

Fabrication and Design of Microchannel Heat Exchanger

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Abstract - Miniaturized scale diverts are principally utilized in biomedical gadgets and small scale fluidic applications. Creation of Micro channels has consistently been an extreme assignment utilizing regular assembling advances. Different sorts of materials are being used for manufacturing Micro directs in various kinds of utilizations including metals, polymers and pottery. Various strategies are being used for creating various sorts of Micro channels. These procedures incorporate both customary and nonconventional creation systems, for example, smaller scale processing, lithography, decorating procedures and laser removal handling. Due to the high performance of electronic components, the heat generation is increasing dramatically. Heat dissipation becomes a significant issue in efficiency promotion and stable operation. Microchannels are of current interest for use in heat exchangers where very high heat transfer performance is desired. Microchannels provide high heat transfer coefficients because of their small hydraulic diameters. In this study, the design and experimental investigation of fluid flow and heat transfer in a microchannel heat exchanger is conducted. Water and air are used as the working fluids and flowed through microchannels.

keywords - Microchannels, Heat Exchanger, Brazing

1. INTRODUCTION

Manufacture of Micro channels is a significant perspective with regards to improvement of small scale fluidic gadgets. Various manufacture strategies have been created and embraced during the years for various kinds of uses and materials. These procedures incorporate traditional tedious advances, for example, photolithography, carving and ultrafast laser handling. Contingent upon the uses of miniaturized scale channel based gadgets, various sorts of materials are liked. The consistently expanding request of these miniaturized scale channel based gadgets has likewise prompted the improvement of a few other crossover strategies to fabricate Micro directs in productive and powerful manner.

A heat exchanger is a device that is used to transfer thermal energy between two or more fluids, between a solid surface and a fluid, or between solid particles and a fluid, at different temperatures and in thermal contact. Typical applications include heating or cooling of a fluid stream of concern and evaporation or condensation of single or multi component fluid stream

2. RESEARCH METHODOLOGY

The capacity to cajole a wide assortment of materials into much littler gadget depends on progress in micromachining and other manufacture procedures. Until this point in time, various sorts of creation strategies for various kinds of materials and applications have been concentrated by various scientists over the world and the rundown is exceptionally thorough. Despite the fact that there are a few strategies, for example, lithography and laser micromachining which have been talked about broadly, there are a few techniques that are extremely exceptional and not many written works are accessible. The greater part of the reports on polymer micromachining for smaller scale fluidic gadgets were licensed and not distributed in open literary works for once in a while in early advancement.

Micro-mechanical cutting

With the coming of high accuracy machining, mechanical smaller scale cutting has risen as a key innovation for making Micro channels. The mechanical miniaturized scale cutting procedure is especially appropriate for creating individual customized segments as opposed to huge group size, which is to a great extent basic for the present market circumstances. With elevated level of machining exactness of ultra accuracy machine apparatuses, great surface completion and structure precision can be accomplished. The high machining pace of miniaturized scale cutting is another bit of leeway over smaller scale producing innovations. In addition, it can create an enormous number of materials, for example, steel, aluminum, metal, plastics and polymers. Not at all like small scale laser bar machining and lithographic methods, it doesn't require a pricey arrangement, which empowers the creation of miniatures at a monetarily sensible expense. Small scale processing and miniaturized scale turning are the two most utilized mechanical cutting procedures. As of late, multi shaper based miniaturized scale processing process has been considered and seen as progressively financial and quicker when contrasted with other contemporary micromachining forms. Figure 1 shows the Micro channels machined utilizing multi shaper processing machine. Right now, cutting instrument has been utilized and the profundities of the Micro channels were found to have irregularity top to bottom. Additionally, it has been seen that the corners were not sharp

rather bended which may bring about making void during fixing or holding process.

Wet and dry etching

Drawing is the most generally utilized subtractive strategy for micromachining. Drawing can be depicted as example move by concoction or physical expulsion of material from a substrate, regularly in an example characterized by a defensive cover layer, for example, an oppose or an oxide. In dry carving, surface is scratched in the gas or fume stage, truly by particle siege, artificially by a compound response through a receptive animal groups at the surface or by consolidated physical or synthetic systems. Once in a while a blend of wet and dry drawing has additionally been utilized as an apparatus for micromachining. Wet drawing strategy results in non equal dividers on glass surface and as the channel scratches further, the dividers are additionally carved. Electrochemical carving in any corrosive arrangement is reliant on etchant fixation just as scratching time. Then again, dry drawing strategies, for example, powder impacting and plasma or profound receptive particle carving have been end up being significantly more compelling strategy than wet scratching. Synchrotron radiation invigorated scratching has been performed on a PDMS base material to carve designs having sidelong measurements as exact as 21–24 mm and 32–35 mm by shifting example veil sizes. Carving is likewise utilized as an auxiliary procedure in different smaller scale channel creation techniques. Wet compound carving has been seen as reasonable for metallic substrates that respond well with synthetic concoctions. Dry scratching has been for the most part used for glass and polymer base materials because of prerequisites of lower responsive vitality.

Lithography

Lithography is one of the significant creation strategies used to manufacture Micro channels. Lithography empowers to manufacture various kinds of geology which is difficult to be produced utilizing other creation systems. The most generally utilized type of lithography is photograph lithography. In the miniaturized scale channel manufacturing businesses, design move from cover onto slender movies is done significantly by photolithography.

Lithography based basic methodology has been embraced for manufacturing round Micro channels on PDMS of different widths extending from 5 to 200 mm in breadth. Buddy and Sato created and showed a manufacture strategy for different states of small scale fluidic directs and microstructures in one stage photolithography. Delicate lithography has been utilized to make Micro channels on PDMS. Right now, is relieved over a designed photograph oppose on the outside of a silicon wafer. The relieved PDMS is then evacuated and afterward joined to a glass surface to make shut Micro channels. A noteworthy advantage of utilizing this creation strategy is that the polymers can be effectively attached to one another or to glass or plastic substrate utilizing conformal contact. Inconveniences utilizing delicate lithography dependent on PDMS incorporate the accompanying:

- shrinkage during slicing extents to over 1% and expanding likewise happens due to non polar solvents, for example, toluene and hexane,
- delicateness of the substrate material confines the reachable perspective proportion through drooping
- distortion of the delicate elastomeric stamps. As of late, X-beam lithography has likewise been utilized to make polymer Micro channels. Interestingly with particle pillar lithography and electron bar lithography, X-beam lithography doesn't require the nearness of vacuum and tidy up room offices, which makes this procedure less expensive and quicker. Most of PDMS based Micro channels have been generally created utilizing this procedure. PMMA assimilates the vast majority of the X-beams and is along these lines most appropriate to be fabricated utilizing this strategy. This procedure can deliver high perspective proportion Micro directs in PMMA.

Laser evolved micro channeling

Undoubtedly, laser related miniaturized scale channel manufacture forms are generally straightforward in nature with capacity of creating pretty much every state of microstructures. Laser preparing is flexible, takes least measure of time and can be utilized on pretty much every kind of substrate material. In the greater part of the cases, the material expulsion marvel is heat subordinate. The preparing must be improved for getting the most ideal outcome. Laser preparing of Micro channels has advanced as of late and has been concentrated by various scientists. In the majority of the looks into, either neodymium doped yttrium aluminum garnet (Nd:YAG) or laser has been utilized. A couple of specialists have additionally utilized CO₂ lasers for manufacturing Micro channels. The greater part of the laser manufacturing forms include possibly one or most extreme two stages just; they don't require tidy up room offices. They don't require the readiness of veil, for example, in photograph litho realistic procedure or carving process. There are various focal points of utilizing lasers as instrument over different procedures. Laser based procedures are earth clean, piece less and dependent on easy to work methods. With the utilization of fitting sort of laser, pretty much every sort of material including metals, nonmetals and fired can without much of a stretch be cut into practically any shape. It likewise covers a wide scope of tasks, for example, boring, etching, scribing, joining, miniaturized scale organizing and surface adjustment which can be utilized to create the entire gadget completely.

3. LITERATURE REVIEW

Various types of materials have been being used for various small scale channel based gadgets. These materials can be partitioned into the accompanying three fundamental classifications.

Polymeric and glass substrates

Over the most recent couple of years, miniaturized scale fluidic gadgets have been begun to be made on polymeric

substrates rather than silicon and glass substrates predominantly due to their minimal effort. The minimal effort additionally permits them to be produced as a dispensable gadget. The first significant polymeric materials for miniaturized scale fluidic gadgets are polymethyl methacrylate (PMMA) and polydimethyl siloxane (PDMS). As of late, PMMA has come up as an answer for wide scope of smaller scale fluidic gadgets as a result of its minimal effort and related simpler manufacturing strategies. PMMA is consummately straightforward and is utilized as a substitute for glass. It is frequently utilized as a medication conveyance framework material, embeds and has high biocompatibility. It likewise creates lesser measure of warmth influenced zone (HAZ) when contrasted with other polymer materials, for example, polycarbonate (PC) and polypropylene (PP) when handled under laser preparing techniques. The edge vitality for PP and polyethylene (PE) is higher than that of PMMA when machined with excimer laser. This is because of the way that they are thick in pressing, have solid entomb nuclear bonds and are impervious to bright (UV) radiation. The miniaturized scale fluidic channels on PMMA can likewise be produced correctly utilizing hot embossing. PMMA has been seen as most effortlessly manufactured substrate materials utilizing propelled laser preparing.

Creating Micro channels on glass represents a major test for customary manufacturing procedures. The procedure requires a progression of steps. This makes the entire procedure cost to get critical. In any case, creating Micro channels on glass substrates is a tedious procedure. In any case, in view of high level of straightforwardness, inactivity to most substances and capacity to continue higher temperature settle on it first decision for the vast majority of the miniaturized scale fluidic gadget

Metallic substrates

The region wherein metallic Micro channels have increased extensive consideration is its use as a cooling gadget in various applications identified with mechanical and hardware designing. The consistently developing interest of dismissing heat at quicker rates and patterns toward scaling down of cooling items has prompted improvement of colossal research right now. Miniaturized scale innovation based vitality and synthetic frameworks (MECS) are utilized to build the warmth and mass exchange rate in heat exchangers by utilizing smaller scope includes inside the gadgets to improve their surface territory to volume proportion. It is likewise attractive to perform numerous endothermic and exothermic responses on such metallic substrates and temperatures can reach as high as 650 °C. Along these lines, the ordinary metals, for example, tempered steel are less favored for MECS gadgets. Commonplace MECS gadgets incorporate fuel steam improving, gas turbine recovery, vent gas desulphurization and portable motor warmth recuperation, requiring temperatures over 650 °C in destructive conditions. Many combinations, pottery and super compounds have been tried, however they are costly. Right now, aluminides have been utilized as elective material. Metal aluminides offer high level of protection from high temperature oxidation. This is a direct result of the intrinsic property of the aluminum (Al) contained in the aluminides to shape defensive oxide layers (Al₂O₃). Nickel aluminide (NiAl) is quite compelling a direct result of its high dissolving temperature (1600 °C).

Semiconductors, ceramics and composites

The majority of the early improvements in miniaturized scale channel put together applications were based with respect to silicon and were initially produced for coordinated circuit (IC) industry. The rapid computerized circuits are required to be cooled at quicker rate for performing better with a huge number of rationale doors worked over it. For cooling of such gadgets, either constrained air convection innovation or fluid based smaller scale channel innovation is utilized. In any case, fluid cooling has been end up being far a lot of effective than constrained air convection cooling. Silicon isn't just utilized for microelectronic gadgets yet in addition applications, for example, energy components. Aside from silicon, quartz is likewise generally utilized as a substrate material for a few miniaturized scale channel based gadgets. Quartz is some of the time more reasonable than silicon for these reasons since it is (1) synthetically idle and steady, (2) optically straightforward, (3) less expensive than silicon and (4) a great electrical separator. Gallium nitride is another significant semiconductor material which has pulled in impressive enthusiasm over late years as a result of wide band hole and can be utilized in different optical gadgets including light discharging diode (LED) and laser diode.

It has been extraordinarily created for 3D miniaturized scale fluidic gadgets. As of late, fired based warmth exchangers have likewise been researched. In spite of the fact that the high assembling cost related with clay heat exchangers frequently represent a test, some new creation advances have been created as of late for assembling of fired based warmth exchangers. Weight covered coordinated structure (PLIS) technique created by Kee et al. offers a financially savvy answer for such artistic based gadgets.

4. CHALLENGES IN MICROCHANNELS AND THEIR APPLICATIONS

The shape, size and structures of small scale channel change with various types of utilizations. While the greater part of the miniaturized scale fluidic channels include high angle proportion, low viewpoint proportion channels are likewise normal in applications, for example, molecule partition gadgets. Right now, having any of the measurements in micron go have been considered as Micro channels. The strategy for creation likewise assumes a significant job. Micro channels are for the most part (with the exception of miniaturized scale processing) manufactured by nonconventional strategies. substrates and metallic substrates are utilized for hardware and mechanical building related applications. Be that as it may, creating these Micro diverts on such substrates in huge numbers has consistently been a troublesome assignment for makers due to the accuracy required in such items. Absence of reasonable advancements for manufacturing these gadgets has upset the further Micro channels with various traverse the years. Most basic cross segments incorporate rectangular Micro channels, square Micro channels, roundabout Micro channels, half round Micro channels, U shape Micro

channels and Gaussian pillar shape Micro channels. But round cross sectional Micro channels, every single other sort of Micro channels are manufactured at the outside of the base material. Round Micro channels are commonly manufactured inside the material through greater part of it. A thickness of barely any microns is commonly extra over the roundabout cross sectional Micro channels along the length for optical and seeing straightforwardness.

5. CAUSES OF PROBLEM

Microchannels have been created on various sorts of substrates throughout the years. Polymers top the rundown undoubtedly. In any case, creating Micro channels on polymers has consistently been an extreme errand for producers as a result of its fragile nature and uncontrolled crack. Metals then again doesn't offer all the necessary properties, for example, nonreactive nature and optical straightforwardness, in this way, can't be utilized in all the applications however manufacturing Micro channels on metals is viewed as simpler than polymers. Since silicon has a high warm conductivity, any warm based creation process doesn't extraordinarily suit the delicate gadgets in light of the fact that the retained warmth diminishes its affectability. A few creators have additionally examined the pottery and semiconductor materials, however the higher information costs related with these materials limit their utilization. Consequently, critical measure of research is required to create materials which are savvy and simpler to manufacture. This will empower the advancements to happen at a quicker pace. Creating Micro channels utilizing ordinary advancements, for example, photolithography and carving takes a great deal of time and frequently confines the creation of smaller scale channel based gadgets as once huge mob. The trouble in these procedures likewise restrains the adaptability and size of creation. Numerous means, arrangements and presentation make these procedures costlier and tedious. With the coming of cover less photolithography process the necessary time utilization has been decreased, yet the procedure has not been programmed completely and effective creation relies upon producer's abilities and experience. Again in the greater part of the lithography based procedures, there is constantly a need to do post handling, for example, wet drawing and other compound medications so as to manufacture channels of high goals, which further add to the expense of creation. Decorating and engraving forms require the need of recreating the small scale includes on a stamp which progressively wears out bringing about ill- advised channel measurements. Further creating these recreating gadgets requires the need of photolithography which again expands the expense of assembling to complex. Diverse different sorts of half and half creation advancements have been utilized by various specialists. In any case, the absence of institutionalization of these procedures doesn't settle on them a producer's first decision.

CONCLUSIONS

Creating Micro channels on various materials is a difficult errand. To meet required exactness in geometry of Micro channels, a lot of research is required. The utilization of Micro directs in different gadgets has acquired an unrest terms of cost, development and proficiency. This permits the simple conveyability of gadget and to manufacture numerous gadgets on a solitary stage (lab on a chip). Subsequently, a lot of research is expected to build up the small scale divert manufacturing systems in most productive manner. A synopsis of all the above examined techniques has been given in Tables 1 and 2 relying upon the sorts of use, materials, favorable circumstances and detriments. Smaller scale channel manufacture utilizing laser is an ongoing pattern and offers answer for some issues. The simplicity of manufacture, least time utilization and efficiency of the procedure settle on it the most favored decision. Be that as it may, the harms happening because of its warm nature can't be disregarded. Now and again, the surface gets harmed in a vague way with the goal that it can't be utilized for the reason it was worked for. Burr arrangements and HAZ additionally limit the utilization of lasers in manufacturing Micro channels. Accordingly, process parameters must be enhanced so as to get quality Microchannels. Besides, a ton of research is expected to decrease the warm surface harm by changing the procedure or by utilizing some post handling. The utilization of mechanical cutting procedures, for example, miniaturized scale processing is additionally picking up notoriety in the territory of small scale gadget producing due to its capacity to cut any material that can be machined. Moreover, the vitality utilization of such procedures is significantly less when contrasted with other nonconventional forms. Notwithstanding a few points of interest related with mechanical cutting procedures, the small scale processing approach isn't completely comprehended and there is least experience pool in industry for its presentation. Further critical advancement is required so as to accomplish the necessary exactness.

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