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Highly Sensitive Amorphous Optical Memory

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Amorphous semiconductor films have been reported to be crystallized with a laser beam to obtain written spots[1], as well as with voltage pulses[2]. Power of the laser beam necessary for writing or erasing a bit of information in the film was about several milliwatts[1), 3)]. Simultaneous application of voltage with the irradiation of a laser beam might lower the laser beam power necessary for writing or erasing. However, as the resistivity of the crystallized spot is much lower than that of amorphous region, we need X-Y matrices of electrodes so as to apply the voltage only at an appointed spot to avoid disadvantages of large currents in crystallized spots. This method, therefore, might lose an advantage of high packing density of amorphous semiconductor optical memory. Our present device, however, made it possible to avoid disadvantages of large currents in written spots without dividing electrodes, and its sensitivity for light was found to be very high.

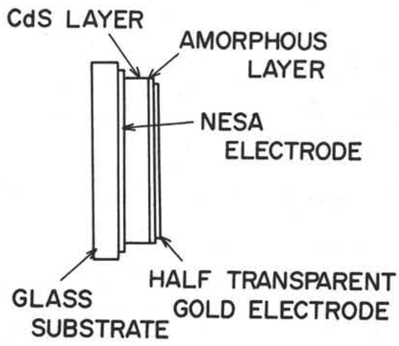

Fig. 1 Structure of the device

The structure of our device is shown in Fig. 1. A thin Te-Ge-As amorphous semiconductor film is formed on a thick CdS layer, and both of them are sandwiched with transparent plane electrodes. With this device, we succeeded in writing small spots in the amorphous semiconductor film with a He-Ne laser beam as weak as 0.02mW irradiated from CdS layer side through one of the electrodes with the aid of short duration voltage pulses applied to the electrodes.

Relation between the minimum height of voltage pulses whose width was 1μs and the minimum power of the laser beam necessary for obtaining visible written spots is shown in Fig. 2. In order to obtain this relation, the device was irradiated with the laser beam about two seconds, and at the end of the irradiation, the voltage pulse was applied. Applied voltage being fixed at 60V, when duration of the preceding laser beam irradiation was shortened

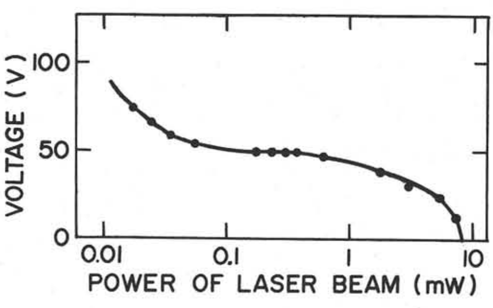

Fig. 2 Characteristic of the writing

from 2s to 15μs, the minimum laser power for writing became only about 2.3 times as large as the power shown in Fig. 2, and when shortend to 5μs, the minimum laser power became about 3 times as large as the power shown in Fig. 2. The minimum light energy for the writing of an about 5μm-diameter spot was 3×10^{-10} Joule. Figure 3 is a photomicrograph of written spots taken with transmitted light. Oscillogram traces of currents are shown in Fig. 4, a current with an irradiation of the laser beam II is shown doubled on a current without an irradiation I. These experimental observations strongly suggest that crystallization of the amorphous semiconductor layer was caused by switching in the CdS layer[4], that the threshold of switching was lowered with the laser beam irradiation, and that the avalanche multiplication of photo-carriers triggered the switching. Since in the CdS layer, switching, not memory effect occurs, the CdS layer can return to initial high resistance state and prevent spurious current from flowing through the written spots. Possibility of microfilm duplication with light from a 30W tungsten lamp and repetitive voltage pulses was also found.

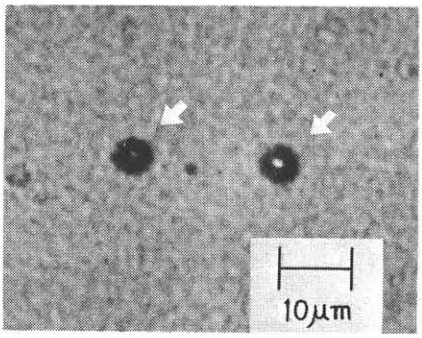

Fig. 3 Examples of written spot

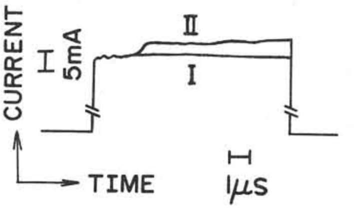

Fig. 4 Oscillogram trace

We can also crystallize the amorphous semiconductor film of this device with the laser beam and voltage pulses lower and much longer than shown in Fig. 2. The crystallization is thought to be due to photoconduction in the CdS layer and written spots were smooth. In this case, as far as the same As-Te-Ge amorphous semiconductor was used as the memory material, at least several hundred microseconds were needed to crystallize a 5μm-diameter spot with the He-Ne laser beam whose power was 5mW.

References

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