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High rate deposition of poly-si thin films using new magnetron sputtering source

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After LeComber *et al.* reported the first amorphous hydrogenated silicon (a-Si:H) TFT, many laboratories started the development of an active matrix LCDs using a-Si:H TFTs formed on glass substrate. With increasing the display area and pixel density of TFT-LCD, however, high mobility TFTs are required for pixel driver of TFT-LCD in order to shorten the charging time of the pixel electrodes. The most important of these drawbacks is a-Si's electron mobility, which is the speed at which electrons can move through each transistor. The problem of low carrier mobility for the a-Si:H TFTs can be overcome by introducing polycrystalline silicon (poly-Si) thin film instead of a-Si:H as a semiconductor layer of TFTs. Therefore, poly-Si has gained increasing interest and has been investigated by many researchers. Recently, fabrication of such poly-Si TFT-LCD panels with VGA pixel size and monolithic drivers has been reported. Especially, fabricating poly-Si TFTs at a temperature much lower than the strain point of glass is needed in order to have high mobility TFTs on large-size glass substrate, and the monolithic drivers will reduce the cost of TFT-LCDs. The conventional methods to fabricate poly-Si films are low pressure chemical vapor deposition (LPCVD) as well as solid phase crystallization (SPC), pulsed rapid thermal annealing (PRTA), and eximer laser annealing (ELA). However, these methods have some disadvantages such as high deposition temperature over 600 ℃, small grain size (< 50 nm), poor crystallinity, and high grain boundary states. Therefore the low temperature and large area processes using a cheap glass substrate are impossible because of high temperature process.

In this study, therefore, we have deposited poly-Si thin films on Si(100) and glass substrates at growth temperature of below 400 ℃ using newly developed high rate magnetron sputtering method. To improve the sputtering yield and the growth rate, a high power (10~30 W/cm2) sputtering source with unbalanced magnetron and Si ion extraction grid was designed and constructed based on the results of computer simulation. The maximum deposition rate could be reached to be 0.35 μ m/min due to a high ion bombardment. This is 5 times higher than that of conventional sputtering method, and the sputtering yield was also increased up to 80%. The best film was obtained on Si(100) using Si ion extraction grid under 9.0×10^{-3} Torr of working pressure and 11 W/cm^2 of the target power density. The electron mobility of the poly-Si film grown on Si(100) at 400 ℃ with ion extraction grid shows 96 cm^2/V sec. During sputtering, moreover, the characteristics of Si source were also analyzed with *in situ* Langmuir probe method and optical emission spectroscopy.