Reduction of the Leakage Current of Thin-Film Transistor on Metal-Induced Laterally Crystallized Polycrystalline Silicon

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Metal-induced laterally crystallized (MILC) polycrystalline silicon (poly-Si) is a promising material for fabricating thin-film transistor (TFT) based active matrix on glass substrate. From the nickel distribution in the different region of MILC poly-Si thin film shown in Figure 1, it is clear that nickel concentration is the highest within the MIC region and the lowest within the MILC region. The nickel concentration at the MILC front is much higher than that within the MILC region. This implies that MILC poly-Si resulting from non-patterned a-Si thin film will have different states of crystallization and different distribution of nickel concentration, when compared to that resulting from patterned a-Si island with edge confinement. The effects of switching the order of island patterning and lateral crystallization were studied.

Two types of TFTs were fabricated in the same process, one (Type A) with active islands formed before MILC and the other (Type B) with active islands formed after MILC. Both types of TFTs exhibit high mobility of ~100cm^2/Vs, steep sub-threshold slope of ~ 0.5V/decade and low threshold voltage of <5V. However, leakage current was found to be reduced when metal-induced lateral crystallization was performed prior to transistor island formation.

Shown in Figure 2 is the dependence of the average minimum leakage current per unit channel width at V_d=-5V and the average leakage current per unit channel width at V_d=-5V and V_g=5V on the channel width. It can be seen that the average leakage current per unit channel width of Type B TFT is much lower than that of Type A TFT. This is particularly true for TFTs with small channel width of 2 and 3μm. The difference between the leakage current per unit channel width can be almost 2 orders of magnitude.

It is presently suggested that the difference in leakage current behavior of the two types of TFTs is caused by the different residual nickel concentrations in the active channels.

For Type A TFT, the MILC front with high nickel concentration moves with the crystallization front and stops at the edge of an active island. Although the TFT channel is located within the MILC region, nickel residing on the left and right side of the active island diffuses back into the TFT channel during subsequent thermal treatments, such as dopant activation. Moreover, the lateral edges of the channel also function as MILC front stopping edges, where the nickel concentration should be higher than that within the TFT channel. The higher nickel concentration causes higher leakage current.

Furthermore, convergent flux of nickel into the channel occurs when the channel width is smaller than that of the crystallization-inducing window. Consequently, nickel concentration within the channel increases with decreasing channel width, that results in an increase of the average leakage current per unit channel width.

For Type B TFTs, the movement of an MILC front is not constrained by any edge of an a-Si island. Consequently, an MILC front moves freely, unless it collides with another MILC front. By confining TFT active islands within a high quality MILC region, MILC/MIC interface and all MILC fronts with high residual nickel concentration are eliminated. Hence, nickel concentration in the channels of Type B TFTs is believed to be lower than that of Type A TFTs.

However, if the channel width is larger than the length of the crystallization-inducing hole, MILC will take place along directions not entirely parallel to the direction of channel conduction. This might be the reason for the increase of average leakage current per unit channel width as the channel width is increased.

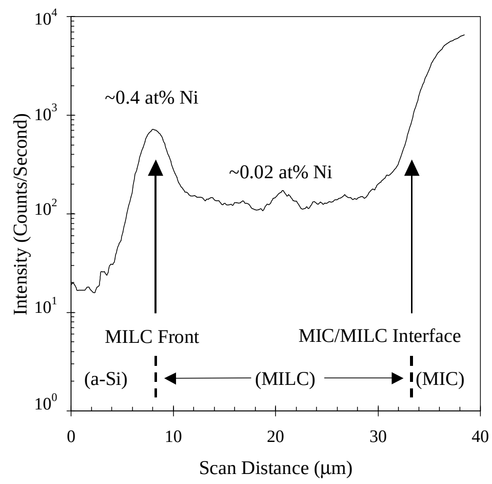

Figure 1. Distribution of nickel concentrations in different regions of MILC poly-Si thin film.

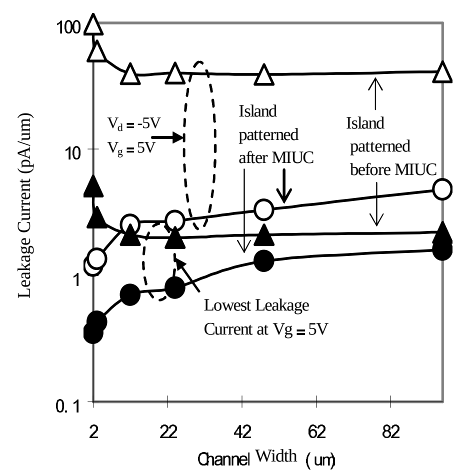

Figure 2. Dependence of the leakage current per unit channel width on the channel width of Types A and B TFTs.