The Photo-erasable Memory Effect Associated with a "Conductive Path" Formed in Ag-doped Chalcogenide Glasses

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We previously reported the rapid metal diffusion into chalcogenide glasses induced by light irradiation,[1] and also the remarkable increase in electrical conductivity in the metal-doped areas.[2] The conductivity of the metal-doped areas was about 10^6 times higher than that of the undoped areas. It has been pointed out that the differences in the chemical and electrical properties between the metal-doped and the undoped areas can be used for a new type of photo-imaging materials.

During the investigation of the electrical properties, a photo-erasable memory effect was found in the silver-doped chalcogenide glasses. The sample was prepared as follows. About a 1000 Å-thick layer of silver was doped with light[1] into the evaporated film of $As_{24}S_{70}$-Te_6 (atomic %). The surface-type cell shown in Fig. 1 (a) was made by the vacuum deposition of gold electrodes on the sample surface. The spacing between the electrodes was 1 mm. The cell showed two stable states in electrical conductivity—the low conductive state (1) and the high conductive state (2), as indicated in Fig. 1 (b). The cell changed from the (1) state to the (2) state at an applied voltage of over 20 V in this experiment. This high-conductive state easily changed back to the (1) state within half a minute upon light irradiation from a 250 W Hg high-pressure lamp. The ratio of the electrical conductivities of the (1) state to the (2) state was over the order of magnitude of 10^3.

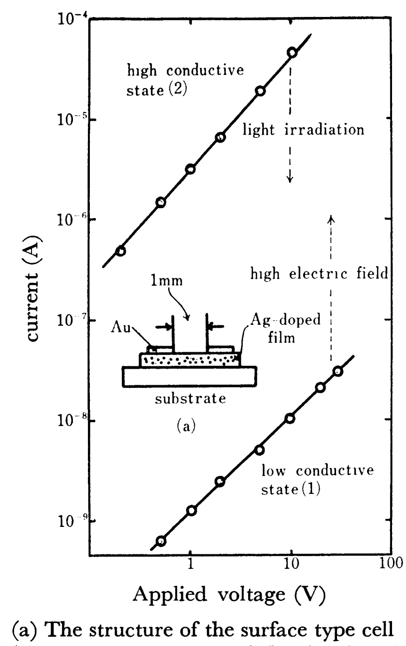

Fig. 1. (a) The structure of the surface type cell
(b) I-V characteristics of the Ag doped chalcogenide film

From observation with a microscope, the high-conductive state was found to be attained by the formation of a "conductive path" between the electrodes. When a high voltage was applied to the cell in the (1) state, the boundary of the negative electrode and the glass film began to darken, and then "branchlike" paths began to grow from the electrode. A microscopic photograph of the path is shown in Fig. 2. These paths stretched toward the positive electrode; high-conductive state (2) was attained when one of the paths reached the positive electrode. Upon the light irradiation, the path faded away and, at the same time, the electrical conductivity returned to the lower state (1). These results indicate that the formation and the disappearance of the "conductive path" caused the memory effect.

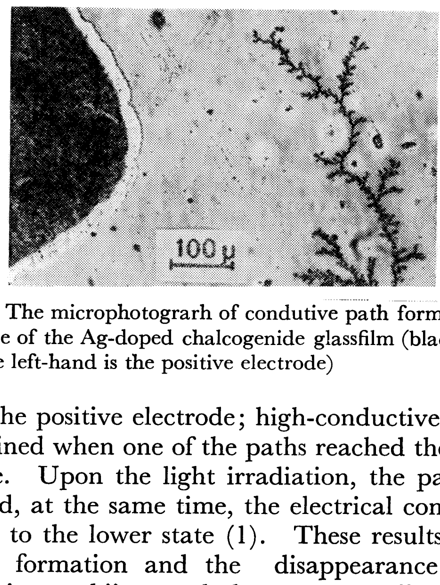

Fig. 2. The microphotograrh of condutive path formed in the surface of the Ag-doped chalcogenide glassfilm (black region on the left-hand is the positive electrode)

This photo-erasable memory effect is similar to the memory effects in chalcogenide glasses reported in other papers recently,[3–5] but the doped Ag is thought to play an important role in this case. At the present stage, the mechanism of the formation of conductive path is not clear in detail, but ionic process (such as the reduction of Ag^+, which is supposed to exsist in the chalcogenide glass) is suggested by the fact that the conductive path always grows from the negative electrode. The path is expected to have an Ag or Ag-rich composition. Its disappearance upon light irradiation can be considered to be connected with the optical diffusion of Ag into chalcogenide glasses.

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