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THERMAL IMAGING EXPERIMENTS ON ANACONDA ION BEAM GENERATOR

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The thermal imaging technique was used in two experimental measurements. First, the ion intensity distribution on the anode surface was observed from different angles by using a multi-pinhole camera. Second, the plume from a target intercepting the beam was visualized by observing the distribution of temperature increase on a thin plate hit by the plume.

The thermal imaging technique[1] for ion beam diagnostics was developed by Los Alamos National Laboratory (LANL). It uses an infrared camera to obtain the two-dimensional distribution of temperature variation of the measured surface where the ion beam energy is deposited. In previous experiments, this technique was used to measure the ion beam energy-density distribution on a certain cross-sectional plane of the beam. In the experiments reported in this paper, we have measured 1) the relative ion beam brightness distribution on the anode surface observed from different angles and 2) the distribution of energy deposition of the target plume generated by the ion beam on a witness plate that is hit by the plume. The experiments were carried out by using the intense ion beam (400 keV, 30 kA, 1 μs) generated by ANACONDA, an ion beam generator located at LANL.

1. Measurement of ion beam intensity distribution

Figure 1 shows the experimental setup for ion beam diagnostics. The ion beam is generated by a focus type B, diode. A pinhole plate is located at the focal point of

![Image](image-url)

Fig. 1 Experimental setup for ion beam diagnostics.
the ion beam, which is about 40 cm from the anode surface. Behind the pinhole plate, separated by 25 mm, there is a titanium witness plate with 0.08 mm in thickness. The temperature distribution of the witness plate is monitored by an infrared camera.

Figure 2 shows a typical infrared photograph of the witness plate obtained after the ion beam shot. For this shot, there were 5 pinholes 2 mm in diameter with one on the axis and the other four uniformly distributed on a circle of radius 3.8 cm. In Fig. 2, we can see five circles, one from each pinhole (some are incomplete), that are the pinhole images of the annular anode. Since the blackness in Fig. 2 is proportional to the temperature increase on the witness plate, the images provide the time-integrated distributions of ion beam energy on the anode surface, observed from different angles.

From Fig. 2, we have obtained two conclusions. First, the ion beam emission on the anode surface is not uniform. The intensity of ion beam emission depends strongly on the location at the anode. Second, the spatial distribution of the ion beam intensity on the anode surface depends strongly on the position of observation. The
image obtained at the center looks more uniform than the other four. The metal supports of the inner cathode cause three breaks on each circular image.

By comparing the images obtained from different shots, we have found that the distribution of ion beam intensity, obtained at the each angle, changes shot to shot. Therefore, the distribution of ion beam intensity on the anode surface is not caused by any asymmetry on the anode surface due to roughness or damage.

2. Measurement of target plume produced by the ion beam

When an intense ion beam strikes a target, some of the target surface material is evaporated or ionized due to the energy deposition of the ion beam. This target material then expands in the vacuum forming a plume containing plasma and hot gas. When this plume hits a solid substrate, some of the material cools and condenses on the substrate forming a thin film. If this plume flows through low pressure gas instead, the plume material combines to form very fine solid particles. These processes have been used for thin film deposition and nano-sized power production.[2,3]

To visualize the target plume, we have used the thermal imaging technique. Figure 3 shows the experimental setup of thermal imaging measurement of the target plume. The witness plate, a titanium plate with 0.08 mm in thickness, is located in front of the target. The temperature distribution of the witness plate is monitored by the infrared camera.

Figure 4 shows a typical infrared photograph of the witness plate obtained after the ion beam shot. For this shot, the target was a titanium disk with 5 cm diameter and the witness plate was set 12.7 cm from, and parallel to, the target. The temperature increase obtained from Fig. 4 is shown in Fig. 5.

The temperature shown in Fig. 5 is not the instantaneous temperature rise on the surface of the witness plate when it is hit by the plume. It is the temperature distribution when thermal equilibrium is reached in the direction of plate thickness, but before significant thermal conduction occurs in the direction along the plate surface. Therefore it shows the distribution of energy absorption from the plume by the witness plate.

By integrating the temperature increase
given by Fig. 5, we have obtained the total energy of ~ 17.8 J, which is the energy absorbed by the witness plate from the plume.

We have observed the dependence of the maximum temperature increase on the distance between the target and the witness plate. Figure 6 shows the results. For each distance, we have taken the data from five shots. In Fig. 6, the circles show the average values and the error bars show the maximums and the minimums. It is seen that the temperature increase decreases with target-substrate distance, which is in agreement with the data obtained previously by another method.[4]

References