論文の要旨
（Thesis Summary）

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論文題目

Investigation on the Mechanism of Millisecond Solid Phase Crystallization of Silicon Films Formed by Micro-Thermal-Plasma-Jet and Their Application to Bottom-Gate Thin Film Transistors
（大気圧マイクロ熱プラズマジェット照射によるシリコン薄膜のミリ秒結晶化メカニズムの解明とボトムゲート型薄膜トランジスタへの応用）

Bottom-gate thin film transistors (TFTs) have attracted much attention because of their advantages in industry. With only four masks for fabrication process, the production cost is reduced. Hydrogenated amorphous silicon (a-Si:H) TFTs are suitable for current sources, on-pixel amplifier, and peripheral driver circuits. However, faster switching circuits are out of their reach because of their low mobility as ~ 1 cm^2/Vs and their insufficient hole mobility for p channel operation. In addition, being a photoconductor, they have a large leakage current when exposed to light. Polycrystalline silicon (poly-Si) is an alternative material for TFTs fabrication. Small grain poly-Si films with smooth surface make good uniformity devices. Several ways have been examined for the formation of these TFTs such as direct deposition methods as well as conversion using amorphous silicon (a-Si) film. The principal technique for the direct deposition of poly-Si is by low-pressure chemical vapor deposition (LPCVD). However, columnar structure with typical grain size as 100 nm and low field effect mobility μ_{FE} of 5 ~7 cm^2/Vs are main weak points. The poly-Si film via solid phase crystallization (SPC) using precursor a-Si film increase μ_{FE} comparing with columnar poly-Si film. This could be done by LPCVD at 550-600 ºC, plasma enhanced chemical vapor deposition PECVD at 350 ºC, or furnace ambient at typical temperature of 600 ºC. However, a long thermal crystallization, up to tens of hours, is required to transfer films to polycrystalline. Some techniques are introduced to reduces this cycle time such as the use of higher temperatures in a rapid thermal annealing cycle and the use of metal induced crystallization. However, large grain size formation and film contamination by either the metal itself or the metal silicide are their issue.

For these issues, we have proposed a new crystallization technique for making SPC film in millisecond region at high temperature, called “millisecond SPC”, using micro-thermal-plasma jet (μ-TPJ). It has a simple structure and high output energy. In this work, we attempted to directly observe the phase transformation, to investigate the growth mechanism, the characteristics of millisecond SPC films induced by μ-TPJ as well as their abilities in bottom gate TFTs fabrication.

My thesis consists of 5 chapters, which are listed below.

In chapter 1, the evolution of thin film transistor technology, the introduction of micro thermal plasma jet irradiation, and the objective of this research are discussed.

In chapter 2, a new method to directly observe the transient reflectivity of a-Si film and the phase transformation simultaneously during μ-TPJ irradiation is presented. The SPC-Si film is produced in millisecond region, calling millisecond SPC. Optical microscopy shows the different morphology of crystallization area when film is melted and millisecond SPC state. Phase transformation is observed in real time by using high speed camera (HSC) which moved with sample during μ-TPJ irradiation. By introducing the He-Ne laser to objective lens of HSC, we obtained the transient reflectivity of Si film during μ-TPJ annealing. (Main paper 1)

In chapter 3, based on the reflectance and transmittance phenomenon, the transient variation of Si film temperature during μ-TPJ irradiation is investigated from obtained reflectivity in chapter 2. The nucleation temperature is around 1000 °C, heating rate is as high as 10^6 K/s. Both increase with the increase of scanning speed *v*. In addition, according to classical nuclear theorical, I suggested a simple physical model to explain the growth mechanism of millisecond SPC at high temperature region around 1000 °C. (Main paper 1)

In chapter 4, phase diagram of μ-TPJ irradiated a-Si/P-doped a-Si films with respect to supplied power *P* and *v* is shown. Based on that, characteristics of millisecond SPC film is investigated by Hall effect measurement, Raman spectra microscopy, and atomic force microscopy. Millisecond SPC films formed at near melted condition show high crystallinity as 61%, low resistivity as 1.36×10^{-3} Ωcm, high concentration carrier as 3.41×10^{20} cm^{-3}, the carrier mobility as 12.2 cm^2/Vs and smooth surface. (Main paper 2)

In chapter 5, bottom gate TFTs fabricated with millisecond SPC film under different conditions of μ-TPJ are prepared. Electrical characteristics of devices are investigated to evaluate the ability of millisecond SPC in TFTs fabrication. The devices show high field effect mobility of 28 cm^2/Vs and a small variation in transfer characteristic. (Main paper 2)

From the achievement of this research, millisecond SPC Si film is a good candidate for small grain bottom-gate TFTs fabrication.