INDIAN INSTITUTE OF TECHNOLOGY GUWAHATI
SHORT ABSTRACT OF THESIS

Name of the Student	:	Enni Krishna
Roll Number	:	186103016
Programme of Study	:	Ph.D.
Thesis Title	:	Non-conventional plasma machining and nano-polishing of optics
Name of Thesis Supervisor(s)	:	Dr Manas Das
Thesis Submitted to the Department/ Center	:	Department of Mechanical Engineering
Date of completion of Thesis Viva-Voce Exam	:	23 Nov. 2023
Key words for description of Thesis Work	:	Plasma polishing, Raman microscopy, Optical Emission Spectrometer, Optics

SHORT ABSTRACT

In this study, a medium-pressure plasma flow system was designed and developed for plasma machining of fused silica optics. The results showed that the plasma flow system can be used for long machining times (more than 60 minutes) with a material removal rate that is 300% higher than the earlier studied confined system. The study also found that there is an improvement in surface integrity, as identified by Raman microscopy, and surface topography, as determined by the 3D profiler. In this study, a non-invasive method was developed using an optical emission spectrometer to predict MRR during polishing. The Comsol® simulation was utilized to optimize the plasma chamber configuration, resulting in a custom-made chamber with a V-shaped groove that showed uniform reactive radical distribution for polishing free-form optics. Confocal Raman microscopy was used to quantify the depth of damage on ground fused silica. This methodology was adopted to optimize the rotary ultrasonic machining parameters for shaping fused silica hemispherical resonator shells (HRG). To investigate the cause of Ring Laser Gyroscope device failure, a photoluminescence spectrometer was utilized for analysis and verification. Furthermore, the SSD depth at the nanometer scale was quantified for the ultra-smooth prism substrate using Secondary Ion Mass Spectrometer (SIMS). A process flow was established for removing 350 nm depth of material without affecting the surface finish of the ultra-fine fused silica substrate, using plasma processing followed by chemical leaching to enhance the surface integrity of the prism substrate. In this study, a non-invasive method was developed using an optical emission spectrometer to predict MRR during polishing. The Comsol® simulation was utilized to optimize the plasma chamber configuration, resulting in a custom-made chamber with a V-shaped groove that showed uniform reactive radical distribution for polishing free-form optics. Confocal Raman microscopy was used to quantify the depth of damage on ground fused silica. This methodology was adopted to optimize the rotary ultrasonic machining parameters for shaping fused silica hemispherical resonator shells (HRG). To analyze and verify the plausible mechanism of Ring Laser Gyroscope device failure, a photoluminescence spectrometer was used. Furthermore, the SSD depth at the nanometer scale was quantified for the ultra-smooth prism substrate using Secondary Ion Mass Spectrometer (SIMS). A process flow was established for removing 350 nm depth of material without affecting the surface finish of the ultra-fine fused silica substrate, using plasma processing followed by chemical leaching to enhance the surface integrity of the prism substrate. This study compares plasma etching versus wet chemical etching and suggests plasma machining as a safer alternative.