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Micromachining technologies for future products

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Abstract ***:*** *Miniaturization is proceeding in various types of industrial products. Micromachining is the foundation of the technology to realize such miniaturized products. A review of the literature, mostly of last 10years, that is enhancing our understanding of the mechanics of the rapidly growing field of micromachining has been provided. The paper focuses only on methods of micromachining process along with applications of major methods of micromachining.this paper gives you idea of current scenario of micromachining market of world along with its benefits and challenges.*

Keywords ***-****micromachiing , micromachining products ,market size,market analysis*

I. INTRODUCTION

Micromachining is the process of machining very small parts with tools smaller than 0.015 inch in diameter and tolerances of just a few tenths. Micromachining can create very small and intricate parts that are required for certain applications, particularly in the semiconductor and medical industry. It takes machinery with both sufficient spindle speed and durable cutting tools to produce the repeatability and strength to run at high speeds. Micromachining tools may be as small as 0.001 inch in diameter (1/3 diameter of human hair) to achieve the precision and detail needed.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 developed as a technique in the late 1990s, in response to an increasing demand for smaller and more intricate parts from the semiconductor and medical industries. In response to this, precision engineers began developing techniques to machine smaller parts with smaller tools, largely by trial and error.Finding the right machinery and tools to deliver results on such a small scale was particularly a problem. Laser cutting couldn't create the clean edges required, and low RPM machines using small cutters could only provide limited results.Upgrading to higher speed spindles and machines that are capable of producing smaller parts was essential, and nowadays precision engineers not only use higher RPM machines to apply their own micro milling capabilities, they also use Swiss-type lathes with live tooling and high-speed air spindles. Swiss-type lathes can be used to create prototypes and produce small batches of turned parts that still require some milling,

The demand of miniaturized parts is increasing day by day in modern world. Micromachining utilizes miniature milling, drilling, cutting, turning, controlled dissolution, polishing and other various operations to produce three dimensional features and formed surfaces in micron and submicron ranges. This scaling down of processes from macro to micro regime also requires lowering down of magnitudes of involving operating parameters. Also, functional requirements of many devices demand very tight tolerances and the use of a wide variety of engineering materials. industrial application of micromachining has been hindered by the lack of experience and knowledge on the micro-machinability of materials [4]. But, emerging miniaturization technologies have been perceived by many potential key technologies of the future that will reveal completely different ways how people and machines interact with the physical world. Various existing miniaturized parts that can be produced by micromachining processes include micro-electromechanical systems (MEMS), micro-sensors, micro fuel cells, micro channels, micro holes, micro grooves, micro pump, micro valves, medical implants and devices, micro-actuators and various other different micron sized features. Another application of micromachining process involves fabrication of integrated circuits (IC) for electronic devices. These ICs have also large scale use in CD players, computer components, etc. Relays and switches are required to be assembled to produce functional micro sized mechanical parts. For making of lighter aircrafts and satellites, miniaturized components are necessary. These type of aircrafts poses increasing demand in this rapidly changing world.

II. METHODS OF MICROMACHINING

2.1 MechanicalMicromachining

- Micro – AJM
- Micro – WJM
- Micro – USM

2.2 ThermalMicromachining

- Micro – EDM
- Micro – LBM
- Micro – IBM
- Micro – EBM

2.3 Chemical And Electrochemical Micromachining

- Micro – CM
- Micro – ECM

2.4 Hybrid Micromachining

- ECG
- ECDM
- Ultrasonic assisted micromachining
- Laser assisted micromachining
- Abrasive assisted micromachining

III . MICROMACHINING APPLICATION

3.1 Automotive

Micromachining in the automobile industry is widely used to increase the functionality of products and for miniaturization. Micromachined devices have applications in accelerometers, speed sensors, and temperature and pressure sensors. The demand for micromachining is also increasing due to recent advancements in micro electro mechanical system (MEMS) devices used in automobiles. Micromachining is widely used in the automotive industry. For example, fuel injector nozzles are used in the fuel injection technology of various automobiles. This fuel injection technology not only improves the mileage of the vehicle but also consumes less fuel. Fuel injector nozzles are normally micromachined by the electrical discharge machining (EDM) process.

The laser technology in micromachining is widely used in seamless welding and joining in the automotive industry for various vehicle components. Electronic components used in automobiles and electro voltaic cells used in electric vehicles are driving the market

3.2 Medical & Aesthetics

The main goal of the medical industry is to reduce the cost of medicines, improve medical outcomes, and shorten recovery times. Medical procedures have to rely on tiny micromachined devices. Minimally invasive medical devices are used in electrophysiology, embolic protection, and stenting. Electrophysiology devices are used to treat cardiac disorders. In electrophysiology, cauterization and cryogenic catheters are used to kill tissue selectively, and this requires the use of micromachined devices. Laser machines are used in Lasik surgery, which requires micromachined precision.

3.3 Aerospace &Defence

Micromachined parts are widely used in engines, navigational systems, and heads-up displays, among others, in the aerospace industry. Micromachining in the aerospace industry includes micro milling and micro turning of various arrays of materials that possess the required high tolerances. The various aerospace micromachining applications include aircraft parts, auxiliary equipment of aircraft and others, engine parts, electronic assemblies, actuators, sensors, measurement systems, optical MEMS, and navigation displays, among others.

3.4 Telecommunications

There is an increasing demand for mobility, interconnectivity, and bandwidth, which is leading to the significant expansion of the telecommunication infrastructure worldwide. The introduction of the optical fiber-based telecommunication infrastructure has led to the high rise of the optically-related MEMS technology system, micro-opto-electro-mechanical systems (MOEMS). Micromachining plays a crucial role in the manufacture of MEMS sensors. Micromachining has enabled the low-cost manufacture of MEMS, and mass production of MEMS optical components and devices is made possible. MEMS are widely used in optical and radio frequency (RF) telecommunication applications owing to advantages in cost, performance, and integration.

IV.MICROMACHINING MARKET REPORT COVERAGE

The report: **"Micromachining Market – Forecast (2019-2024)"**, by Industry ARC covers an in-depth analysis of the following segments of the micromachining market.

By Technique: Bulk Micromachining, Surface Micromachining.
By Type: Lithographic, Laser Micromachining, Electro Discharge Machining, Electro Chemical Machining, Micro Ultrasonic Machining, Hybrid Machining, Others.
By Material: Ceramics, Metals & Alloys, Polymers, Glass& Quartz.
By Application: Micro hole drilling, Cutting,3D Machining, Scribing, Contouring, Micro Milling, Welding, Surface Treatment, Others.
By end uesd industry
:Medical,Automotive,Aerospace&Defense,Semiconductor&Electronics,Energy,Telecom,Industrial,Others.
By Geography: North America, Europe, APAC, RoW.

4.1 Micromachining Market Segment Analysis - By Technique

Bulk Micromachining technique has been estimated to attribute the major market share in the micromachining market, accounting $2.2 billion in 2018. Moreover, the global automotive sensor market registered a growth from $29 billion in 2017 to $36 billion in 2018. Supporting the fact, bulk micromachining is used in production of various automotive sensors such as flow sensors, pressure sensors, and inertial sensors. Hence, increasing usage of bulk micromachining in various industrial production will drive the micromachining market growth.

a. Micromachining Market Segment Analysis - By Type

Laser micromachining is widely used method for micromachining, with major applications in subtractive manufacturing for MEMS formation. Laser Micromachining is poised to **grow at a CAGR of 5.16%** during the forecast period. In February 2019, California-based Coherent Inc., a photonics manufacturer launched an ExactCut micromachining system with latest generation of pulsed fiber laser sources, for precision cutting of metals, alloys, sapphire, polycrystalline diamond (PCD), and ceramics. Its additional features include remote diagnostics and predictive maintenance. Such developments will encourage other players to expand their product portfolio and create new revenue streams.

4.3 Micromachining Market Segment Analysis - By Material
Metals & Alloys in Material segment hold major market share in 2018, while Micromachining on Polymers is projected to grow at a highest CAGR of 5.72%, owing to increasing usage of polymers in biomedical applications such as drug delivery, tissue engineering, diagnostics, and therapeutics.

4.4 Micromachining Market Segment Analysis - By Application
Micromachining helps in minimizing the size of gadgets which leads to development of smart wearable in consumer electronics and micro-sized medical implants. Micromachining is helpful in realizing miniaturized 3D structures on micrometer scale retaining the normal functionality of the product. For precise shapes of equipment, various industries such as plastic, metal fabrication and others are increasingly adopting the wire EDM contouring, as EDM operations allow to carry out outer and inner contour machining speedily. Hence, Contouring application in the micromachining market is forecast to grow at a CAGR of 6.93% during the forecast period.

4.5 Micromachining Market Segment Analysis - By End Use Industry
There is a growing demand of micro industrial products in various industries such as healthcare, automobile, and semiconductor & electronics, among various others. Rising penetration of medical devices in developing countries, and worldwide increased research rate for dissolvable and non-dissolvable medical micro implants, to meet cost effective healthcare treatments is set to escalate the micromachining market growth. The medical segment is anticipated to dominate the micromachining market by 2024, growing **with a CAGR of 6.3%** during the forecast period 2019-2024. Companies serving in these industries are strategically enhancing their product portfolio. In 2016, GF Machining Solutions acquired Microlution Inc., a major developers of micromachining products incorporating milling and laser technologies, to expand its product portfolio globally in aerospace and medical sectors.

4.6 Micromachining Market Segment Analysis - By Geography
North America dominated the micromachining market with about 35% of market share in 2018 which was majorly attributed by the U.S. Automotive industry. The increased usage of micromachining technique for fabrication of automotive sensors, actuators, vehicle dynamic controls, and navigation systems is driving growth of the market. Globally, FCA, Ford and General Motors together invest more than $18 billion in R&D every year. From 2013 to 2017, these companies made a total investment of $35 billion in their U.S. facilities. Such, investments will boost the growth of micromachining market for automotive industry in the region. Further, with the increasing penetration of electric vehicle in the U.S., will boost the application of micromachining in manufacturing of batteries for electric vehicles.

- The main benefit of Micromachining using specialized techniques and tools is that it allows the reliably repeatable as efficient production of small and intricate parts that have tight tolerances.
- Micromachining offers a method for single process machining for smaller parts, so milling and turning can be done on the same machine. This reduces lead time and allows parts to be machined more efficiently.
- Micromachining is ideal for machining prototypes and parts with micro features in both plastics and metals, and has a variety of applications.
- Micromachining using machines with high spindle speeds or Swiss-type lathes has the advantage of creating cleaner cuts, more precise dimensions and tighter tolerances to fit their specialized applications in the semiconductor and medical industries.
- Implementing Micromachining in your precision engineering practice provides the opportunity to take on a greater range of scope of bids and make more diverse and specialized parts. Even larger parts can be machined with greater accuracy and speed on machines used for micromachining.

- **High cost of micromachining equipment**

To achieve high precision manufacturing, micromachining equipment makes up major cost. These high costs are restraining the usage of Micromachining equipment especially by Small and Medium-Sized Enterprises (SME), thereby posing challenges for the micromachining equipment market growth. According to OECD, in 2017, the U.S. had maximum number of SMEs i.e. 4.41 million followed by Italy having 3.67 million. The high cost of micromachining is restraining the micromachining market growth in these potential regions.

- **Market Landscape**

Product launches, and acquisitions along with expansions are the key strategies adopted by players in the micromachining market. As of 2018, the Micromachining Market remained moderately consolidated with the

top 5 players accounting for 43% of the market share. The major players include Mitsubishi Electric Corp., IPG Photonics Corp, Amada Holdings Co., Electro Scientific industries and OpTek Ltd.

- **Partnerships/Mergers/Acquisitions**

In the financial year 2018, Mitsubishi Electric (China) Co., Ltd. and Mitsubishi Electric Automation (China) Ltd., entered into a strategic partnership with the Instrumentation Technology and Economy Institute, P.R. CHINA (ITEI) to promote standardized intelligent manufacturing..In August 2018, Mitsubishi Electric acquired ASTES4 SA (ASTES4), a company based in Switzerland to strengthen its product portfolio.In 2017, IPG Photonics acquired Laser Depth Dynamics (LDD), a provider of quality monitoring and control solutions for laser based welding applications. The acquisition led to strengthen the product portfolio of IPG Photonics.

- **R&D Investments/Funding**

Micromachining based product manufacturers are investing significantly in R&D of miniaturized, cost effective, and energy efficient products to augment entry into markets such as in telecommunications where 5G infrastructure is at initial stage, in major markets such as the U.S., China, and South Korea. The investments are also focused on enhancing product capabilities through company acquisitions. The potential application of micromachining in electronic devices, automotive, industrial, and energy, is set to raise the huge demand of micromachining worldwide.

V.CONCLUSION

The Micromachining Market size was accounted $3.24 billion in 2018, and is anticipated to grow at a CAGR of 5.16% during the forecast period 2019-2024. The market is majorly driven by increased demand for miniaturized electronic components and micro-sized medical implants that reduces the overall space, weight and cost of the final product. The increasing demand for micro-scale products from industries such as automotive, telecom, energy, and aerospace among a few will further drive the micromachining market growth.

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