investigations of micron-precision cutting, trepanning and scribing of PETG, PMMA and other industrial polymers using high-pulse-rate uv copper lasers. Typical laser characteristics are 0.7 W average power, diffraction-limited at 255 nm and pulse rates 5-15 kHz. Materials removal (ie machine) rates and machine quality (minimum HAZ) have been determined for various combinations of beam/sample scan rate, pulse rate, spot size (and spot overlap) and single-pulse fluence.

For fixed fluence, linear machine rates generally scale simply with pulse rate. In the case of highly-absorbing polymers such as PETG, machine rates actually increase at a somewhat faster than linear rate with prf, an effect we attribute to cumulative heating when there is high spot overlap. Machine quality as measured by the appearance of HAZ (peripheral melt zone and rounded edges) is superior at lower fluences and higher beam/sample scan rates.

By careful control of machining parameters *it is possible to achieve both good quality and* reasonable process speeds. Results will be presented for a number of materials and machine functions.

1. E.K. Illy, M.J. Withford, D.J.W. Brown and J.A. Piper, Proc ICALEO'96 Laser Materials Processing, LIA vol 81E pp 92–98 (1996).

CThK10

Efficient 193 nm-laser assisted cryogenic etching of GaN with Cl_2/CH_4

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Cryo-etching provides a unique etching mechanism which combines cryogenic cooling of the substrate with laser-assisted excitation to enhance the anisotropy of the etching without causing damage to the etched surface. For etching GaN, by lowering the substrate temperature in a chlorine/methane ambient, a layer of Cl_2/CH_4 is physisorbed on the GaN surface. Excimer laser radiation at 193 nm dissociates the condensed phase chlorine and methane molecules to form reactive Cl, H, CH_x and HCl radicals, which are confined to the illuminated zone and react with the GaN surface. The etching products ($GaCl_x$ and NH_x), are then desorbed with the assistance of laser irradiation, resulting in etching. The confinement of the reactive species and etching product desorption to the laser illuminated zone lead to laser defined etching pattern. Also, the etching results from low energy reactive species minimize substrate damage which is often produced due to momentum transfer of high energy reactive ion species in ion beam techniques.

Figure 1 shows the etching rate as a function of laser fluence. For acquiring these data, we developed an efficient way for characterizing the etching rate. Since the etching is optically assisted, the etched pattern is expected to have strong dependence on laser fluence. We can obtain all the data of the etching rate dependence on laser fluence directly by scanning the depth of the etched profile along the edge diffraction pattern. With fluence above 180 mJ/cm^2, the etching rate increases almost linearly with fluence, as suggested to be due to single-photon photochemical process. No significant etching was observed below 150 mJ/cm^2, which is believed to be the threshold for achieving the desorption of the surface compound products. Above 240 mJ/cm^2, the etching rate increases super-linearly with fluence. This result indicates that laser heating enhanced etching may become significant in the range of high laser fluence.

We have found that the addition of the methane to the chlorine ambient could enhance the etching rate significantly. Figure 2 shows the variation of the etching rate with various chlorine/methane mixing ratios while keeping GaN substrate temperature and excimer laser fluence unchanged. Due to the limited resolution in reading of the baratron pressure sensor used, we observed a steep jump of the etching rate from 0 to 1/3 methane/chlorine mixing ratio. In addition, the etching became impossible without chlorine (methane 4 mTorr). The almost linear dependence of the etching rate on chlorine mixing ratio suggests that chlorine is the key reactive specie in this etching reaction and methane seems to act as the reaction catalyzing element. Note that the highest etching rate we obtained is 0.028 nm/pulse. With our 5 Hz laser system, the etching rate is equivalent to 8.4 nm/min. If a new model excimer laser with the pulse repetition rate as high as 500 Hz is available, the etching rate can be up to 840 nm/min, which is as good as those with ion etching techniques.

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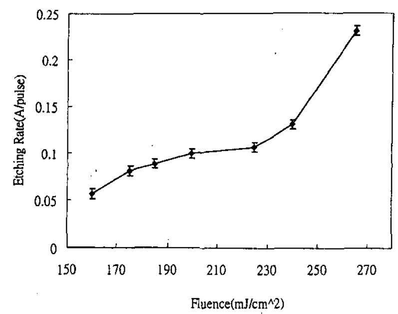
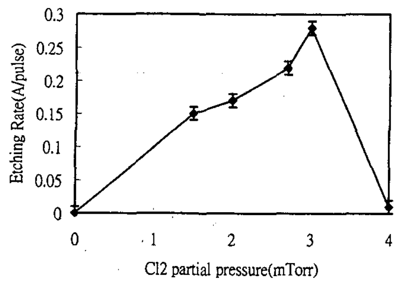


CThK10 Fig. 1. Etching rate dependence on laser fluence.



CThK10 Fig. 2. Etching rate dependence on Cl_2:CH_4 ratio.

CThK11

An improved interferometry for laser tracking system

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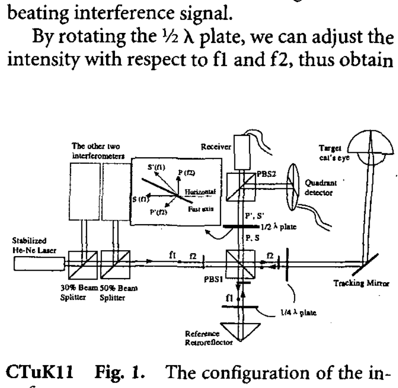
Laser tracking systems (LTS) include single-beam and multiple-beam tracking system. A multiple-beam tracking system based on the trilateration is treated as with high accuracy. At least four interferometers are needed for 3D measurement and self-calibration, which results high cost. Here we introduce an improved interferometry, in which three interferometers are linked by only one laser source and one Filed Programmable Gate Array (FPGA) card for numbering.

Figure 1 shows the improved interferometry system. Compared with the conventional heterodyne interferometer, the key point of this interferometer lies on using a ½ λ plate and a polarizing beam splitter PBS 2 to generate the tracking signal. Consider a beam with two polarization components, P (in vertical plane) and S (in horizontal plane) with respect to the laser frequency f1 and f2, respectively. When the beam reaches the PBS 1, the component P is reflected to the reference retroreflector, while the component S goes through the PBS 1, and then reflected by the target retroreflector, cat's eye. After reflected by reference retroreflector and cat's eye, two beams are combined again in the PBS 1. Note now P and S with respect to f2 and f1, respectively. We place a ½ λ plate between PBS 1 and PBS 2, the fast axis of the plate makes an angle of 22.5 deg. with the horizontal direction (see Fig. 1). Passing though ½ λ plate, the component S rotates 45 deg. as shown in S′, and P rotates 135 deg. as shown in P′. Then after PBS 2, the f1 and f2 oscillate in the same direction and generate the beating interference signal.

By rotating the ½ λ plate, we can adjust the intensity with respect to f1 and f2, thus obtain



CTuK11 Fig. 1. The configuration of the interferometry.