Editorial

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Biographical notes: Vijay Kumar Jain has done his MTech and PhD from the University of Roorkee (now IIT Roorkee). He has about 32 years of teaching and research experience. He has won three gold medals, two silver medals and one best paper award as recognition to his research work. He is Editor of two International Journals and Associate Editor of International Journal of. Advanced manufacturing. Systems and Member of the editorial board of ten *International Journals*. He has around 200 publications to his credit. He has also written 4 books. He has various research areas of interest, viz. advanced machining techniques, computer aided manufacturing and CAPP.

New fabrication technologies are being developed to meet the challenges of low cost, low power consumption, high productivity and miniaturisation. Those industries involved in the manufacture of integrated circuits, microsystems, optical electronics, flat plate displays and similar other products, rely on the microfabrication (μ-fabrication) technologies, namely, thin plate fabrication by sputtering and vacuum evaporation; pattern generation by optical, X-ray and electron beam lithographic techniques and μ-machining using electrochemical machining, electrodischarge machining, laser beam machining, dry etching and similar other processes. These technologies are employed to fabricate end products in various areas. For example, fabrication of membranes and filters for artificial lungs and kidneys, artificial retinas. In the optical area, the ability to fabricate minute lenses, prisms and other optical elements has given rise to integrate optical devices that are currently revolutionising communication science. In the area of instrumentation, we may visualise ultra-small devices to probe and manipulate with ever increasing sensitivity and precision.

Microfabrication can be achieved through two different routes – attrition (or material removal) processes and accretion (gradual increase/growth by addition of new layers) processes. Both routes have their own importance. The technologies currently in use for μ-fabrication are largely based on the principle of fabrication by material removal. In the more distant future we may look forward for molecular engineering technologies that will enable us to construct the devices atom by atom, much like a builder constructs a house brick by brick. Presently, most of the researchers follow the first route that is, μ-fabrication using attrition processes. These processes can be divided into two main categories: traditional micromachining and advanced micromachining. In most of the cases, the researchers are trying to modify the existing machine tools such that machining at microlevel (μ-machining) can be achieved. For example, micromilling and microdrilling. However, this trend may not sustain for a long time. One needs to design and fabricate altogether a smaller and more stiff machine tool to produce miniature devices with much higher accuracy and much lower tolerances. In the second category of processes, advanced micromachining processes are the modified versions of the advanced machining processes to achieve material removal at microlevel. These processes can be classified into mechanical advanced μ-machining processes (μ-AJM, μ-AWJC, AFM, MAF, etc.), thermal advanced micromachining processes (μ-EDM, μ-LBM, μ-EBM) and chemical and electrochemical advanced micromachining (μ-ECM) processes. The processes related to the second route (accretion type) include Chemical Vapour Deposition (CVD), electrochemical spark deposition, electrodischarge deposition and Focussed Ion Beam (FIB). The FIB technology is useful for fabrication of new devices and nanostructures but the initial investment cost and running cost are very high that inhibit its frequent use. We can also see from the nature of the papers in this special issue that majority of them are related to the class of advanced micromachining processes.

This special issue consists of total of 17 research papers. Out of these 17, four papers are from the traditional micromachining area. Zhang et al. have reported the enhancement in grinding performance by combining grinding of sintered Nd-Fe-B permanent magnet with ultrasonic vibration which improves the stability of grinding. The mechanism of material removal has also been investigated. The paper by Jackson and Robinson *describes* micromilling of fuel cell plates that are machined at very high speed in order to produce low surface roughness value and results in high cutting tool life. This process uses a novel nanocrystalline diamond having titanium coating that has been specially designed to cut strain hardening alloys (nickel chromium) at extremely high speeds. Another paper on micromilling is by Lakshmi et al. which presents stability lobe diagram as an analytical tool that aids in the selection of suitable cutting parameters for micromilling. They have considered 0.6 mm end mill as a cutting tool. Wu et al. have reported the parametric study using finite element analysis and design of experiments technique for soft pad grinding of 300 mm wire-sawn silicon wafers. They have explored several methods including soft pad grinding to enhance waviness removal ability of the grinding process. A paper on the fabrication and characterisation of nitrogen-doped diamond microtool by Jackson has been included in this special issue. In this paper, experimental results are presented on the effects of nitrogen doping on the surface morphology, crystallite size and wear of μ-tools. The value of 200 ppm of nitrogen is found as an optimum value and at any value above this the surface becomes too smooth and crystal size decreases considerably.

Total of six papers on thermal advanced μ-machining have been incorporated in this issue. Olivier and Joshi have analysed Heat Affected Zone (HAZ) in μ-EDM process and found a reduction in μ-hardness along the length of μ-holes and it is attributed to the annealing phenomenon around the hole. It may be due to the absence of recast layer ahead of the HAZ on the μ-EDM'd surface. Parametric study of drilling of μ-holes and μ-machining of electrically non-conducting materials has been presented in the paper by Sarkar et al. They have reported the values of process parameters for optimum MRR and overcut during μ-drilling of holes in Al_2O_3 and ZrO_2 using KOH and NaOH as electrolytes. Wire Electrical Discharge Machining (WEDM) is one of the variants that can be well adapted for μ-fabrication applications as claimed by Alam et al. In this paper, the experiments have been reported that were conducted to study the effects of the process parameters specially on improving the gap width and efficient removal of the debris produced during machining. They have used CNC μ-WEDM machine with tungsten wire of 50–70 μm diameter. The use of laser dragging process to ablate the groove pattern on PolyCarbonate (PC) sheets has been demonstrated by Hocheng and Wang. For this purpose, a predictive model has been proposed to study single and cross dragging. The process parameters that they have studied include dragging velocity, pulse rate, pulse frequency and mask parameters. Plasma arc has been used by Wu et al. for flexible forming of sheet metal components. Edge effect is one of the basic problems being faced during fabrication using this method. The mechanism and the transient process of edge effects are studied using numerical simulation and the results have been compared with the experimental observations. The agreement is found to be satisfactory. Tseng and coworkers have studied the influence of μ-plasma arc welding process parameters on the joining strength of the weld on the thin stainless steel sheets commonly used in industries. It is concluded that the workpiece exposure height must be above a minimum limit in order to prevent undesired joining.

Selective laser sintering (or layered manufacturing) is used to make strong and hard metallic functional components. During the process, thermal stress distribution has been studied using finite element method. The two process parameters (laser power and scanning time) have been considered by Yadava and Makarand to evaluate the product quality. Avinash and others have presented the findings related to bulk micromachining for SOI based μ-systems using double side XeF_2 etching.

Surface finishing of macro- and μ- components is important from functional point of view. Jha and Jain have reported the parametric experimental findings of a newly developed MRAFF process. The experiments were conducted on stainless steel workpieces using statistical design of experiments technique. The best surface finish with the present set-up configuration that has been reported is 30 nm.

Three papers in this special issue are related to the MEMS. Mahalik has reviewed the principle and applications of MEMS. The second paper by Nichols et al. deals with a review of MEMS metrology dealing with some current tools in use and their fundamental limitations. It deals with scaled down conventional metrology tools and some new one for MEMS inspection. The third paper by Wang et al. deals with micro and nanofabrication of pyrolysed photo resist carbon. Carbon based MEMS and NEMS can provide solutions (millimeter to nanometer), alone or in combination with Si for μ-electronics, nanoelectronics, sensors, etc.

Thus this special issue incorporates the papers related to microfabrication based on attrition processes (mechanical, thermal as well as electrochemical and chemical), accretion processes (laser based), surface nanofinishing processes and a detailed discussion on MEMS fabrication, applications and MEMS metrology. Hence, this issue should be a useful special issue for μ-fabrication researchers and professionals.

The Guest Editor (Dr. V.K. Jain) is very much thankful to Dr. M.A. Dorgham, Editor-in-Chief of *IJMTM* and his team for theircooperation and help during the process of bringing out thisspecial issue on ‘Microfabrication’. The Guest Editor would also like to acknowledge with thanks the timely completion of thereview process of internationally high quality.