Forced-Controlled Machining-Head For Glass Micro-Drilling

MECH 490 Capstone Team 11

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Abstract

The presented micromachining head is designed by Capstone Team 11 under strict specifications for use in the Spark Assisted Chemical Engraving of non-conductive materials.

Spark Assisted Chemical Engraving Process (SACE)

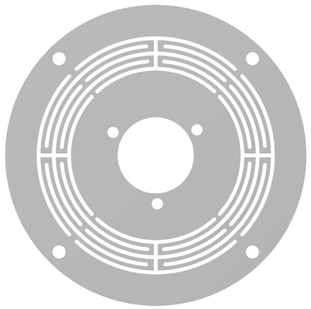
SACE is based on electrochemical discharges. The principle is simple: the work-sample and two electrodes are dipped into a NaOH electrolyte solution. The cathode is used as a tool electrode. When a voltage higher than a critical value is applied, typically of about 30V, a gas film around the tool is formed by coalescence of the bubbles growing on its surface. Electrochemical discharges occur between the tool and the electrolyte. The heat generated locally melts the work-sample.

Features and Mechanism

The micromachining head acts as a force sensor using the principle of zero displacement force measurement. By controlling the vertical position of the machine shaft during the machining process and monitoring the input forces needed to achieve this control, an extremely accurate real-time measure of the input disturbances encountered during the SACE machining process can be obtained. This valuable process information can be subsequently used in research endeavours to optimize the SACE machining process in an ultimate attempt to introduce this method to the industrial processing of non-conductive materials.

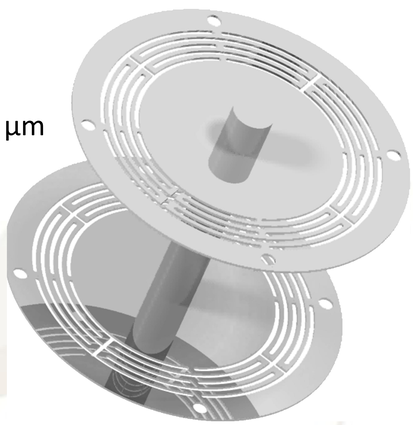
Other features include:

- High Precision Diaphragm Flexures
- Design for Assembly Concept
- Vertical Frictionless Motion
- Light Movable Mass



Desired Specifications

- Run-out: 10 µm
- Rotation: 500 -6000 rpm
- Force sensor
- Maximum z-error tolerated < 3 µm
- Force range: -1N to 5N
- Resolution: 1mN
- Response time of 10ms
- Current: 3-5 A
- Voltage: 20-30 V
- Tool Holder: 300 µm to 8mm

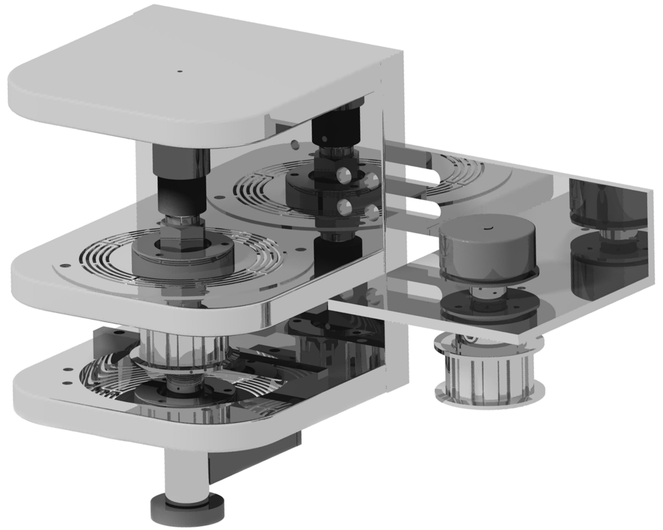


Recommendations

The diaphragm flexure sheets can be replaced to provide a better in plane stiffness and limit the parasitic motion. A lighter movable mass can be obtained by machining a collet adapter out of aluminum.

In addition, hardware improvements to the motion controller, and reducing the movable mass could optimize the speed and accuracy of the positioning system

Overall, the Micromachining Head meets its utmost important criteria in high precision repeatable Spark Assisted Chemical Engraving machining of non-conductive materials.



Acknowledgements

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For further reference on the research of Dr. Rolf Wuthrich in the field of novel micro-machining technologies for a variety of materials, consult his book: *Micromachining Using Electrochemical Discharge Phenomenon.*