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3-D Microsystem Packaging for Interconnecting Electrical, Optical and Mechanical Microdevices to The Eexternal World.

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I. INTRODUCTION

It is always a problem to interconnect MEMS/MOEMS to the external world. Solutions for interconnections have been proposed: the planar ligthwave circuit platform [1] for only optical connections and microelectrical connectors[2]for only electrical connections. This paper reports a 3 Dimensional Microsystem (3DM), as a new packaging with both optical and electrical interconnections. We have extended silicon micromachining technology to solve the electrical and optical packaging issue with subsequent mechanical assembly in the module level, which allows for each submodule the use of different technological process, which may not be compatible together. To demonstrate the ability of this packaging, a first realization using only silicon micromachinning is reported: a WDM filters based on Fabry Perot cavity with a moveable silicon mirror.

II. CONCEPT

The 3DM integrates:

– Electrical connection to be able to actuate the mirror from outside;

– The alignment between the filters and the optical fibers.

That is the reasons why the following key technologies are essential bases for the 3DM:

– V-grooves, well known to permit an easy and precise alignment of optical fibers.

– Microconnectors, previously developed in our laboratory [2] to perform electrical connections of multichip microsystems.

– Delay Masking Process [3, 5] for multiple height structures using Deep RIE, which can be also used as a very accurate dicing tool.

To guarantee a very precise assembly, the 3DM is composed of three silicon boards, precisely cut and inserted in on another:

– An optical filter board which contains the optical devices (series of eight filters) and one edge patterned in pin shape, which constitutes the microconnectors.

– A V-groove board with a well defined chip size, which allows the alignment of the optical fibers from both side of the filter board.

– A mother board which has a recess and receptacle holes to accommodate the two precedent boards. Its role is in two folds: to establish the alignment between the V-groove board and the filter board; to allow the electrical connection between the external world and the microconnectors. Therefore the accuracy of the optical alignment and the electrical connections are insured.

The assembly of these pieces is represented on Figure I, as well as close views of the different parts of the 3DM: a filter, a microconnector with a filter, the frontside and the backside of a filter with the aligned V-groove.

The 3 silicon boards are mechanically assembled using tweezers. At first, the V-groove board is inserted in the motherboard, and then, through a large hole designed in the V-groove board, the filter-board is vertically assembled to the motherboard. It can be noticed that the mechanical loads between the filter and the motherboards are supported by larger microconnectors, which also guide the filter-board during its insertion and permit to remove and insert it again easily.

From the technological point of view Deep-RIE is a common technological step for all the 3 silicon boards, to achieve very well defined assembling structures and to realize the dicing operation.

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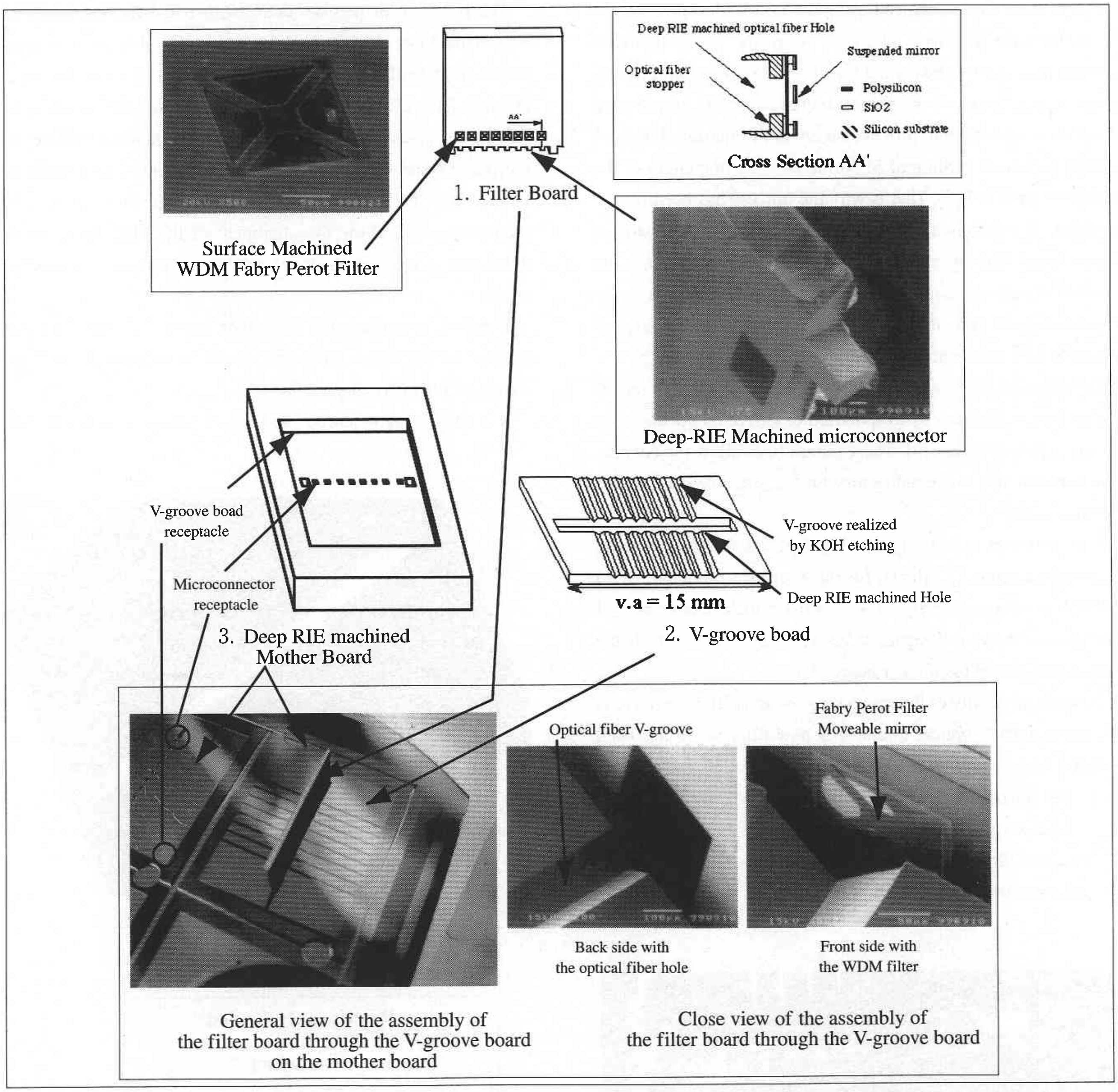

Fig. I Design and assembly of the 3 Dimensional Microsystem. : Using tweezers, the 3 silicon submodules are assembled. The V-groove board (2) is inserted in the receptacle of the motherboard (3), and then, through the large hole in the V-groove board, the filter-board (1) is vertically assembled to the motherboard, with electrical contacts realized with the micrommectors.

However the interest and the advantage of this packaging platform is to allow, for each submodule, the use of different technological process which may be not compatible together, such as CMOS process, III-V devices...

III. TECHNOLOGICAL POINT OF VIEW

To achieve very well defined assembling structures the final step of all the technological processes is an operation of dicing by ICP-RIE. The machine used is a Plasma Term one, using the BOSCH Process optimized in Japan. Each board is realized independently from each other.

The motherboard is realized using the Delay Masking Process [3, 5]. Because its role is partly to insure the good alignment between the V-groove board and the filter board, its receptacle has to be very flat. In other words, it is essential to prevent the presence of particles, which could provoke an effect of micromasking and prevent a uniform etching of Si during the step of etching of the receptacle by ICP-RIE. That is why the process has been lightly modified, in confrontation to the one for the mother board of Figure I, and it has been realized a three level mother board: the presence of pads in the receptacle area and of the loop-holes on the edges reduce the risk of having to many particle and not enough flat areas This new board is shown figure II.

The fabrication of the motherboard is followed by the realization of the circuit lines, by evaporation of Cr/Au on the backside through a shadow mask [6]. These circuit lines allow the connection between the microconnectors of the filter board and the external world.

The V-groove board (figure III) is realized by combining anisotropic etching of Silicon, for the V-groove fabrication, and ICP-RIE to define precisely the size of the chip. The large hole of the V-groove board is designed to insert the filter board inside the receptacle holes of the mother board.

To study the ability of this packaging to insert III-V devices, as InP based tunable optical filters[4], a new filter board has been designed and realized in two pieces (figure IV):

- The filters bar, with a well defined chip size and the 8 filters.
- The receptacle board in which the filters bar is inserted. It has one edge patterned in pin shape, which constitutes the microconnectors.

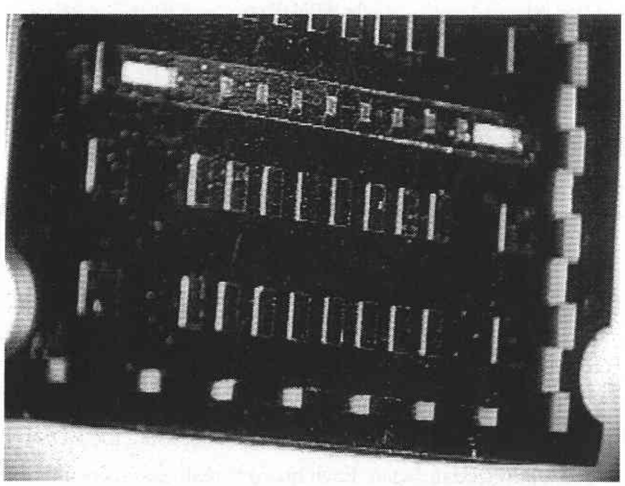

Fig. II Photography of the mother board.

The principle of precise dicing with ICP-RIE permitting the alignment of one piece to the other is maintained. It can be noticed that the rectangular shape of the filters bar should allow the use of classical III-V dicing tools. The connection between the filters bar and the receptacle board is insured by wire bonding. As before, the receptacle board with the inserted filters bar is inserted through the large hole of the V-groove board in the motherboard. As well, the microconnectors allow the alignment of the filter board to the motherboard and the electrical connection towards the external world.

Figure V represents the new filter board with the filters bar inserted in the receptacle board. It can be noticed the different shapes of the microconnectors:

- The V shape allows the lateral alignment in the mother-

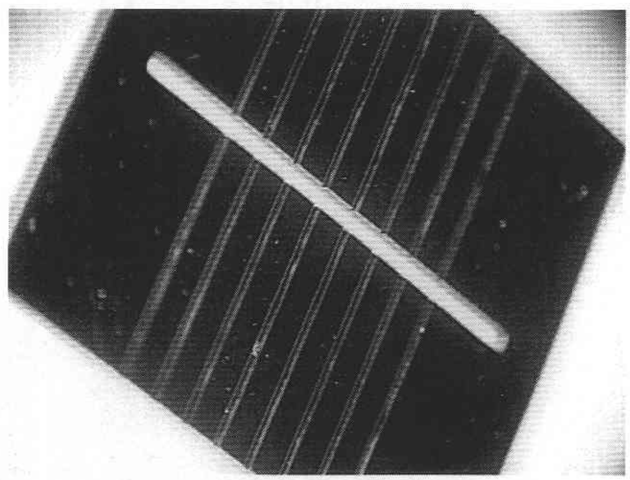

Fig. III Photography of the V-groove board.

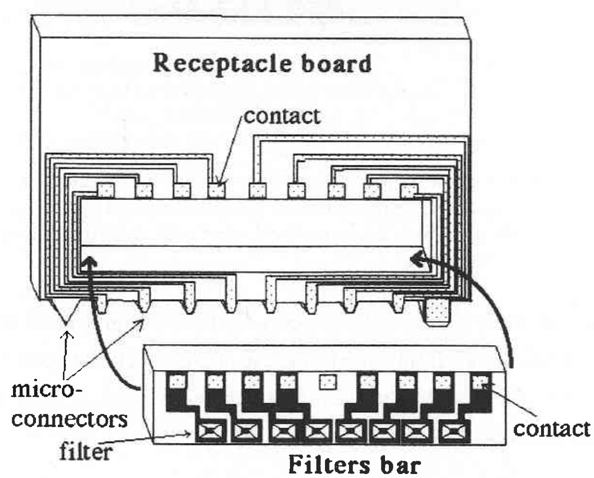

Fig. IV The new filter board scheme.

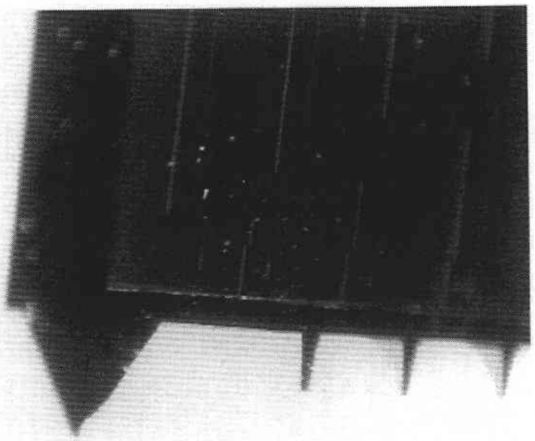

Fig. V The new filter board.

board, as its dimension at the top is the same as its corresponding hole in the motherboard.

– The U shapes are microconnectors to which are connected the movable mirror of the filters.

– The |_| shape is the large microconnector permitting to guide the filter board during its insertion. It also plays the role of ground.

VI. CONCLUSION

A 3 Dimensional Microsystem has been realized combining optical alignment and electrical actuation of 8 WDM filters. For the application presented in this paper, the microsystem has been realized fully in silicon.

The four pieces needed for this 3DM have all of them either receptacle holes or patterned edges precisely fabricated with ICP-RIE. It allows them to assemble byinserting one in each other. The necessary optical alignement between the WDM filters board and the optical fibers, placed inside the V-grooves of the V-grooves board, is insured by mechanically alignedboards through the mother board. This mechanical alignment reached a measured maximum range play of $\pm$ 14μm to $\pm$ 19μm. These values are compatible with the maximum play allowed by the mirror width: $\pm$ 19μm.

The electrical actuation is realized through microconnectors. For the optical characterization, the 3DM exhibits a clear tuning effect and insertions losses less than 6 dB, which confirms the proposed packaging concept.

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