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Investigation on solid-phase crystallization of amorphous silicon films

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박막 트랜지스터 (thin film transistor, TFT)는 고밀도, 대면적화로 높은 전자의 이동도가 요구되면서, 비정질 실리콘 (a-Si)에서 다결정 실리콘 (poly-Si) TFT 로 연구되었다. 이에 따라 비정질 실리콘에서 결정질 실리콘으로의 상변화에 대한 결정화 연구가 활발히 진행되었다. 또한, 박막 태양전지 분야에서도 유리기판 위에 비정질 층을 증착한 후에 열처리를 통해 상변화하는 고상 결정화 (solid-phase crystallization, SPC) 기술을 적용하여, CSG (thin-film crystalline silicon on glass) 태양전지를 보고하였다. 이러한 비정질 실리콘 층의 결정화 기술을 결정질 실리콘 태양전지 에미터 형성 공정에 적용하고자 한다. 이 때, 플라즈마화학증착 (Plasma-enhanced chemical vapor deposition, PECVD) 장비로 증착된 비정질 실리콘 층의 열처리를 통한 결정화 정도가 중요한 요소이다. 따라서, 비정질 실리콘 층의 결정화에 영향을 주는 인자에 대해 연구하였다. 비정질 실리콘 증착 조건(H2 가스 비율, 도펀트 유무), 실리콘 기판의 결정방향, 열처리 온도에 따른 결정화 정도를 엘립소미터(elipsometer), 투과전자현미경 (transmission electron microscope, TEM), 적외선 분광기 (Fourier Transform Infrared, FT-IR) 측정을 통하여 비교 하였다. 이를 기반으로 결정화 온도에 따른 비정질 실리콘의 결정화를 위한 활성화 에너지를 계산하였다. 비정질 실리콘 증착 조건 보다 기판의 결정방향이 결정화 정도에 크게 영향을 미치는 것으로 확인하였다.

Keywords: Solid Phase crystallization (SPC); Crystallization; Amorphous Silicon (a-Si); Plasma-enhanced chemical vapor deposition(PECVD); Crystalline Solar cell

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Luminescence properties of InGaN/GaN green light-emitting diodes grown by using graded short-period superlattice structures

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InGaN/GaN multiple quantum wells (MQWs) have been attracted much attention as light-emitting diodes (LEDs) in the visible and UV regions. Particularly, quantum efficiency of green LEDs is decreased dramatically as approaching to the green wavelength (~500 nm). This low efficiency has been explained by quantum confined Stark effect (QCSE) induced by piezoelectric field caused from a large lattice mismatch between InGaN and GaN. To improve the quantum efficiency of green LED, several ways including epitaxial lateral overgrowth that reduces differences of lattice constant between GaN and sapphire substrates, and non-polar method that uses non- or semi-polar substrates to reduce QCSE were proposed. In this study, graded short-period InGaN/GaN superlattice (GSL) was grown below the 5-period InGaN/GaN MQWs. InGaN/GaN MQWs were grown on the patterned sapphire substrates by vertical-metal-organic chemical-vapor deposition system. Five-period InGaN/GaN MQWs without GSL structure (C-LED) were also grown to compare with an InGaN/GaN GSL sample. The luminescence properties of green InGaN/GaN LEDs have been investigated by using photoluminescence (PL) and time-resolved PL (TRPL) measurements. The PL intensities of the GSL sample measured at 10 and 300 K increase about 1.2 and 2 times, respectively, compared to those of the C-LED sample. Furthermore, the PL decay of the GSL sample measured at 10 and 300 K becomes faster and slower than that of the C-LED sample, respectively. By inserting the GSL structures, the difference of lattice constant between GaN and sapphire substrates is reduced, resulting that the overlap between electron and hole wave functions is increased due to the reduced piezoelectric field and the reduction in dislocation density. As a results, the GSL sample exhibits the increased PL intensity and faster PL decay compared with those for the C-LED sample. These PL and TRPL results indicate that the green emission of InGaN/GaN LEDs can be improved by inserting the GSL structures.

Keywords: InGaN/GaN, Green LEDs, photoluminescence, time-resolved photoluminescence