**N.G. Basov, A.F. Plotnikov, and V.N. Seleznev,** *Electronic processes in metal-silicon nitride-silicon dioxide-semiconductor* (MNOS) *structures.* One trend in the search for new principles of recording and storing information is associated with the use of optics in high-capacity storage devices. We investigated the possibility of using a multilayered dielectric-semiconductor structure as a highly sensitive reversible medium for an optical storage unit.[1] This structure was investigated with a view to the possibilities of obtaining high light sensitivity by absorption of the light in the semiconductor base on the one hand and, on the other, of long-term (more than a year) storage of the information by accumulating charge on traps in the structures broad-band dielectric. To build such a structure, it will be necessary to find an effective method of charge injection from the semiconductor into the dielectric that forms when the structure is illuminated. Experiments made with a silicon base/tunnel thin (20–25 Å) $SiO_2$ layer/$Si_3N_4$ (500–800 Å) layer structure showed that the silicon-to-dielectric injection tunnel current reaches A/cm$^2$ at a voltage across the structure that exceeds a certain threshold value. Because of the difference between the values of the injection current and the current flowing through the bulk of the $Si_3N_4$ film, a polarization charge accumulates in the silicon nitride layer next to the $SiO_2$ = $Si_3N_4$ boundary (memory effect). Depending on the polarity of the voltage, it is possible to inject either electrons or holes from the silicon and, consequently, to accumulate either positive or negative charges in the dielectric. The optical switching is based on the threshold-type dependence of the amount of charge accumulated in the dielectric on the voltage across the dielectric layer. In the absence of light, the voltage across the dielectric must be lower than the threshold value, and in the presence of light it must be higher.[2] The upper metal electrode is made transparent to light. The concentration of the doping additive in the semiconductor base must not exceed $10^{16}$ cm$^{-3}$. In this case, 80–90% of the pulsed switching voltage, the polarity of which corresponds to depletion on the semiconductor surface, will fall on the depleted layer in the silicon. The voltage across the dielectric layer will be quite far below threshold, and the structure will not switch. At room temperature, nonequilibrium conditions may persist in the semiconductor for several seconds. Illumination of the structure which is in the state of nonstationary semiconductor-surface depletion with light at a wavelength that generates electron-hole pairs in the semiconductor will result in the accumulation of minority carriers at the semiconductor-dielectric boundary and in screening of the electric field in the semiconductor. The voltage across the dielectric layer rises and the structure is switched. Optical control of the switching makes it possible to combine many memory cells ($10^4$) under a common metal electrode. The correct cell is selected with a laser beam. The density of the surface charge created in the illuminated cell at the Si–$SiO_2$ boundary is $10^{13}$ cm$^{-2}$. About 20% of these charges tunnel into the dielectric and are captured on deep traps in the $Si_3N_4$. In order to prevent charge transfer from the traps into neighboring unlit memory cells, it is necessary to prevent minority carriers that have accumulated at the Si–$SiO_2$ boundary from leaking along this boundary. For this purpose, the dielectric is thickened in the gaps between cells. Under the action of a voltage applied to the structure, a potential relief appears along the dielectric-semiconductor surface and retains the carriers generated by the light in the illuminated cell. The light-pulse energy necessary to switch a single cell with a linear dimension of 10 microns is $10^{-11}$ J. Reading of the information is based on photoelectric measurement of the semiconductors surface potential, which is related to the charge in the traps of the dielectric.[3] The nonequilibrium carriers produced by the light lower the surface bending of the semiconductor's bands to zero. The resulting electric signal at the structures contacts characterizes the dielectric-trap charge. The information can be read repeatedly without damaging it.

Structural schemes for storage devices using an optically controlled MNOS medium have been proposed.[4] A diagram of such a storage device is shown in Fig. 1. The light beam of the addressing laser electron beam tube (LEBT) passes through a splitter that forms a ray matrix. The memory plate contains a matrix of structures (chips), and the number of chips is equal to the number of rays. The lens focuses each ray onto a certain chip. The beam can be scanned over all cells of the chip by varying the position of the laser-tube light spot. Beam-splitter cubes are placed between the lens and the storage medium to increase

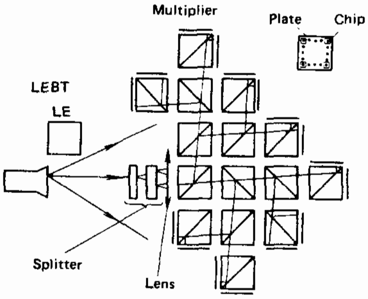

FIG. 1.

the size of the data set that can be processed at one time. This gives parallel access to all plates and to chips on a plate, but only one cell is illuminated on each chip. Accordingly, each chop has only two common electrodes for all cells to handle the write and erase signals and register photodurrent signals in reading. In a storage device of this kind, a $10^4$–bit block of information is processed in 30–50 μsec, and the total capacity of the storage may be as high as $10^{10}$ bits. The largest admissible number of switchings of a single memory cell in such a storage device is an important question. Up to this time, the number of cycles has been limited to $10^4$–$10^5$, after which the trapped-charge storage time decreases to a few days. Investigation of the physical causes of these changes showed that they result from accumulation of thermodynamically nonequilibrium compensated charges in the $Si_3N_4$. Recombination processes in the amorphous broad-band dielectric are hindered, and this results in an increase (with increasing number of switching cycles) in the population of donor and acceptor traps in the $Si_3N_4$. The decrease in storage time results from the increase in the conductivity of the structure with increasing trap fill factor. It has been possible to increase the allowed number of switching cycles to $10^8$ by optimizing the parameters of the structure, and specifically by adjusting the stoichiometric composition of the silicon nitride.

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