Characterization of Low Temperature Poly Silicon TFTs with Laser Crystallization Technique

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ABSTRACT

It was extensively discussed the high-performance low temperature polycrystalline silicon (LTPS) application in monitor. In this thesis, many processes of crystallization means were discussed and the characterization of low temperature polycrystalline silicon (LTPS) thin film transistors (TFTs) were studied, in which the HF with the concentration of 0.1 percent was utilized by pre treatment clean process. Many methods and techniques had been proposed to further improve the performance of LTPS TFTs, which include means of prior clean treatment of amorphous silicon thin films, while most of the effort was focused on crystallization of amorphous silicon (a-Si) thin films.

First, the electrical characteristics of LTPS TFTs fabricated by excimer laser annealing (ELA) of a-Si thin films which was used different pre treatment processes. From the results of material analysis and device characterization, the relation between electrical characteristics of LTPS TFTs and pre treatment processes conditions with laser annealing conditions had been identified. It was found that caused the surface oxidation of a-Si thin films by pre treatment process and laser energy density had a deep influence on the resulting poly-Si grain structure and electrical characteristics of LTPS TFTs. It was included the different methods of pre treatment process, the first method is surface cleaning with O3 water which concentration was 20ppm, the second method was surface cleaning with H2O2 water which concentration was

30%, the third method was surface cleaning with UV light exposure which wave length was 254um, and all of these methods can advance the surface oxidation of a-Si thin films, it had the difference at long time or short time treatment. When surface of a-Si thin films was completely oxidized by pre treatment process then treated by ELA, the LTPS thin films will be fabricated with grain size about 0.3um, grain shape like square and uniform distribution on surface. In this situation, the LTPS TFTs fabricated by ELA with optimization laser energy density, the field effect mobility of 130 and 90 $cm^2/V*s$ could be achieved for n-channel and p-channel ELA LTPS TFTs, respectively. The thresholds voltage had different shift owing to the difference surface oxidation on a-Si thin films.

Changing laser scan frequency and energy couldn't improve the crystalline quality and uniformity of crystallized poly-Si thin films and electrical characteristics of LTPS TFTs. In different ambiance of ELA crystallization had different efficiency, before mention the process of ELA crystallization had ambiance of N2 gas, now the concentration of low O2 with 2000ppm was utilized in ELA crystallization ambiance. From the results of material analysis, the LTPS thin films fabricated by ELA crystallization in ambiance of low O2 concentration had surface roughness like before mention process, the maximums surface roughness was about 80nm and average surface roughness was about 9nm, but the shape had some difference, the LTPS thin films surface roughness of low O2 concentration status had the shape like the cylinder in which the position was grain boundary and potential barrier was larger than grain area. The cylinder top surface were close to the gate bottom, when gate applied the forward bias, it would enhance the high electric file near the gate then induced the average thresholds voltage degradation. LTPS TFT's fabricated by ELA crystallization in ambiance of low O2 concentration had lower thresholds voltage than N2 ambient condition, the thresholds voltage of +2 and –2 V could be achieved for n-channel and p-channel ELA LTPS TFTs, respectively.

At last part of this thesis, the crystallization of continuing wave laser (CW laser)

technology would be discussed. Crystallization of amorphous silicon (a-Si) thin films utilized the wavelength 532nm of CW lasers with different power and scan speed. Many factors of influence for grain size were discussed. It included the speed control in stage with different power during laser scanning; front and backside scan on substrate at different scanning speed. Owing to the laser beam energy distribution was the Gauss shape and laser beam size was affected by focus lens and laser power, we employ the focus lens with focus 600mm and focus the laser beam on substrate where the beam diameter was about 150um, when laser power more high the diameter more long. The LTPS thin films were fabricated by CW laser with grain size about 3um, grain shape like long bulk and large grain was aggregated in center area of laser beam on crystallization surface and the LTPS TFTs fabricated at large grain size area, the field effect mobility of 298 and 210 $cm^2/V*s$ could be achieved for n-channel and p-channel LTPS TFTs, respectively. The threshold voltages were shifted to 7V owing to the crystallization ambiance was atmosphere.