

COMMENT

EXISTENCE OF ONE-DIMENSIONAL PERFECT BINARY ARRAYS

A recent letter claims to prove that the only perfect binary sequence has length four. The proof is not correct.

The main result in Xian's recent paper¹ is the following theorem.

Theorem: There exist no two-dimensional cyclic Hadamard matrices of size $m \times m$ for any m greater than four.

This result has long been conjectured, see for example section IV.C of Baumert's book.² There are also important corollaries to the 'theorem' which are not noted by Xian, such as the nonexistence of Barker sequences of length greater than 13; for further details see Reference 2.

The proof of the 'theorem', given in an Appendix to the letter, is flawed in part (2) of the proof of subsidiary lemma 2. The sentence beginning 'Because $b_i = 0$ or 1, the length of every term ...' purports to show that a product of terms b_i must be zero. This is not the case. We construct a counterexample as follows.

Let $k = 4$, and hence $l = 6$. Consider the sequence

$$(b_i) = (1 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1 \ 1 \ 0 \ 0 \ 0 \ 0 \ 0 \ 0) \quad 1 \leq i \leq 16$$

Let i_j ($1 \leq j \leq 16$) satisfy

$$i_j = \begin{cases} 1 & 1 \leq j \leq 9 \\ 7 & 10 \leq j \leq 16 \end{cases}$$

Then the terms b_k for k satisfying

$$k = i_j \quad \text{and} \quad k = i_j + j$$

are all equal to 1, and hence the product of these terms is nonzero. We have therefore constructed a counterexample.

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References

- XIAN, Y. Y.: 'Existence of one-dimensional perfect binary arrays', *Electron. Lett.*, 1987, **23**, pp. 1277-1278
- BAUMERT, L. D.: 'Cyclic difference sets' (Springer-Verlag, Berlin, 1971)

THROUGH-WAFER OPTICAL INTERCONNECTION COUPLING CHARACTERISTICS

Indexing terms: Optical connectors and couplers, Optical receivers, Crosstalk

Both the optical coupling and resulting optical crosstalk characteristics for LED-based through-wafer optical interconnections have been measured within a simulated stacked wafer environment. Using integrated SiO_2 Fresnel phase plate lens arrays, a nearly 4:1 improvement in received signal was noted over the configuration without lenses. Interchannel crosstalk measurements indicate that from an optical standpoint, high interconnect densities ($250\ \mu\text{m}$ pitch) are obtainable with reasonable noise margins over a range of distances of interest for stacked wafer architectures.

Stacked wafer architectures using both full and hybrid wafer-scale integration (WSI) are being explored both for signal processing and for more general-purpose computing

applications.^{1,2,3} Vertical free-space optical interconnections between wafers have the potential to provide connectivity without the repairability and reliability difficulties presented by mechanical connections. Through-wafer free-space optical links have been proposed as one approach to achieve noncontact optical interconnections between wafers within stacked wafer modules.⁴

This letter presents experimental optical crosstalk and coupling measurements obtained from through-wafer optical interconnections within a simulated hybrid-WSI environment. The experimental wafer configuration is shown in Fig. 1 and

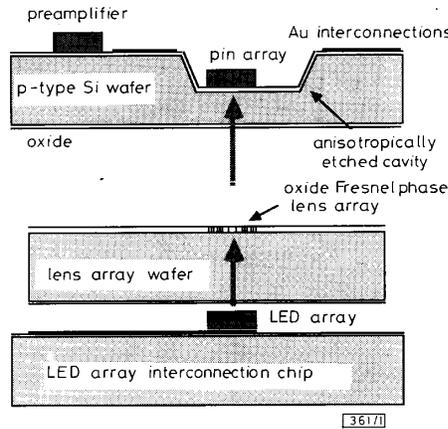


Fig. 1 Experimental test environment simulating a stacked wafer module

consists of a separate transmitter, lens and receiver wafer. Fresnel phase plate lens arrays described previously⁵ were fabricated in the thermal oxide of a separate silicon wafer. The $1.3\ \mu\text{m}$ wavelength, GaInAs/InP 1×12 LED array with $250\ \mu\text{m}$ device spacings⁶ was bonded to a Au fanout on a silicon substrate, and driven from an external pulse generator. The receiver wafer was composed of a simple preamplifier circuit with a Signetics 5212 transimpedance amplifier hybrid mounted along with the GaInAs/InP detector array.⁷ A $100\ \mu\text{m}$ -deep cavity was anisotropically etched in the (100) p -type wafer using ethylene-diamene-pyrocatechol (EDP) and the detector array mounted in it.

Coupling measurements were first taken with the lens wafer removed and the receiver wafer placed $\sim 200\ \mu\text{m}$ from the LED array. Fig. 2 shows the received signal with the LEDs at positions 1 and 3 biased with 60 mA and the LED at position 2 turned off as a single detector is linearly scanned over them. Considerable crosstalk is evident and it is only at interconnect densities of $\geq 1\ \text{mm}$ that distinct channels can be discerned. The same experiment was then performed with the lens wafer in place, as in Fig. 1. Measurements were made with the

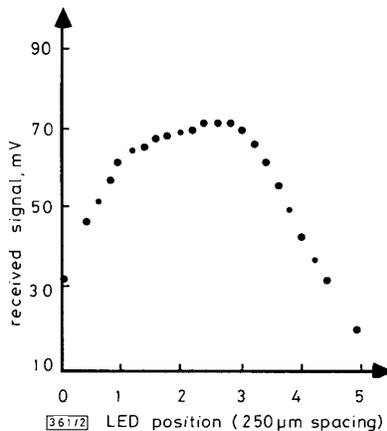


Fig. 2 Received signal against linear detector scan with lens wafer removed and receiver wafer 0.2 mm from LED array LEDs at positions 10 and 30 are biased