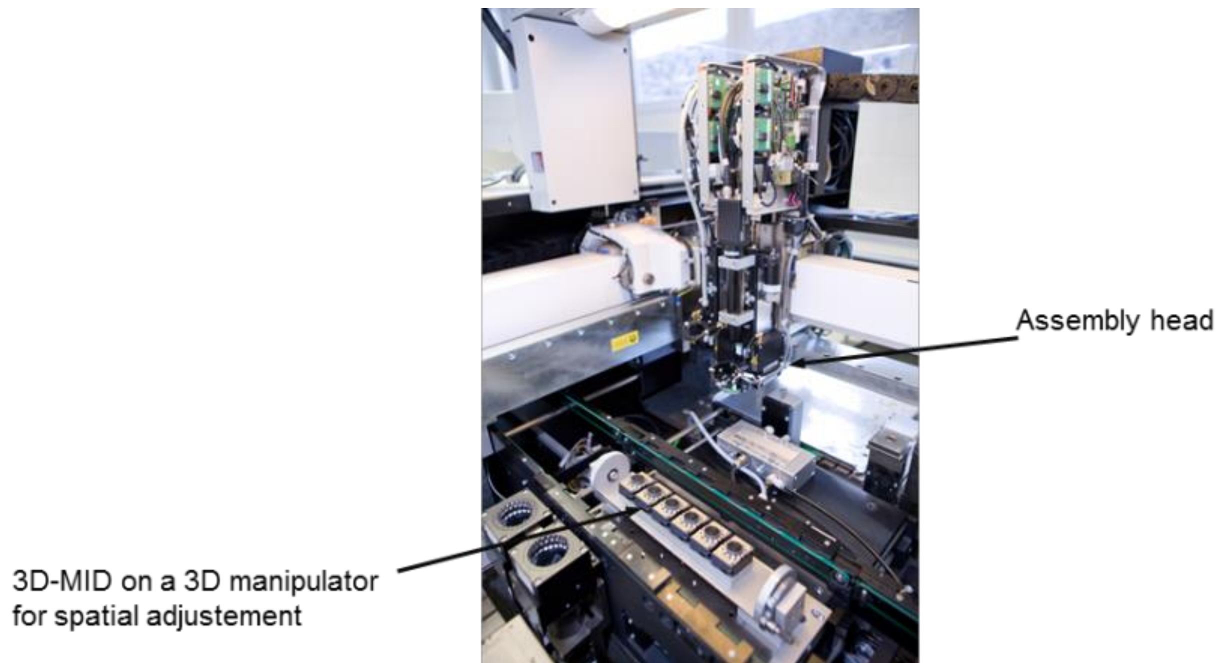

Fig. 4: Adapted assembly machine for the spatial placement and exact orientation of the LEDs

3.2 Sensor carrier for a multi-giga-pixel camera system

The composition of multiple CCD sensors the large-format camera (Fig. 2, right side, Fig. 5) creates high-resolution images in the gigapixel range. Fields of application are for example traffic control or bird counting. Besides high-resolution images the novel camera system allows an extended field of view, higher distance visibility, and multiband-imaging capability.

The moving of an optical lense for focus instead of the sensor allows using a smaller motor. Thus it is possible to miniaturize the whole system (which means more pixels made possible in less space) with a reduced unit weight (from 42 g to 8 g). Besides, the assembly is simplified and an expensive and bulky FPC could be replaced. The new ultra-narrow sensor module design will be compatible with a wide range of future camera systems.

The 3D-MID functions as a carrier of the CCD image sensor and integrates the electrical connections to the module board (PCB). Furthermore, the 3D-MID enables

an interface to a heat sink with directly fixing aluminum pieces to the CCD sensor for heat dissipation. [3]

The manufacturing of the substrate follows the process described for the 3D-MID lighting module: Structuring of the MID substrate (material LCP; Vectra E 840i LDS) by LDS technology and electroless plating with Cu, Ni, and Au. The laser direct structuring requires a fixture that is capable of turning the parts in process, because six sides are structured and a high precision positioning of tracks is necessary to fulfill sensor accuracy requirements.

Fig. 5: 3D-MID sensor carrier

The CCD sensor is attached on the 3D-MID by lead-free soldering without solder mask. Just on single solder cycle for the assembly of the CCD-sensor, the 3D-MID and the PCB is installed. The packaging of the 3D-MID is similar to SMD components using ESD trays. The assembly is done with an automated pick & place machine.

4 Conclusion

3D-MID technology is the bridge between available micro-technologies and various applications in automotive, medical technology as well as sensor packaging and sensor modules. 3D-MID technology allows the combination of mechanical, electrical optical and fluidic functions in one component.

The combination of 3D-MID and PCB leads to highly integrated 3D packages. Both technologies offer specific advantages to optimize either the product or the manufacturing process and consequently, for the development of a technologically and economically optimized mechatronic 3D system. The presented lighting module for a sensor-based security system and the sensor carrier for a large-format camera demonstrate this impressively.

5 References

[1] Goth, C.: Analyse und Optimierung der Entwicklung und Zuverlässigkeit räumlicher Schaltungsträger (3D-MID). Bamberg: Meisenbach Verlag, 2013.

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[3] Wittwer, F.; Goth, C.: Sensor Carrier for a Multi-Giga-Pixel Camera System in 3D-MID Technology. Innovative Anwendungen der MID-Technik, Hahn-Schickard-Gesellschaft Institut für Mikroaufbautechnik (HSG-IMAT), Stuttgart, 9. Oktober 2013.