B-6-4 "Integrated Photo-coupled Semiconductor Crosspoint Switches"

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Recently, fully electronic telephone switching system using integrated high voltage semiconductor crosspoint switches have been developed.[1~3] These switches consist of thyristors and control circuits. The thyristor and the control circuit are coupled electrically or optically.[3] Optical coupling is superior to electrical coupling, because the control circuit is not disturbed by accidental electric surges in the speech path, neither is noise generated in the speech path by the drive current.

On the other hand, the photo-coupled switch has a difficult problem ; that is a trade-off between a gate trigger power and an allowable dv/dt of the thyristor. This problem becomes more difficult in highly integrated photo-coupled switches. In this paper, new techniques are presented to solve this problem.

In the first place, a mounting structure suitable to highly efficient photo-coupling has been developed. In order to increase the photo-coupling efficiency, a highly radiant light source and an accurate positioning of elements are necessary, because the area of the light sensitive region is very small in highly integrated circuit. Figure 1 shows a cross-sectional view of the newly developed device. The ceramic substrate consisted of two layers. GaAs LED's were mounted on the lower metal layer and a silicon chip was mounted on the upper metal layer. A transparent resin was filled between the elements. The silicon chip was dielectrically isolated IC and included light activated thyristors. The surface vertical to the junction of LED was opposite to the thyristor, because the light emitted from this surface was more highly radiant than that emitted from the surface parallel to the junction. For easy and accurate mounting, several thick metal electrodes were fabricated on the surfaces parallel to the junction of LED. The LED was face-down- bonded on the lower solder pedestals by these electrodes.

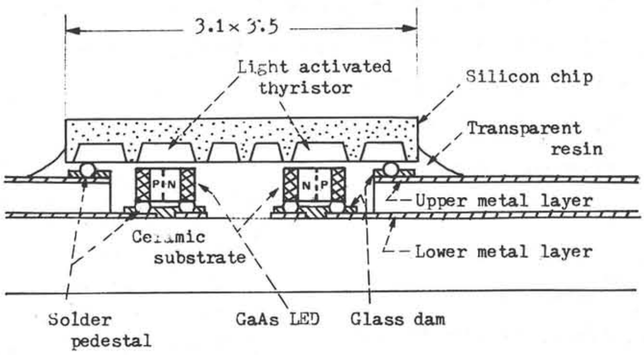

Figure 1 Cross-sectional view of the photo-coupling portion.

The silicon chip was also face-down-bonded on the upper solder pedestals by the solder ball. Each solder pedestal was provided between glass dams which prevent solder from flowing out during bonding. Even if the elements are placed on the pedestals incorrectly, these are automatically and accurately aligned to the correct position by the surface tention of the solder during bonding. Thus, high photo-coupling efficiency was achieved.

A trade-off between the triggering sensitivity for light and the allowable dv/dt of the thyristor was improved by the following method. Figure 2 shows a unit circuit of the device. Transistor Q1 is driven by a current induced through a change in the anode voltage of the thyristor. Thus, the dv/dt capability of the thyristor increases. The transistor Q2 is a photo-transistor and prevents Q1 from being driven by any stray light. When the triggering gate current drives the LED, the light emitted from the LED drives the thyristor and Q2 simultaneously. Thus, Q1 cannot act, since the emitter junction of Q1 is shorted by Q2, and the triggering sensitivity of the thyristor does not decrease.

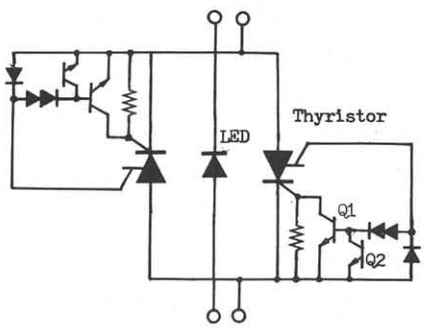

Figure 2 Circuit of the photo-coupled crosspoint switch.

Table 1 shows the electrical characteristics of the device which integrates the four circuits shown in Figure 2. The isolation voltage between the speech path and the control circuit is high as compared with the current coupled crosspoint switch as shown in that table. The trade-off between the gate trigger power and the allowable dv/dt has been improved significantly and the device is seen to be fit for practical application sufficiently.

Table 1 Electrical characteristics

Parameter	Result
Blocking voltage	±250～270 V (at 10 μA)
Average current	200 mA
On-state voltage	1.10～1.15 V (at 50 mA)
Triggering gate current	15～30 mA (at V_{AK}=10 V for 4 thyristors)
Triggering gate voltage	1.12～1.16 V (at V_{AK}=10 V for 4 thyristors)
Static dv/dt	>1000 V/μs (at V_{AK}=±200 V)
Isolation voltage	>1000 V

References

1) M.Tokunaga et al : ISS-76, 221-4
2) Y.Suzuki et al : ISS-76, 243-1
3) N.Akiyama et al : presented at the Technical Meeting on Electronic Exchange IECE Japan, SE77-39, Sept. 1977.