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MICRO BARRIER DISCHARGE CONTROLLED BY AN EXTERNAL IRRADIATION OF LASER

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In a barrier discharge, a dielectric surface acts as an electrode and the characteristics of discharge are determined by surface phenomena such as behaviour of excited and charged species on the surface. We have proven that an optical evanescent wave is valuable for spectroscopic plasma diagnostics in the vicinity of a dielectric surface.[1] An optical technique using an electrooptic crystal has been also developed to measure spatial and temporal changes of a wall voltage induced by charges accumulated on the dielectric surface.[2],[3] We have also proven that an external irradiation of light can change the surface voltage of a dielectric barrier.[4] In ref. 4, it has been found from the measurement of the surface voltage using a coplanar electrode-type single-gap barrier discharge device that the change of the surface voltage can be induced by a external irradiation of a YAG laser with a weak intensity and the change is induced only on the area of the laser irradiation.. The change of the induced voltage is linearly dependent on the laser intensity less than 0.2 μJ and recovers with a lifetime of 20 ms. It is also experimentally confirmed from the measurement of the light emitted from the plasma and the discharge current that the barrier discharge is induced by external irradiation of the YAG laser. In this paper, we make detailed experiments concerning with the induced voltage and describe the change of the surface voltage may be mainly produced by the change of a refractive index induced from second order nonlinear susceptibility of an electro-optic crystal. Finally we show that an array of microbarrier discharge can be controlled by an external irradiation of a laser light.

At the first experiment, we used single barrier discharge device. The side view of a coplanar type microdischarge device with an electrode gap distance of 100 μm is shown in Fig. 1. The detail of the discharge device and experimental procedure has been described in ref. 4. One example of the transient waveform of a discharge current is shown in Fig. 2. Each waveform in Fig. 2 shows the result obtained from an average of 100 times of measurement. The upper trace shows a free running discharge without any external irradiation of laser and the lower trace shows the discharge current induced by the YAG laser irradiation. The irradiation time of laser with a pulse width of 10 ns is indicated by a dotted vertical line and it is clear that the discharges are induced just after irradiation. The same phenomena are observed even when the pulsed applied voltage with a negative phase is selected

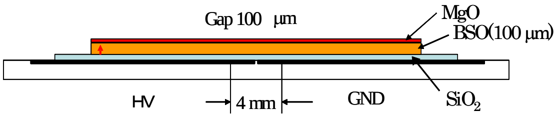

Fig. 1. Side view of single array discharge device.

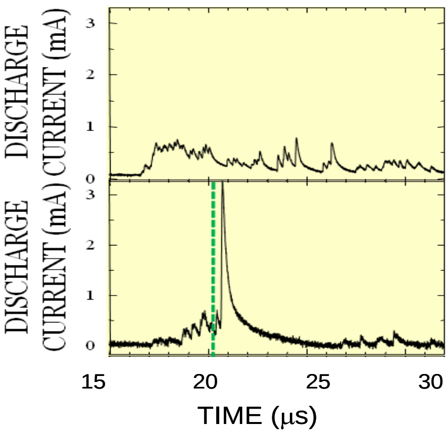

Fig. 2. Transient waveforms of the discharge current with and without using the irradiation of a YAG laser.

or the ground electrode is exchanged by a high voltage electrode.

In next experiment, an array-type device of ten microbarrier discharges is used. The top and side views are shown in Figs. 3 and 4. The gap distance of ITO electrodes of each channel is 100 µm and is covered by SiO2 with thickness of 10 µm, an electro-optic crystal, z-cut $Bi_{12}SiO_{20}$ (BSO) with thickness of 100 µm and MgO with thickness of 0.6 µm. The discharge space of one channel is limited to 0.5 x 1.5 mm using a glass cover. The device was set in a vacuum chamber and the gas mixture of Ne+Xe(10%) was filled at pressure of 300 Torr. Ten channels of microdischarge were electrically connected in parallel and a pulsed voltage with a frequency of 400 Hz was externally applied.

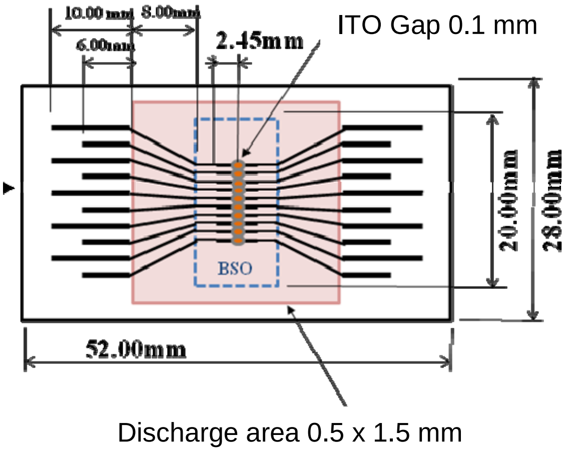

Fig. 3. Top view of an array-type microbarrier discharge device with ten discharge channels..

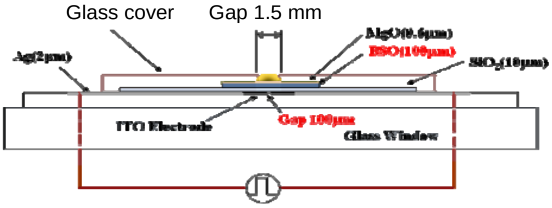

Fig. 4. Side view of a array-type microbarrier discharge device..

When the applied voltage is 750 V, all gaps of ten channels break down and ten plasma spots are observed. However, when the voltage is applied with 700 V, any channel does not discharge. Under this condition of 700 V, the second harmonics (532 nm) of a YAG laser with a frequency of 800 Hz and a intensity of 0.1 µJ is radiated in the direction perpendicular to the barrier surface. The diameter of the laser spot on the barrier surface was kept to about 0.5 mm which was less than the discharge space of one channel. It is confirmed from the light emitted from plasma that one discharge in this channel is induced by the laser. Even if the laser irradiation was stopped, the gap of the channel continuously keeps the discharge. Under this condition, when the second discharge gap in other channel is radiated by the YAG laser, the second gap starts on discharging in addition to keep the discharge in the first channel.

It is found that a discharge of any channel be selected by the irradiating position of a pulsed laser and a breakdown of microbarrier discharge array can be controlled by an external irradiation of laser without using an electrical control.

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