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A—2—3 Photocurrent-driven B-MOS Without External Power Supply

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In order to realize miniaturization of integrated circuits, exploitation of low-power devices is needed. Along this line, a new low-power device has been proposed, which uses the back gate of an MOSFET as the input terminal and the insulated gate as a bias terminal, contrary to the ordinary mode of MOSFET operation. The new device is named back-gate-input MOS(B-MOS). It operates with supply voltages less than 0.5 V and at current levels in the region between 10^{-9} and 10^{-6} A[1]. Therefore, the B-MOS can operate on a small-size photo-cell. Moreover, as demonstrated in this paper, it is possible to construct a B-MOS circuit with a built-in power supply. Such a circuit is driven by the photocurrent flowing across the built-in junction when illuminated.

When the B-MOS is irradiated with light, a forward-biasing current source is formed between source or substrate and back-gate terminal, as shown in Fig. 1. The current was about 10^{-7} A in a 20 x 80 μm photo-cell at a tungsten light intensity of 3000 Lux. Thus, the B-MOS can operate using power derived from absorpted light without an external power supply. A similar light-powered operation is known in integrated injection logic(IIL)[2].

The oscillation waveforms of a ring of 21 stage inverters obtained for different luminous intensities are shown in Fig. 2. Oscillation frequency increases with the increase in light intensity. Propagation delay time per gate of the B-MOS and IIL was measured as a function of light intensity using inverter chains. The results are shown in Fig. 3. The propagation delay time in either device is inversely proportional to light intensity. Thus, the B-MOS is about ten times faster than an IIL. The difference in the delay time between the B-MOS and IIL is explained by the difference in operating voltage and junction capacitance.

Therefore, the photocurrent-driven B-MOS provides logic circuits, which operate on the energy of incident photons, with a very high conversion efficiency. Such circuits will advance the concept of solar-cell powered IC's and integrated photo-detector arrays.

References

1). S. Asai, T. Masuhara and T. Nakamura, Technical Digest, 1976 IEDM, 185(1976).

2). K. Hart and A. Slob, IEEE J. Solid State Circuits, SC-7, 5, 346(1972).

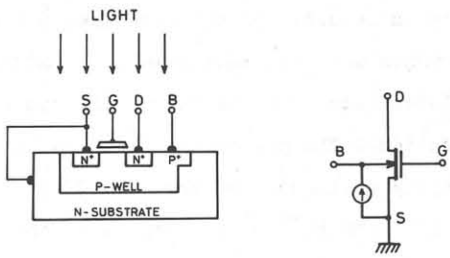

Fig. 1. A B-MOS irradiated with light. Current source is formed across the junctions between source or substrate and p-well.

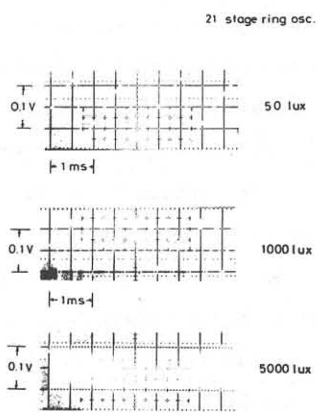

Fig. 2. Oscillation frequency of B-MOS inverter irradiated with light.

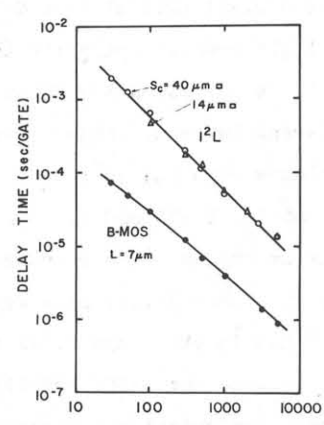

Fig. 3. Delay time per gate B-MOS and IIL as a function of light intensity.