Chapter 5

Conclusions

In this thesis, uniformity polycrystalline silicon thin-film and electrical characterization for low-temperature polycrystalline silicon thin-film transistors fabricated by excimer laser annealing (ELA) have been investigated. Physical characterizations of pre treatment processes of ELA poly-silicon thin films had been accomplished in chapter 2, and the different laser annealing conditions of ELA poly TFTs device fabrication had been studied in chapter 3. To improve the device performance, continuing wave laser crystallization were proposed in chapter 4. The proposed CW poly TFTs exhibited excellent carrier mobility.

In chapter2, the electrical characteristics of LTPS TFTs fabricated by excimer laser annealing (ELA) of α-silicon 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 α-silicon thin films by pre treatment process and laser energy density had a deep influence on the resulting poly-silicon grain structure and electrical characteristics of LTPS TFTs. It was included the different methods of pre treatment process, the first method was 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 α-silicon thin films, it had the difference at long time or short time treatment. When surface of α-silicon thin films was completely oxidized by pre treatment process then treated by ELA, the LTPS thin films would be fabricated with grain size about 0.3um, grain shape like square and uniform distribution on surface. But the surface was more roughness, this structure was named 1D self-alignment grain structure that was produced in optimization energy density region and direction was same as laser scanning direction. The pre treatment clean condition had 1D self-alignment grain structure, it was included the O3 water clean time 50 seconds at least, H2O2 clean time 300 seconds at least and UV exposure time was 200 seconds at least. The optimization condition of every pre treatment clean was decided in this situation, the LTPS TFTs fabricated by ELA with optimization laser energy density, the field effect mobility of 130 and 90 $cm^2/V*s$ can be achieved for n-channel and p-channel ELA LTPS TFTs, respectively. The thresholds voltage have different shift owing to the difference surface oxidation on α-silicon thin films.

In chapter 3, Modification parameter of excimer laser with different frequency and energy conditions were studied. As a result of different frequency condition was less relation with grain size, only the energy density was relation with grain size. If the laser frequency was 300Hz the scan speed was higher, because of the scan speed equal to frequency (Hz) multiplied by pitch (mm), owing to the running throughput was considered the frequency was set 300Hz always. As a result of different energy condition was less relative with grain size, the laser energy just only influenced the high voltage value of laser, when laser energy was increased the high voltage value would be increased by laser machine. 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 90nm and average surface roughness was about 11nm, but the shape has 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 can be achieved for n-channel and p-channel ELA LTPS TFTs, respectively.

Continuing wave laser crystallization for poly-silicon TFTs were developed in chapter 4. Crystallization of amorphous silicon (α-silicon) 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 was 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 employed the focus lens with focus 600mm and focus the laser beam on substrate where the beam diameter was about 300um, when laser power more high the diameter more broad. It was observed the region "a" that was included complete melting and partial melting region, variation was relation with scan speed and laser power, first, the scan speed was increased the region of "a" will be decreased; second, the laser power was increased the region of "a" would be increased. The broken hole occurred in constant power 3W and scan speed less than 5cm/sec; constant power 4W and scan speed less than 6cm/sec; constant power 8W and scan speed less than 12cm/sec. The large grain size and usable poly crystallization were not found in low laser power, the large grain size region wider was better, so the optimization condition was laser power 4W and scan speed 7cm/sec. The better condition of backside irradiation of substrate was obtained to utilize the constant power 4W and the some heating was absorbed and reserved by substrate, this mechanism slowed down the super cooling taking place before the onset of solidification due to homogeneous nucleation. So the large grain distribution was wider than front side irradiation. The LTPS thin films were fabricated by CW laser with grain size more than 3um, grain shape like long bulk and large grain was aggregated in “a” 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 can be achieved for n-channel and p-channel LTPS TFTs, respectively. The threshold voltages are shifted to 7V and –4V for n-channel and p-channel LTPS TFTs, owing to the crystallization ambiance was atmosphere. In the future, CW poly-silicon TFTs could be combined with the low O2 ambiance, structure-design to provide the excellent device performance for next-generation low-temperature polycrystalline thin-film transistors technology and more applications.