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The Bulk Charge Transfer Device

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In any charge transfer devices[1),2)], such as the BCD[3)], that transfer the majority carriers inner the bulk of the semiconductor, the fringing field E_f formed by the potential difference between neighbouring electrodes is large as compared with that in the CCD, and hence strongly contributes to high speed charge transfer needed in the video applications.[4)]

The fringing field is by more than 10 times stronger in the BCD and is dependent on the electrode length, the channel depth and the channel impurity concentration. The effect of the fringing field becomes most prominent in charge transfer when the field exceeds 1×10^2 volts cm^{-1} at the middle of the electrode. In Fig. 1, the charge transfer characteristics of the BCD having a channel thickness of 1 um are shown with that of the CCD with and without the fringing field for comparison. The transfer inefficiency in high frequency may become smaller with a deeper channel depth at the cost of significant decrease in signal charges. For most applications, a channel depth of 0.5 to 1 um and a channel dose of 1 to 2×10^{12} cm^{-2} are likely practical by adding a claim to treat an enough amount of signal charges with a clock voltage swing of under 10 volts.

Now, the device structure with Al electrodes overlapping poly Si electrodes has come more and more into use because of its outstanding device stability and ease of forming properties.[5)] Fig. 2 shows the structure of such electrodes. In order to attain higher packing density, an improved structure of self-aligned electrodes was reported.[6)]

In our laboratory, experiments have been undertaken on 128 element BCD video delay lines. Two phase and three phase BCDs with the self-aligned electrodes and with the overlapping electrodes were fabricated for comparison. A 4 MHz signal band-width with a signal to noise ratio of 42 dBs was obtained at 10 MHz operation with a clock voltage swing of 10 volts. The devices were also operated with a transfer efficiency of 99.95 % at higher frequency even over 20 MHz. The signal ~~stroage~~ storage time T_s of the BCD is mostly determined by the GR current generated at the Si/SiO_2 interface on the depleted channel layer and strongly depends on fabrication conditions.[7)] T_s obtained was spread over 1 to 10^{-2}s at room temperature.

Another excellent performance with a similar device named the PCCD was reported.[8)] A transfer efficiency of 99.98 % was attained with the PCCD having a profiled channel structure.

In conclusion, the BCD must be acclaimed as one of the key elements in the future video and computer applications.

References

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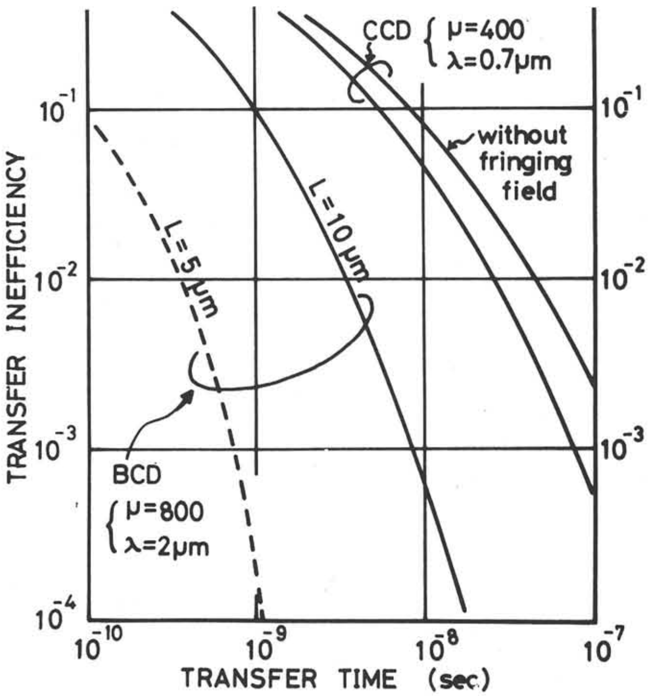

Fig. 1 Charge transfer characteristics of the BCD and the CCD (computed).

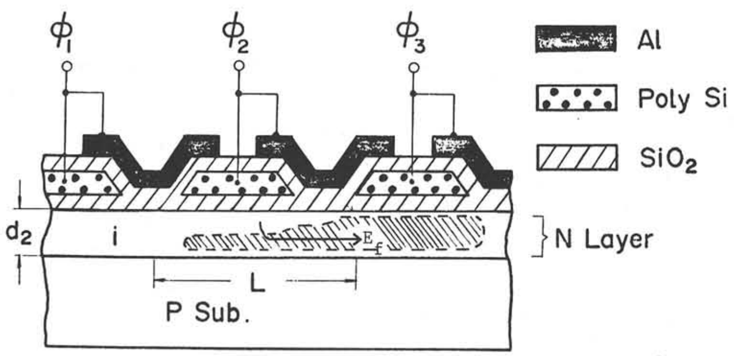

Fig. 2 Schematic cross-sectional view of the overlapping electrodes BCD.