Shadowmask-controlled circuit fabrication – an obsolete technology resurrected

T. Peter Brody

Abstract

Advantech has revived the shadowmask process of manufacturing TFT circuits, which promises low cost, in-line system fabrication of active matrix backplanes and other circuits. We discuss the philosophy and justification of the revived process and report on initial results of color AMOLED and e-paper backplanes.

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Technical Summary

The pioneering active matrix work at Westinghouse in the ‘70s used adjustable shadowmasks to create the world’s first active matrix addressed liquid crystal and electroluminescent panels [1,2]. Since Westinghouse’s abandonment of the project in 1978 (“unprofitable”), the subsequently emerging fabrication technology reverted to conventional photolithographic processing.

Modern shadowmasks, consisting of electroformed Ni foils, when properly mounted, allow us to generate evaporated patterns of +/- 1 micron accuracy and 5 micron size over areas of 8”. Thin film electronic circuits, consisting of superimposed patterns of metals, insulators and semiconductors, can be formed on a substrate by successive evaporation of the materials, in superimposed patterns defined by appropriately designed shadowmasks, such that complete electronic circuits, for example active matrix backplanes, can be built.

Currently we use a single high vacuum chamber, into which we place a target substrate, appropriate masks and suitable materials, to be evaporated by a focused e–beam gun. The masks are successively placed under the target substrate, aligned with a +/- 1 micron accuracy, and held in contact by magnets located behind the substrate.

The masks define the patterns of the chosen materials, which, accurately superimposed, form completed circuits. A quartz crystal thickness gauge continuously monitors film thicknesses and deposition rates, and a computer program controls.the entire process. The finished circuit, for example a backplane designed to drive OLED panels, is removed from the vacuum system for annealing and further processing, such as inspection, random device testing and attaching line and column driver chips to tested good circuits.

The present fabrication process is lengthy and cumbersome, since we have only one deposition system in which all the levels of the circuit are formed. We are currently designing an in-line fabrication system, in which each

circuit level is deposited in a dedicated chamber, with all chambers operating simultaneously, in a loose analogy of a multicolor printing press. Such an in-line system, the first one of its kind, will be capable of a finished circuit TAC time of 5 minutes. The in-line deposition system will essentially constitute the entire factory, with some ancillary facilities like substrate/mask inspection and cleaning, final testing and packaging.

Such a factory can replace the enormous complexities, large footprint, need for large Class 1 cleanrooms and attendant huge costs of a contemporary semiconductor plant. As the technology develops, it will be able to produce thin film circuits of progressively larger sizes at a fraction of he cost of photolithographically produced circuits, as our cost analysis shows. Admittedly it will not have the versatility of a photolithographic process, but will be eminently suitable for fabricating display backplanes and similar circuits (as reported in a companion paper).

Currently the most complex circuit fabricated by our technology is a 4" diagonal, 100 dpi color OLED backplane, in which the color subpixels, consisting of two TFTs, a storage capacitor and an output terminal, measure 83 x 250 microns, 960 x 240 subpixels forming a QVGA image. We have a design for a 200 dpi full VGA backplane, currently being reviewed by our mask fabricator.

References

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