The inspection of open defects in a TFT-LCD panel by using an low energy electron microcolumn

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The demand on the electron beam (e-beam) for the inspection of semiconductor devices or display panel is rapidly increasing since e-beam can not only monitor the small structures but also has the potential of detecting electrical troubles or repairing the defects. However, the merit of e-beam is limited because of the high cost, low throughput, and the possible damages due to the high e-beam energy. A microcolumn is a strong candidate to solve these limitations as its size is extremely miniaturized (both column diameter and height can be reduced down to a few mm) and the output e-beam energy is as low as 100~1000 eV.

In this work, we tried to test the inspection of defects by applying a microcolumn to LCD panel. In order to demonstrate our inspection method, we extracted a 7" TFT-LCD panel from the production line just after completing the pixel structures and used this panel as a test sample. On the selected panel, we intentionally made some defects such as open data or gate lines by cutting some points using a laser beam. The optical microscope image of the test panel and open defects are shown in Fig. 2, and Fig. 3 presents the schematic diagram of an unit pixel and its equivalent circuit.

We operated our microcolumn with 300 eV e-beam energy and obtained the scanning images of the panel while operating the panel with specific operation conditions. The operation parameters for the test TFT-LCD panel such as the voltages applied to the gate lines, data lines and storage capacitors was fixed at two specific sets of values. Then, the image obtained by the secondary electron reflects the informations on the electrical state of the pixels as well as the geometrical ones. A typical example obtained at the panel operation condition (1) is presented in Fig. 4(a). Panel operation condition (1) is as follows; (i) -5 V and +20 V was applied to the odd and even numbered gate lines, respectively, (ii) odd and even numbered data lines were grounded and floated, respectively, and (iii) -3 V was applied to the storage capacitor. Fig. 4(b) schematically illustrates the situation of secondary electron generation at each pixels based on the whole equivalent circuit considering the open defects introduced in Fig. 2. In Fig. 4(a), almost all of the horizontal and vertical lines showed a regular behavior in contrast, black lines for the odd numbered lines and white ones for even numbered. However, we could observe irregular behaviors from some of the points as denoted by D3, D4, or G7, G9, etc. These irregular behaviors are thought to be originated from the existence of the open defects. In addition, we observed similar data with different panel operating condition also. By combining the two sets of data, we could explain the correlation between the irregular behavior in the image contrast and the open defects and the detailed results will be discussed.

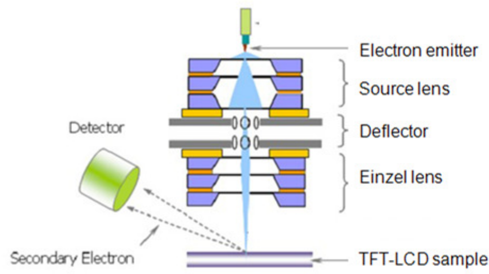

Fig. 1. The structure of a microcolumn and the detection principle of a secondary electron

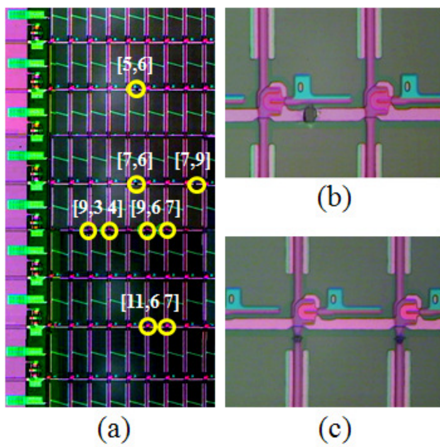

Fig. 2. (a) Optical microscope images of the test 7" TFT-LCD panel and the intentionally introduced defects. Enlarged images of an open gate line (b) and an open data line defect (c).

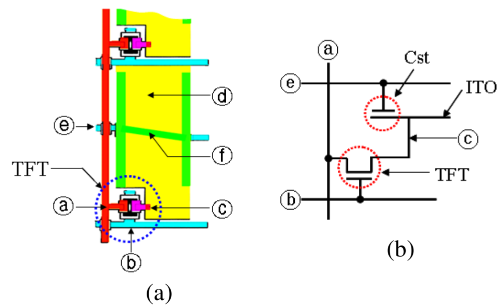

Fig. 3. The schematic diagram for a unit pixel (a) and its equivalent circuit (b). ⓐ source electrode ⓑ gate electrode ⓒ drain electrode ⓓ ITO ⓔ electrode for storage capacitor, ⓕ storage capacitor (Cst)

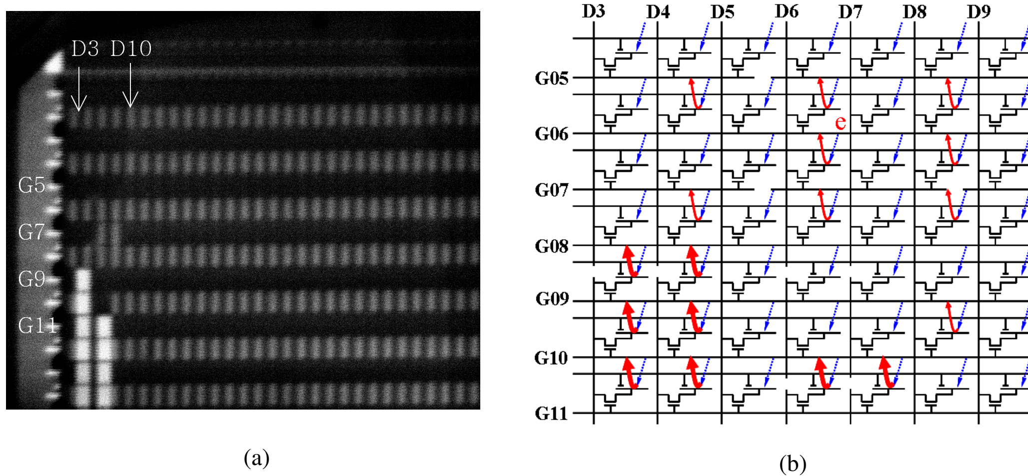

Fig. 4. Typical example of the SEM image obtained with the panel operating condition (1) and the schematic illustration of the secondary electron generation at the pixel based on the equivalent electric circuit.