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FREEDOM OF MICRO MANUFACTURING TOOL-FREE SERIES PRODUCTION IN INDUSTRIAL APPLICATIONS OF MICRO- AND NANOTECHNOLOGY

Dipl.-Ing. Reiner Götzen, microTEC Gesellschaft für Mikrotechnologie mbH
goetzen@microTEC-D.com

1. INTRODUCTION

RMPD®, which stands for Rapid Micro Product Development, is a family of technologies designed to generate with a parallel batch process, microstructures, microsystems and/or MEMS or MOEMS in a parallel batch process. Photo polymerized monomer, oligomere and hybrismaterial (sol-gel) polymerized with uv-light and generate the system. The technology's 3D-CSP (tree dimensional chip sice packaging), RMPD®-multimat (volume specific material propertys), RMPD®-stick2 (mechanical parts directly to a foil, wafer and so on) and RMPD®-nanoface (surface roughness in sub-nm range) have since 1996 been key elements in this worldwide-patented family of technologies, which has allowed System in Packing SiP to develop into a virtually tool-free production process. Additive and parallel processes give these technologies a cost-efficient and customer oriented strategic direction.

2. MICROFLUIDICS

Microfluidic structures are applied to anything from high-performance lab-on-a-chip systems to simple ink rollers. The tool-free, RMPD®-mask process offers fast production of ready-to-run prototypes and direct transition to series-production with the same processes and materials. The system can quickly generate an extremely wide range of designs for filter structures used in the creation of laminar flows in large tubes, cost-efficient dispenser nozzles and simple fluidic stop filters for the ventilation of ampoules. Three-dimensional microfluidics work totally without pumps, using only the force of capillary action in an exchange cycle with hydrophilic and hydrophobic materials (RMPD® -multimat) to move liquids and fill cavities with the analyte. This process takes advantage of intrinsically hydrophilic materials and very sharp edges. The example shows a microfluidic structure which has already demonstrated its function during the weightlessness provided by a parabolic flight, making it suitable for use in space.

Other designs make use of rotary forces to carry out complex chemical and biological functions without any drop in conduit pressure. Customers, who range from large industrial concerns to small research institutes, use the advantages of fast production to manufacture products for which surface finishes are less likely to be worn down by various machining processes, as there are no awkward angles and milling radiuses can be kept to a minimum.

FIG. 1: CAPILLARY-ACTION MICROFLUIDICS 20X37 MM USED IN OPTICAL ANALYSIS AS A LAB-ON-A-CHIP SYSTEM

Microfluidic chips are not just read optically, with RMPD®-nanoface with surface qualities in the sub-nanometre range performing their role; a further analytical method is provided by electrodes that make use of impedance measurements within liquids in order to determine parameters. RMPD® structures can be vapour-deposited with various metals, such as Au, Ag, Pt, Cu, Al, NiCr, Sn, etc. The electrically or thermally conductive functions thus made available are integrated into the system. One example is provided by a microfluidic structure in which – in addition to two microfluidic levels and two levels with electrodes

consisting of silver and conductors – even a plug interface has been created.

FIG. 2: MICROFLUIDICS WITH TWO FLUIDIC AND CONDUCTOR LEVELS EACH

Microfluidic structures are partly of large dimensions, and since – as in microelectronics – the RMPD®-mask process uses the simultaneously-illuminated surface to determine the number of components to be generated, the permanent expansion of the size of the mask is a decisive priority. Starting with a five-inch mask, the surface was increased to nine and then fourteen inches. microTEC can thus offer its customers, depending on the size and quantity of the items concerned, cost-efficient production of their components. In the case of a 1x1x1mm component, for example, cycle times of 1µ second can be achieved. In other words, one component leaves the production line every microsecond.

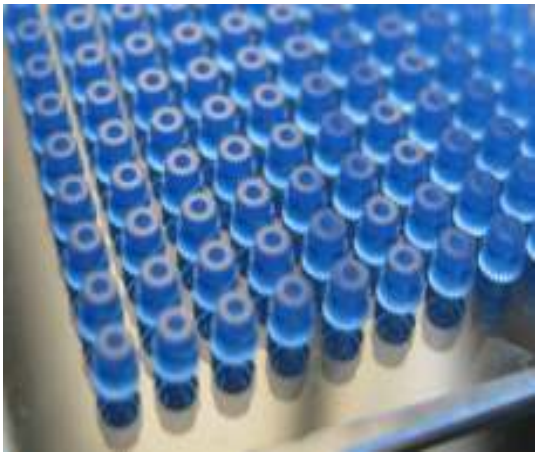

FIG. 3: BATCH WITH RMPD® GEARS, MODULE 0,06; DIAMETER 1,2MM AND 0,86MM

Other components are integrated by using the RMPD®-mask process to produce cavities into which the components are automatically inserted.

FIG. 4: RMPD® - BATCH WITH INTEGRATED DIE

3. 3D-CSP

One important component in the microsystem is microelectronics. microTEC can integrate microelectronic dies, pure silicon with its electrical function and pads as an electrical interface to create electrical contacts.

With a high degree of parallelism, completely independent of the number of electrical contacts, these can be connected to each other electrically while the housing is generated with RMPD®. 3D-CSP is used to produce three-dimensionally stacked systems and also ones with vertically-aligned dies for sensor purpose. Four steps are involved in the integration of microelectronic components into MEMS: RMPD®-mask, pick-and-place, PVD vapour deposition and the structuring of conductor levels. This all takes place in a parallel batch process, with only the pick-and-place procedure carried out separately.

One very good example is the microSD card, the dimensions of which make it ideal for 3D-CSP. In the example shown, there are also two stacked dies apart from the controller. Thanks to care in the processing of dies and the absence of bonding wire, it is possible to achieve very high stacking densities. Die thickness of 30µm have already been involved.

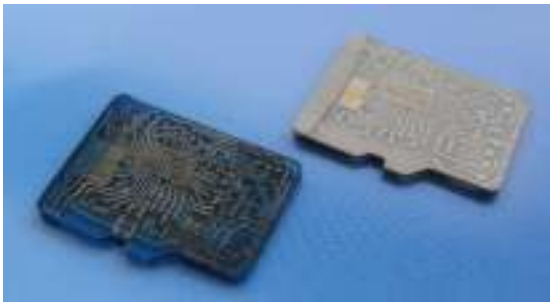

FIG. 5: MICROSD CARD WITH DIE STACKING

4. SYSTEMS

Microsystems, MEMS and MOEMS incorporate several of the technologies discussed above. The RMPD® family permits the creation of systems that require all or one of the above-mentioned technologies as part of a parallel batch process. The plug-in contacts on a microSD card are thus configured in parallel in the same way as the contacts inside the structure. Conductors are configured as conduits that can also be used to carry liquids.

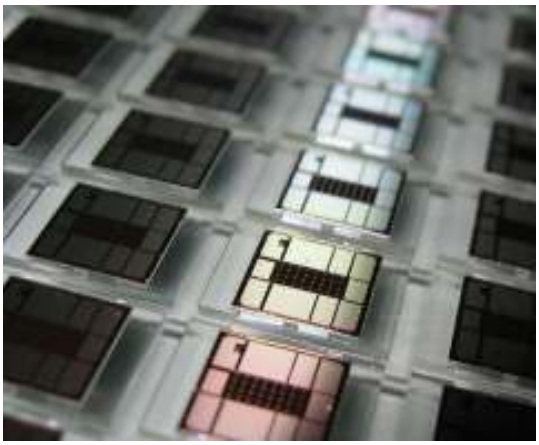

FIG. 6: 3D-CSP BATCH AFTER THE PICK-AND PLACE PROCESS

This family of technologies offers microfluidics for cooling, without the use of additional energy. Microfluidic conduits carry the condensate from the condenser surface back for evaporation, with the fluid ensuring that the required evaporation energy cools the electronic components and that the condensate is evaporated once more, while the heat is transported at a thousand times the speed of a copper conductor. Passive heat-transfer, using capillary action, could be used to cool such items as LED components, or for dissipating the heat from solar cells on days with strong sunlight, thus increasing their effectiveness in the long term. An example of a design is illustrated below.

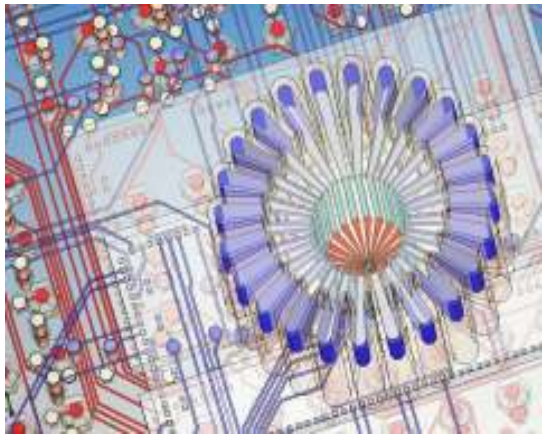

FIG. 7: HEAT PIPE WITH 3D-CSP DESIGN

This example also shows the link between the virtual and the real, with everything defined here as it actually occurs. All models are set up in three dimensions to allow them to be used in simulations at any time. Active systems are incorporated, and liquids are moved, mixed and also separated using electrical fields. The EHD pump makes it possible to transport liquids without the use of moving mechanical components, once again using microfluidics to perform these functions.

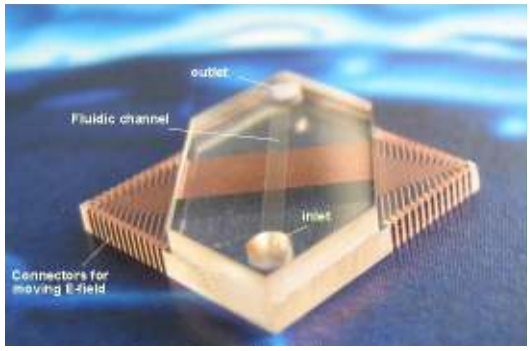

FIG. 8: EHD PUMP, 15X15 MM

All the elements concerned can be combined to create a system that amounts directly to a disposable item, likewise making the microsystem suitable for use in the health care sector. This is used for diagnosis of the stomach and intestines. Systems of this type are gaining worldwide market share at the expense of conventional – and painful – invasive procedures. Three-way acceleration sensors with a drag-type wiring loom are a thing of the past; today's systems require wireless communications and energy transfer. microTEC is in a position to develop design rules for antennas, with baluns based on HF technology to permit cost-efficient batch production, without the need to use costly silicon, assembly processes and toolmaking.