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Characteristics of New Thyristors

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I. Introduction

Two new types of thyristors have been fablicated. One is a static induction thyristor (S.I.thyristor) shown in Fig.1, which has a similar gate structure to the static induction transistor (SIT) proposed in 1950[1]) and realized in 1970[2]) by J.Nishizawa. The other is a beam base thyristor (B.B.thyristor) shown in Fig.2, regarded as an intermediate type between the S.I.thyristor and a conventional four-layer thyristors. Both types of new thyristors have beam-regions containing high impurity contents in the base regions.

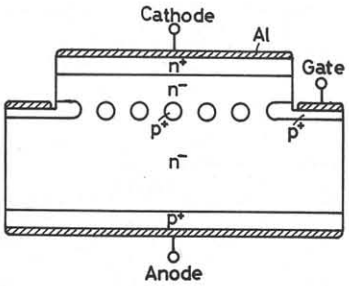

Fig. 1

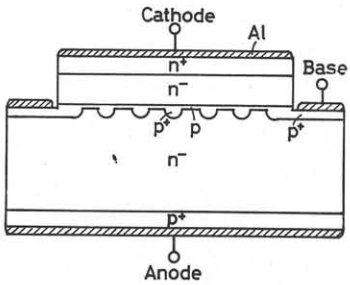

Fig. 2

II. Experiment

New thyristors was fablicated through similar process to those for the static induction transistor with an embedded gate regions such as a selective impurity diffusion and an epitaxial growth. Figures 3 and 4 show examples of the static and the switching characteristics of the S.I.thyristor. It is normally in "on-state" and turns to "off-state" by applying a negative gate bias voltage. The best data of the turn-off time is less than 0.5 μsec. While the B.B. thyristor acts by the conventional trigger and moreover in fast switching time less than 1 μsec. The switching characteristics were measured by the testing circuit shown in Fig.5, applying the d.c. voltage between the anode and the cathode, and the negative pulsive voltage to the gate. In figures, suffixes A,K and G show the positions of the anode, the cathode and the gate respectively.

Figure 6 shows the relation between the turn-off time t_{off} and the gate voltage V_G with a parameter

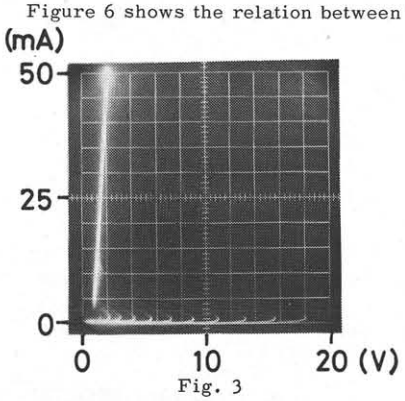

Fig. 3

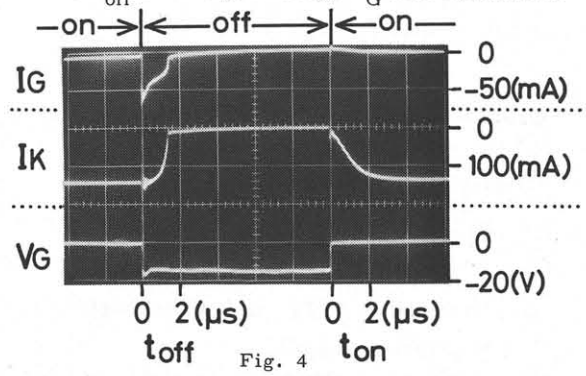

Fig. 4

of the cathode current density J_K. Increasing J_K, the gate voltage that is necessary for turn-off increases. Figure 7 shows the similar curves to Fig.6 but with the parameter of the external resistance of the gate R_G. Increasing R_G, the gate voltage for turn-off increases, and at the same time, a necessary peak value of the gate current decreases, and the product of both values increases.

III. Discussion

These new thyristors seem to act with quite different mechanisms of switching from the conventional thyristor. That is the carrier control by varying potential barrier in the depletion region between beams of the gate made by the negative gate bias. And because of the beam structure of gate regions heavily doped with impurities, the lateral resistivity and the parasitic capacitance are very small, which make the R-C time constant very small, and the switching speed of thyristors expremely fast. Moreover, excess of the carriers stored in the devices is drawn by the gate bias, so that this action also makes turn-off time short. In addition, these switching mechanisms makes the necessary power to the gate for turn-off very small, and also, they can have a new ability to cut off the d.c..

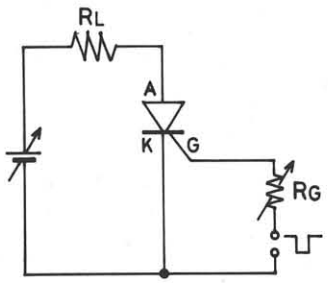

Fig. 5

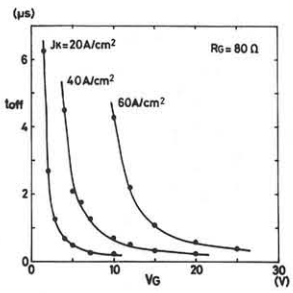

Fig. 6

IV. Conclusion

The S.I. thyristor and the B.B. thyristor, who belong to the SIT family devices, have a lot of merits, such as the very fast switching, the very low control power and the d.c. cutting. And when the area of the device is enlarged, these desirable merits can be maintained using the strain compensation technique in heavily-doped region[3]) and the epitaxial growth of highly pure crystal[4]).

Therefore these new thyristors should be useful in high-speed and high-power switching uses.

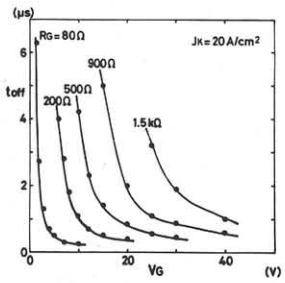

Fig. 7

References

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(2) J.Nishizawa, T.Terasaki and J.Shibata, IEEE Trans. Electron Devices, ED-22 (1975) 185.

(3) J.Nishizawa, T.Terasaki, K.Yagi and N.Miyamoto, Proc. Seoul Int. Conf. Electrical and Electron. Eng. (1970) 239.

(4) H.Nihira, T.Shirasu, T.Terasaki and J.Nishizawa, J. Electrochem. Soc., 122 (1975) 781.