Micromachining: A New Trend in Manufacturing

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Introduction

Micromachining refers to techniques for fabrication of 3D structures on the micrometer scale. Until recently watch parts were considered to be the micro components produced for the purpose of making watches. Recent demands for micro parts have required us to manufacture variety of micro components used in different fields from entertainment electronics to biomedical implants. The convenience and value of many products can be substantially increased with reduced size and weight. With the trend toward miniaturization, micromachining becomes increasingly important in fabricating micro parts[1].

In the medical field, diagnosis and surgery without pain is possible through miniaturization of medical tools. The convenience and value of many products can be substantially increased with reduced size and weight. With the trend towards miniaturization, micromachining becomes increasingly important in fabricating micro parts. Micro parts may have overall size of few millimeters but it has many features that falls in micro range from 1 µm to 500 µm. features size of 100 µm is common in micromachining. This means small as hair size, the average hair diameter is about 100 µm[1-5].

The design and construction of tools, tool holders, cutting tools, and electrodes need to evolve as greater demands are placed on them for machining these miniature parts. A study of micromachining process proves that micro cutting processes are not just a miniaturization of the conventional cutting technology, and requires an adjustment of the entire machining setup and processes. Miniaturization technologies are perceived as potentially key technologies of the future that will bring about completely different ways people and machines interact with the physical world.

In the industrial world the interest in microscopic scale manufacturing is exponentially increasing in relation to the rapid growth of Micro Electro Mechanical Systems (MEMS) research. Thus a greater attention is given to improve traditional techniques and developing nonconventional methods, in order to obtain more precision.

Micromachining Techniques

Micromachining is a specific technique applied to micro scale parts. Micro Electro Mechanical Systems (MEMS) are microscopic devices processed, designed, and used to interact with or modify the local environment. They can be referred as microstructures, microsystems, mechatronics and microstructure technology. MEMS can also be referred to devices with moving parts (smaller than human hair) containing both mechanical and electrical components on silicon. With rapid growth of MEMS a greater attention is given to traditional methods and developing non-conventional machining methods. The most important techniques are used for

micromachining are photolithography, laser, micro-EDM and micromechanical machining (micro-cutting and micro-milling) which is the focus of this paper.

Lithographic Process:

It is a traditional technique of micromachining on silicon based on lithographic approach, by etching and deposing process used in microelectronics. Silicon wafers are machined with chemical or physical etch and parts are realized layer by layer from silicon wafer. This non-contact method is based on masking and light exposure[2].

Laser Micromachining:

Laser uses light radiation with high energy as a machine tool. High precision can be achieved and material removal is obtained by ablation. Ceramics and metal layers can be machined with higher laser densities. Focused beam could allow real 3D shaping by correct motion control[3].

Micro Electronic Discharge (EDM) Machining:

The erosive action of an electric discharge between conductive tool and work piece is used to remove material. Electro-thermal erosion creates small craters in the piece during machining process. The tool shape is copied in the work piece with a no contact system. EDM machining process is able to machine both hard materials like steels and carbides and semi conductors and conductive ceramics[4].

Micro Ultrasonic Machining:

Micro ultrasonic machining is a process that uses micro tool ultrasonic vibration to create accurate holes in brittle materials like silicon, glass and ceramics. Abrasive slurry is interposed between tool and work piece and the tool is used as a micro-mill to obtain drills or pattern on the work piece surface. The vibrating tool impacts abrasive grains into the work piece producing a mechanical removal of the material[5].

Mechanical Micromachining Technology:

Mechanical micromachining technology is a new field in micromachining that is achieved by optimization of cutting process for micro-milling, turning and grinding process for a wide range of materials. In this process the unwanted part of the work piece is removed by mechanical force through brittle breakage. A high stress that causes breakage of material is applied to a very small area or volume of the work piece. Extremely precise cutting machines with high level of positioning accuracy are designed to perform milling, turning and grinding in micro scale.

Tool dimensions and cutting edge sharpness represents challenges in developing this technology in micrometer scale. Coated micro mills down to 30 µm in diameter are commercially available for micro machining purposes. Mono crystalline diamond cutters of no less than 50µm in

diameter is also used in the mechanical micro machining process and the diameter cannot be any smaller due to part stability reasons during manufacturing of the part.

Mechanical machining because of removing the material by contact and chip generation is linked with heat generation. The cutting fluid is used to prevent the heat and keep the cutter sharp. The cutting fluid is applied as mist; a few milliliters of oil per hour are atomized by pressurized air. The right amount of oil in the air stream is essential in mechanical micro machining to prevent the sticking of chips to the tool[6].

The shape of the micro cutting tool also has been modified to reduce breakage and chatter. The fluted length has been reduced to increase stiffness. The conical part of the cutting tool, where bending occurs has been designed to a round shape. The shape prevents it from cracking and breakage due to machining stress.

The CAD/CAM process and 3D modeling can be used to create G-code program for a mechanical micro machine using Computer Numerical Control (CNC) system. An effective CNC support is required to machine curvilinear features and sculptured 3D surfaces.

The emerging miniaturization technologies are perceived as potentially key technologies of the future that will bring about completely different ways people and machines interact with the physical world. A study of micro machining processes proves that micro cutting processes are not just a miniaturization of the conventional cutting technology, and requires an adjustment of the entire machining set-up and process to implement this technology.

Review of Micro System Educational Programs in Technical Colleges

There are two technical colleges that offer a program in Micro Electromechanical System (MEMS) technology. Dakota County Technical College in Minnesota which offers a program in Nanoscience Technology and Central New Mexico Community College that offers a program of study in Advanced System Technology with an emphasis in Microsystems and laser Optic Concentration. Both programs are supported by the National Science Foundation (NSF) grants and they are pioneer in MEMS education and training offering Associate in Applied Science (A.A.S.) degree in this field.

Dakota County Technical College (DCTC):

Nanoscience technology program at Dakota County Technical College prepares students for careers in nanobiotech, nanomaterials, and nanoelectronics industry. The curriculum is a lecture and laboratory experience with hands on use of nano scale equipment. Nanoscience technologists work in multiple business environments including research, production, testing, training and marketing. A total program requirement is 72 hours. Table 1 shows the degree plan for nanoscience technology at Dakota County Technical College.

Associate in Applied Science Degree (A.A.S) NANO-Science Technology				
General Education and Supporting Subjects				45 hrs
MEMS related courses				
NANO1100	Fundamental of Nanoscience I	3 hours		
NANO1200	Fundamental of Nanoscience II	3 hours		
NANO1210	Computer Simulation	1 hours		
NANO1211	Student Research	3 hours		
NANO2101	Nanoelectronics	3 hours		
NANO2111	Nanobiotechnology	3 hours		
NANO2121	Nanomaterials	3 hours		
NANO2131	Manufacturing Quality Assurance	2 hours		
NANO2140	Interdisciplinary Lab	3 hours		
NANO2151	Career Planning and Industry Tours	1 hours		
NANO2970	Industry Internship	2 hours		
Total Core Credit Hours		27 hours	Program Requirements	72 hrs

Table1: NANO-Science Technology Dakota County Technical College

Central New Mexico Community College (CNM):

CNM Advanced System Technology program enables its students to succeed in Electronics, photonics and MEMS. The Automation and Telecommunication concentration provides CNM students with the analog and digital lab and hands-on experience to get started in high tech career of industrial automation and control. Courses offered in this concentration provide hands-on experience in robotic automation, microcontroller and PLD programming.

The Microsystems and Laser Optic concentration provides CNM students with educational experience in the application of laser, optics and micro-system in industry.

Associate in Applied Science Degree (A.A.S) Microsystems and Laser Optic				
General Education and Supporting Subjects				43 hrs
MEMS related courses				
MEMS 1002	Introduction to MEMS Theory	2 hours		
MEMS 1092	Introduction to MEMS Lab I	1 hours		
PHOT 1003	Fundamental of Photonics	3 hours		
MEMS 1101	Plasma-RF-Vacuum System	2 hours		
MEMS 1192	Plasma-RF-Vacuum System Lab	2 hours		
MEMS 2102	Manufacturing Process Theory	2 hours		
MEMS 2192	Manufacturing Process Theory Lab	1 hours		
MEMS 2206	MEMS Design Theory	2 hours		
PHOT 2003	Photonics and Laser Systems	4 hours		
MEMS 2015	MEMS Manufacturing Technology/lab	5 hours		
PHOT 2013	Advanced Photonics & Laser Systems	5 hours		
Total Core Credit Hours		29 hours	Program Requirements	72 hrs

Table1: Microsystems and Laser Optic Central New Mexico Technical College

The program of study uses facilities containing modern equipment for testing, troubleshooting, calibrating, analyzing, designing and fabricating electronic and micro systems for processing wafers in MEMS applications.

Assessment of Micro System Educational Programs at DCTC and CNM

Dakota County Technical College (DCTC) and Central New Mexico Community College (CNM) are both pioneers in providing training at the associate level for micro and nano scale science and technology. The purposes of the programs are to create a skilled workforce of micro and nanotechnologists.

Both programs train micro and nanoscience technologists who will work as part of a team of scientists and engineers. Their job mostly will be in laboratory environment preparing test samples, microscope operation and testing, fabrication, documentation and analysis and communication of results.

Courses Related to Micromaching Techniques

Both technical colleges offer courses related to the fabrication and manufacturing of micro scale MEMS components. Dakota County Technical College offers NANO 2101, Nanoelectronics which "provide students with study, measure, evaluate and create fabricated structures such as nanowires and nano channels. Application of nanoscale principles will be used to discuss imprint lithography and etching to produce memory devices." NANO 2121, nanomaterials "covers creation of nanomatrials, particles and crystals by various processes including colloidal suspensions, deposition, evaporation and plating."

Central New Mexico Community College offers MEMS 2102 Manufacturing Process Theory and MEMS 2015 Manufacturing Technology Lab focused on Micro Electro Mechanical systems (MEMS) fabrication process control. Topics include fabrication processes related to photolithography, etch and thin film deposition.

This fact suggest that teaching of micromaching practices is an integral part of MEMS technology and as technology advances new methods like laser micro machining, micro Electric Discharge (EDM) machining, micro ultrasonic machining and mechanical micromachining techniques will be adopted by technical programs.

Conclusion

With increased demand for miniaturized functional equipment, micro machining is becoming an important industry. Micromachining is the technology for manufacturing micro sized structures. This technology has many applications, and has driven innovation in many areas such as the automotive and biomedical engineering fields. The potential of micromaching has been noticed by the research community, inspiring the creation of many academic works. Since its beginning, micromachining has evolved greatly to include more techniques and methods, and the array of

materials being processed under these techniques also has expanded. With the prediction of nanotech and micromachining market expansion by 2015 to 1 trillion dollars and creation of new industries related to this technology the demand to technical workers in this fields will increase.

This will provide a great opportunity for technical programs at two year colleges to offer programs related to micromaching. This will be possible by getting involve in the trends and acquiring technology and tools used in this new field. Some conventional methods like laser cutting, Electrical Discharge Machining (EDM) and conventional machining at the existing programs can be updated by purchasing micro scale machines to provide training in micromachining technology.

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