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B — 3 — 4 Rotating MNOS Device Using a PVD Electrode Deposited on a Diamond Stylus

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As previously reported in the paper, "Rotating MNOS Disk Memory Device" (IEEE Trans. on ED-28 No.7, July 1981), we presented a new recording and reproduction system using a disk-type charging medium which consists of a single stationary "Metal" electrode and "NOS"disk rotating in contact with it, as shown in Fig. 1, and estimated a prospective memory density of a model operating in an ideal state at about 0.1 - 1 μm^2/bit.

We experimented on the disk device using a metal stylus coated with PVD TiC, where an FM carrier signal of 2 MHz was recorded in a wave length of 5 - 10 μm on a recording track, and reproduced a still picture of a single field of TV signals with an error rate of 10^{-3} - 10^{-4}.

In principle, the memory density given as a reciprocal of the product of a recorded wave length and a track pitch may be restricted by the surface roughness and thickness of the memory (Si_3N_4) layer of the disk. In our case, these dimensions of 2 and 50 nm are negligible, so that the density is practically limited by the thickness of the electrode or the depth of depletion layer, 100 - 300 nm, which depends on a doping concentration of a bulk.

In this paper, we report a newly fabricated memory device with an electrode made of PVD TiN in a thickness of 400 nm on a side of a diamond stylus, as shown in Fig.1, which is similar to the stylus structure used in the VHD video disk system. By adopting the diamond stylus the following merits are earned: (1) the recording ability of the shorter wave length, due to the thinner electrode; (2) a longer life due to the hardness of the diamond body, which supports the electrode in its contact with the disk. On the other hand it is necessary to make the structure and mechanism more accurate. Specifically, it is necessary at recording to reduce the surface roughness and bow of the disk and to align and fasten the stylus-sole surface just in parallel with the disk surface.

The surface roughness of a polished silicon wafer and that of a CVDsilicon nitride measured by Talystep are shown in Fig. 2, compared with a precisely polished glass substrate for an IC mask blank. Therefore, since the air-gap may be assumed to be about 2 nm or more, the DC drop across the air-gap at recording results from the charge-transport by field emission.

Then as it was necessary to perform a simulation test under a negligibly small air-gap, aluminium was evaporated through a mask into dots on disk surface, and C-V curves were measured before and after a single pulse was impressed through a prober in contact with the dot-electrode. Fig.3 shows the curves shifted by a single pulse of a different height.

Using the diamond stylus at a linear velocity of 4 m/s, we suceeded in writing and reading the video signal of a narrow band within 1.5 MHz through an LPF on an FM carrier of 2.5 MHz on a track of 7 μm wide and 20 mm in a diameter. The peak amplitude necessary to record with the diamond stylus was ± 60 V, so we assumed that the voltage drop across the air-gap was about 15 - 20 V and the recorded wave length was 1.5 - 2.0 μm.

The picture reproduced from a single-field TV signal recording is shown in Fig. 4, where the drop-outs found as black bursts in a few of the lines seemed to be caused by the instability of the stylus' contact with the disk rather than by the defects in the structure of the disk. The observed number of burst errors does not exceed 3, and a single field of the carrier consists of 4×10^4 ($=2.5 \times 10^6/60$) cycles. Consequently, by assuming that a burst error results from a bit error, the error rate is estimated at 10^{-4}.

For a nondestructive reading test, reading from the same track was continued for more than 6 hours, i.e., the number of reading times of 1.2×10^6. Ther was no deterioration in the reproduced picture quality by the end of the test. However, because of the wear in the tip of the stylus we found some slight damage in a square-shouldered portion of the electrode-sole, as shown in Fig. 5.

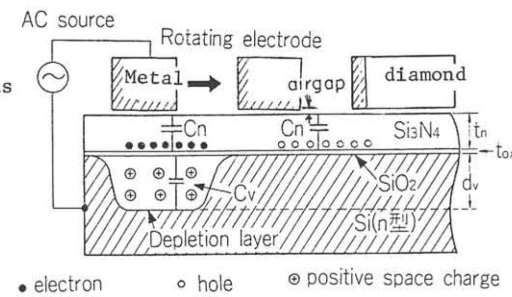

Fig.1 Rotating NMOS structure with a moving stylus

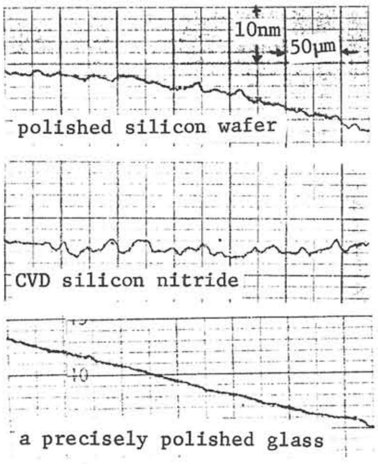

Fig. 2 Surface roughness of the disk

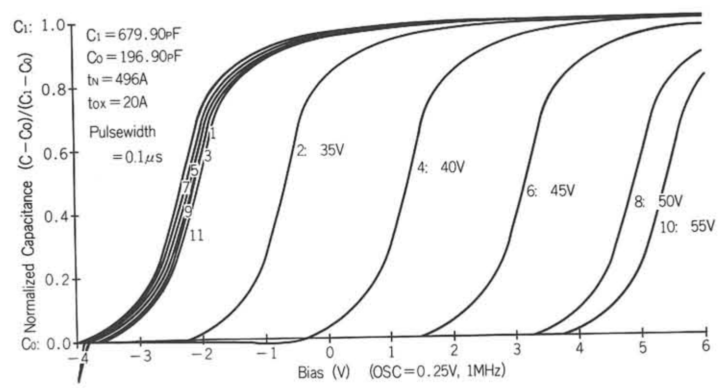

Fig. 3 C-V curves of MNOS capacitor shifted by a impressed pulse

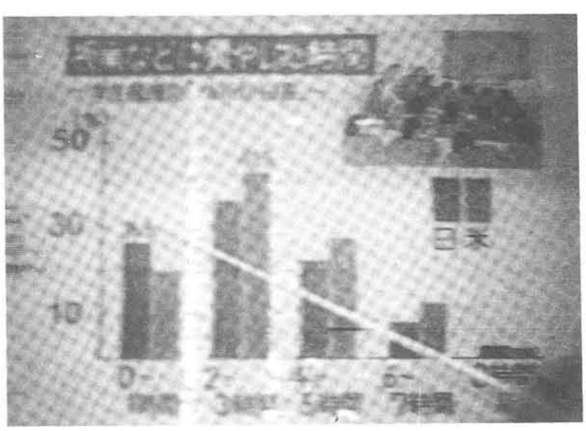

Fig. 4 The reproduced picture of a single field TV.

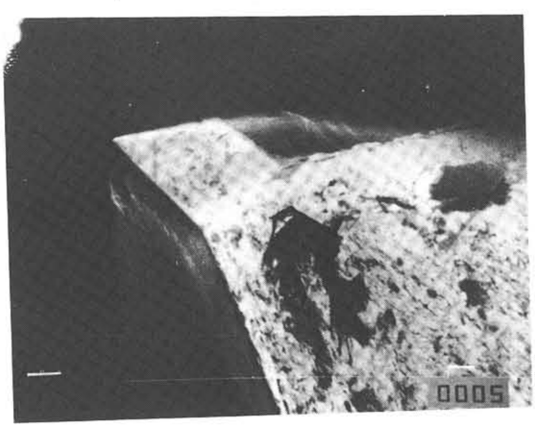

Fig. 5 The tip of the diamond stylus