論文の要旨
（Thesis Summary）

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論文題目 (100) Oriented Poly-Si Thin Film Formation and Ultrahigh-Performance Poly-Si Thin Film Transistors Fabrication with Multi-Line Beam Continuous-Wave Laser Lateral Crystallization
（マルチライン連続発振レーザ・ラテラル結晶化による(100)面方位制御多結晶シリコン薄膜形成と高性能多結晶シリコン薄膜トランジスタの作製）

Ultrahigh-performance, low-temperature polycrystalline silicon (poly-Si) thin film transistors (LTPS-TFTs), which are comparable to single-crystal Si devices, have been a key requirement for the development of a new era of Si electronic technology for flat-panel displays (FPDs), integrated circuits (ICs), system-on-panel (SOP) devices, and three-dimensional (3D) electronics. Recently, the development in LTPS-TFT manufacturing technology has focused on improving the electrical properties of Si films and reducing the cost in order to achieve commercialization. The electron field effect mobility enhancement of TFTs plays a decisive role in developing high-performance LTPS-TFTs. Excimer laser annealing (ELA) has been successfully applied to high performance active-matrix TFTs in liquid crystal display (LCD) technology owing to its high performance and uniformity of devices. The continuous-wave laser lateral crystallization (CLC) with a diode-pumped solid-state (DPSS) continuous-wave laser has, on the other hand, been widely investigated to have a much higher mobility owing to Si crystal grains with a size larger than the TFT feature size. Utilizing CLC, high-performance TFTs with μ_{eff} of 566 $cm^2V^{-1}s^{-1}$ have been achieved. However, the CLC poly-Si thin films have random orientation resulting from the Gaussian distribution of laser beam. The performance of the TFTs fabricated on these films is remarkably different. Therefore, controlling the preferential orientation of poly-Si thin films plays a very important role. For dealing with the non-uniformity of poly-Si thin films, the CLC is combined with a diffractive beam homogenizer and an optics to deform the Gaussian laser beam into a multiline beam (MLB) shape. In the previous work of our group, a highly bi-axial oriented poly-Si thin film were formed by MLB-CLC at a high laser exposure energy level (9 W laser power and 0.1 cm/s scanning speed). MLB-CLC is a promising technology to make the poly-Si thin films oriented uniformly. Poly-Si TFTs with a 450 $cm^2V^{-1}s^{-1}$ mobility was fabricated on these poly-Si films. For ultrahigh-mobility TFTs, (100)-dominantly oriented poly-Si thin film with large crystal grains have generated high demand.

In this work, we formed highly (100) oriented poly-Si thin films by using MLB-CLC and investigated the effect of crystallization conditions on the crystallinities of the poly-Si thin films. We found a correlation between laser power and scanning speed to form (100) poly-Si thin films. For practical applications, we developed (100) textures in large areas with overlapping scanning. Moreover, we fabricated LTPS-TFTs with the highly (100) oriented poly-Si thin films. Ultrahigh-performance TFTs were achieved on the (100) poly-Si thin films and crystal

orientation dependence of TFTs' performance was shown. In addition, we attempted to study the mechanisms of (100) texture formation and TFT's performance enhancement.

In the chapters 2 and 3, we demonstrated (100)-oriented poly-Si thin films formed by MLB-CLC with single scans. Si(100) crystal grains were developed along the laser scanning direction. They were relatively uniform and had a very large size of 20 × 2 μm^2. The crystallization conditions for forming (100) crystals were just above a threshold for lateral-crystallized Si. At these conditions, the poly-Si thin films had (100) orientation in all surface, scanning, and transverse directions. By overlapping scanning, (100) textures were achieved in large areas. Moreover, the poly-Si thin films had a high bi-axial tensile strain in planar direction and a compressive strain in depth direction. The MLB-CLC poly-Si thin films generally had excellent orientation preference, large crystal grain size, well structural order that was comparable to the c-Si, and had high bi-axial tensile strain. We also investigated the effect of crystallization conditions including overlapping scanning, scanning speed, and laser power on the crystallinities of the laser-crystallized poly-Si films. We found that these conditions were major factors for the preferential orientation of the poly-Si thin films. The preferential orientation of the laser-crystallized poly-Si films was strongly dependent on the scanning speed and laser power and optimal conditions for (100) poly-Si thin films were clarified. These excellent crystallinities are great potentials that make the MLB-CLC a promising technology for high-performance TFTs.

In the chapter 4, we show ultrahigh-performance poly-Si TFTs fabricated with a low temperature process. Characterization of parallel and perpendicular TFTs was described, especially, parallel TFTs with ultrahigh-electron mobility were achieved on the highly (100) surface oriented poly-Si thin films. 1010 $cm^2V^{-1}s^{-1}$ electron field effect mobility is extremely high. The crystallinities of the poly-Si channels were characterized to evidence high mobility characteristics and orientation dependence of the mobility. The correlation between the surface orientation and electron mobility was shown. High-performance perpendicular TFTs were also realized, they however had twice lower mobility than the parallel ones. Both parallel and perpendicular TFTs had high performance variation due to the difference of surface orientations and grain boundaries.

In chapter 5, the mechanisms for the above results were discussed. For (100) surface orientation, it is believed that the SiO_2/Si interfacial energy control the surface orientation of the poly-Si thin film crystallized at low laser exposure energy regime. Another possibility is the nucleation between line-beam exposures where the temperature of the poly-Si film is more uniform, and then these nuclei control the film oriented preferentially. Finally, we explained the mechanism of TFTs' performance enhancement and ultrahigh electron mobility achievement. By examining the crystallinities of the poly-Si channel, Si(100) single crystal grains with high biaxial tensile strain were observed parallel to the current flow. They brought about a significant TFTs' performance enhancement.

The results of this research were concluded in chapter 6. These achievements is promising to develop LTPS-TFTs in FPDs as well as digital processing applications.