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Study of a Process from Liquid Silane to Laser - Crystallized Poly - Silicon Film.

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The solution processing has been expected as an effective alternative for complicated vacuum processing in terms of process cost and the consumption of energy and materials. Recent progress of the solution processing is remarkable especially in the field of organic materials such as the organic light emitting diodes, organic thin film transistors. However, the solution processing of inorganic materials such as silicon, metals, oxides have not been so much studied whereas they would play extremely important roles once used in present semiconductor processing and related technologies. Polycrystalline silicon (poly-Si) is very attractive for thin-film transistors. The typical starting material in the crystallization process is amorphous silicon (a-Si) or hydrogenated amorphous silicon (a-Si:H) that can be deposited by various vacuum deposition techniques. However, these processes usually need equipments with high cost and their material utilization efficiency is quite low. If high-quality poly-Si films are formed by liquid processing, that would make a great impact on Si device industry. This work relates to a process of forming poly-Si films by liquid silane coating on substrates and green laser annealing (GLA). Hydrogenated polysilane, which was obtained by irradiating CPS (cyclopentasilane) with 365 nm UV light, was used as a precursor to form an a-Si:H film. And a silicon ink was prepared from polysilane diluted with organic solvent. The ink was spin-coated on quartz substrate, and it was converted to an a-Si:H film with a thickness of 100 nm by annealing at 400 °C on a hot plate. Dehydroganation of the a-Si:H films was performed by rapid thermal annealing at 700 °C for 30 minutes under 1 Pa. These samples were irradiated by a 300 ns pulsed Yb:YAG green laser (515 nm) at a frequency of 10 kHz. The laser energy density was varied from 300 to 1100 mJ/cm2 in 100 mJ/cm2 steps. Raman spectra of the samples irradiated from 400 mJ/cm2 to 1100 mJ/cm2 clearly showed sharp peaks around 515 cm-1 which indicated that a-Si was crystallized by GLA. Sharp peak with 4.9 cm-1 of full width at half maximum (FWHM) at 515.3 cm-1 was obtained from the sample treated with 1000 mJ/cm2. This value is as good as one of the best results obtained by conventional methods.1) The results of transmission electron microscopy (TEM) and electron backscatter diffraction (EBSD) of the sample revealed the lateral growth of poly-Si with a needle shape along laser scanning direction. It is concluded that a-Si:H films can be formed on substrates by using hydrogenated polysilane through spincoating and annealing process. And lateral growth of poly-Si by GLA was confirmed by the results of Raman spectra, TEM, and EBSD. We successfully demonstrated the solution processing of forming poly-Si films with high-quality. Those techniques will have potential applications including printable silicon-based devices. 1) K. Kitahara et al., Jpn. J. Appl. Phys., 41, 5055 (2002)

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