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Invited

Large Area Circuit Network

Eiji Kaneko

Giant Electronics Research Laboratory, GTC Corporation
Higashi Nihonbashi Sato Bidg., 1-6-5, Higashi Nihonbashi
Chuo-ku, Tokyo, 103, Japan

"Large Area Circuit Network" refers to complicated electronic devices, and active circuits technology, in which a great number of thin film transistors and passive elements are fabricated on a large area substrate. The circuit is sometimes referred to as "Giant Electronics". The necessity of giant electronics for human activity, problems encountered in their realization, and several techniques for solving these problems will be discussed in this paper.

Introduction

"Giant Electronics" are the opposite of "Micro Electronics". In this technolgy, a great number of electronics devices are fabricated on a large area substrate.

The substrate is usually not a silicon wafer, but glass having an area of more than $1m^2$. Quite a large number of TFTs (Thin Film Transistors) are sparsely mounted on the substrate to construct the giant sized electronic network.

1. Necessity for giant electronics

With the invention of germanium transistors in the mid 1940s, electronic engineers said good bye to bulky vacuum tubes and introduced the tiny transistors for its main active elements. Since that time, engineer have made efforts to miniaturize the size of active devices and peripheral circuit components, and electronics devices are being miniaturized annually.

However, efforts to improve electronics technology are directed not only toward miniaturization of the circuits. There are, at least, three areas of demand in which giant electronics are required.

A. Demand for machine operation ability

There are minimum sizes for computer keyboards because they are manually operated. For instance, it is not convenient to use a wrist watch mounted tiny calculator which has a very small keyboard and requires operation with a pencil point.

On the other hand, only very simple orders are acceptable for communication between a human and music instruments using pedal action.

The optimum sizes are definitely determined according to the sizes of human appendages, like feet and hands.

B. Demand for human visual ability

There is a minimum solid angle in viewing a TV screen image. The viewer cannot recognize the image precisely if the angle is too small and the image is much too complicated.

C. Matching between machine and human resolution of sensing

In printing, it is meaningless to reproduce extraordinarily precise images which cannot be resolved by human eyes.

The characters and image information input to a copy machine are usually output from printed materials which can be read by humans. Therefore, there must be a size matching between read-ability by the human eyes and that of the image pickup part of the copy machine.

2. New fabrication process of TFTs

A. Engineering limits of photolithographic process

Usually LSIs are fabricated using photolithographic technology. A stepper is repeatedly used to expose partial circuit patterns, changing the relative exposing position gradually on the wafer, and the whole circuit pattern is synthesized on that wafer when an LSI is fabricated.

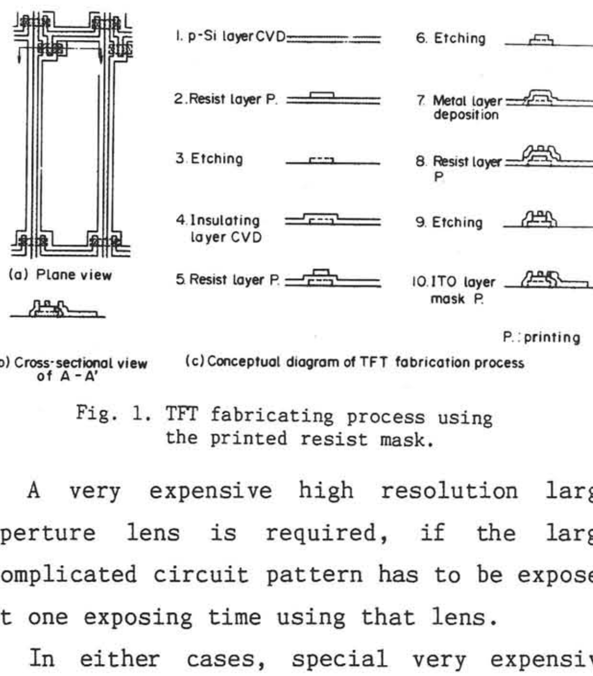


Fig. 1. TFT fabricating process using the printed resist mask.

A very expensive high resolution large aperture lens is required, if the large complicated circuit pattern has to be exposed at one exposing time using that lens.

In either cases, special very expensive production equipment must be developed if giant electronics network were fabricated using such a traditional photolithographic technology.

B. Etching process using printed resist film mask

In order to solve the previously described problems, it is preferable to replace photolithographic processes by other process. One possible candidate for removing the stepper from the exposing process would be to use printing masks.

Fig. 1 shows an example of the TFT fabrication process using the printed resist masks.

C. Precision of present printing technology

Presently, a screen printing method is used in fabricating printing circuit boards. The maximum precision attainable with this method is about 30 μm.

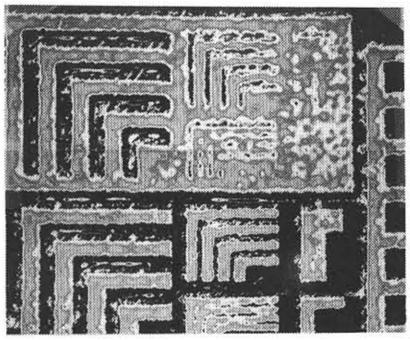


Fig. 2. Example of screen printed etched pattern.

Each corner of the presently available printed pattern becomes rounded, having a curvature radius of more than 30 μm with this method, as shown in Fig. 2. There are many invisible zigzag portions at the pattern periphery.

The maximum precision attainable with an intaglio printing or an off-set printing method on paper is regarded as about 20 μm. However, it is very difficult to remove pin-hole defects from the printed pattern.

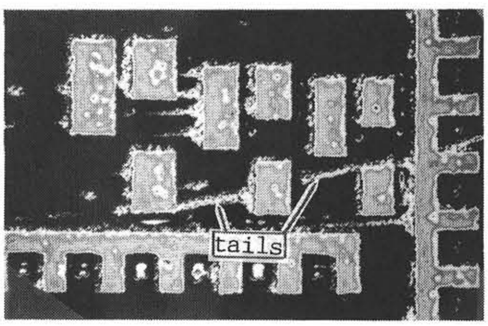


Fig. 3. Example of off-set printed etched pattern.

When the off-set printing method is used, tails sometimes occur on printed patterns in the direction of the printing as shown in Fig. 3.

It is necessary to decrease the positioning errors which occur in each printing step, if the multi-printing method is used to construct TFT circuits.

D. Printing ink

Some suitable resist ink should be developed in order to obtain good printing mask patterns. The amounts of pin-holes, zigzags, and tails are affected by the adhesion property and viscosity of the ink used.

Above all, some new ink and printing method, by which very precise patterns can be obtained, should be developed in order to fabricate TFT circuits which have excellent performance.

3. Application fields of giant electronics

A. Liquid crystal TV display panel

The TFT addressed liquid crystal TV display panel is the most suitable application

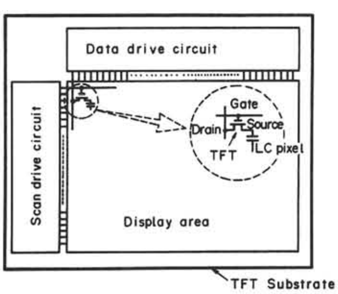


Fig. 4. Circuit configuration for TFT addressing LC-TV display panel.

field of giant electronics. Fig. 4 shows an example of the circuit configuration in such a panel. The main portion of the circuit is an image display area. This portion consists of more than 10^6 switching TFTs and the same number of transparent pixel electrodes. There are data and scan TFT driving circuits at the top and the left of the panel, respectively. There are more than 4×10^3 TFTs in these portions. The total area occupied by all these TFTs is about 5 - 10 % of the whole substrate area. Therefore, the TFTs are distributed very sparsely on the substrate.

B. Image sensing and printing array

Fig. 5 shows a schematic construction of an image pick-up part of a copy machine.

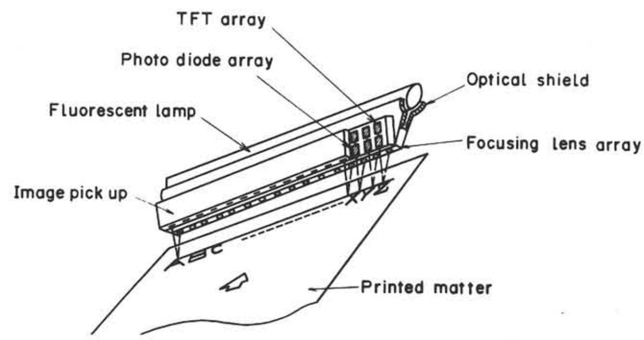
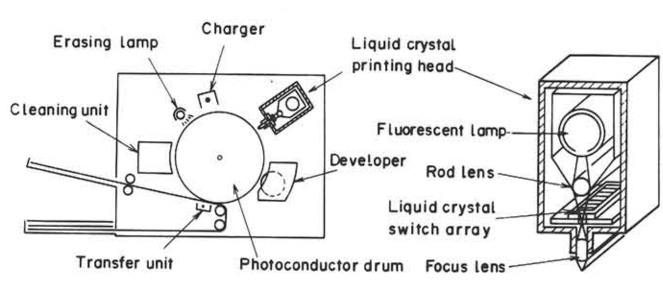


Fig. 5. Construction of an image pick-up part of a copy machine.

A light, from a fluorescent lamp, is separated into many light beams and focussed onto a printed material through a focusing lens array. An image sensor, an photo diode array, is mounted on a substrate. The reflected lights are picked up by individual diode. The array accompanies a TFT switching array which scans the operation of the diodes. There are more than 2×10^3 TFTs and diodes.



(a) Printer (b) Printing head

Fig. 6. Construction of copy machine and LC printing head.

The TFT array can also be used in xerographic copy machines as a light switch array for exposing image on a photoconducting drum, as shown in Fig. 6. The array consists of liquid crystal cells and corresponding TFT switches. The latter controls the amount of light beams passing through the corresponding cells.

C. Two-dimensional parallel operating optical computer

In Fig 7, two TFT matrix addressed liquid crystal panels are independently controlled regarding their light transimission of individual pixels with input sigal A and B.

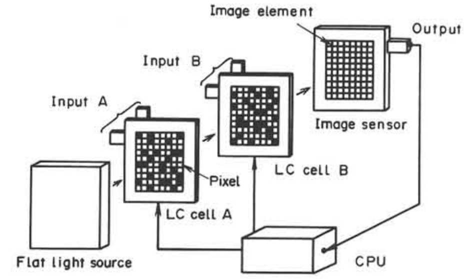


Fig. 7. Construction of a matrix liquid crystal two-dimensional parallel signal processing system.

Individually modulated light beams hit corresponding individual image element on a matrix image sensor. Then, the output of the sensor is fed to the CPU.

4. Special problems and techique to be solved in producing giant electronics.

A. Mechanical distortion of the panel during fabrication.

The minimum requirement for manufacturing precision in a TFT is about 10 μm.

Therefore, the total manufacturing precision of the pattern on the glass substrate, such as having 1 m^2 area, should be higher than 10 μm/1m. This value corresponds to a thermal change of less than 1 °C change over the glass substrate assuming a thermal expansion coefficient of 5×10^{-5}/°C.

B. Repair of defective portion

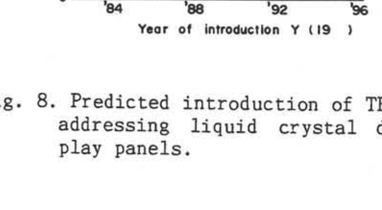


Fig. 8. Predicted introduction of TFT addressing liquid crystal display panels.

Fig. 8 predicts demand to increase the panel size in the near future. The number of defective portions on the substrate also will increase as the circuit area becomes larger.

Some method must be developed to rescue defective areas in order to increase product yield rate. For instance, a repair technique, such as laser trimming of bridged portions of the circuit (short circuit) should be developed in order to allow use of as many panels as possible.

C. Addition of redundancy to the circuit

Application of redundant technology to the circuit design is also important in order to increase yield rate of giant electronics circuits. A special redundant circuit pattern, which meets printing technology limitations, must be developed in order to increase the product survival rate.

Conclusion

There are many fields in which giant electronics are effective. It is, however, very difficult to fabricate such devices using the traditional photolithographic fabrication process.

The giant electronics circuits will be fabricated at low cost if the printing resist mask fabricating process can be used.

Redundancy circuit design and defective part repair techniques should be developed in order to obtain giant electronics in high yield rate with low cost.

The author would like to thank all GTC researchers for their enthusiastic efforts to develop giant electronics.

References:

1) E. Kaneko: "Liquid crystal TV displays" (Book) KTK/Reidel Scientific Pub. Co., Tokyo, London, Amsterdam, 1987

2) M. Kaji:"Printed image". (Book: in Japanese) Printing Soc., Tokyo, 1988