Control of deposition rate and structure of crystalline Si film by dual frequency PECVD

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Crystalline Si thin films are synthesized at low temperature less than 350 ºC on glass by various dual frequency plasma CVD utilizing dual power inputs in a frequency range of RF to UHF. The deposition rate of crystalline Si film is significantly enhanced by RF plasma CVD using SiH₄ and H₂ gas mixture with additional power input of very high frequency (VHF) and ultra high frequency (UHF). The deposition rate is enhanced in a range of 0.8 nm/s to 2.0 nm/s with additional power input of increasing frequency from VHF to UHF in RF discharge. The volume ratio of crystalline and amorphous Si film structure is also varied in a range of 45 % to 70 % with change of dual frequency power inputs and partial pressure ratio of SiH₄ and H₂. The typical grain size of crystalline Si film at substrate temperature less than 350 ºC is measured to be 10 nm by TEM analysis. It is noted that additional power input of UHF to RF discharge is most effective for enhancement of deposition rate with improvement of crystalline Si film structure. The plasma discharge with VHF and UHF is well known to generate high density electrons of low temperature. The significant improvement of deposition rate with additional power input of VHF and UHF is consequently associated with enhanced generation of SiHₓ radicals from SiH₄ molecules due to the secondary high density plasma generated by additional high excitation frequency. Hydrogen radical which contribute the formation of crystalline Si film with surface diffusion and chemical annealing is also generated intensively. This paper illustrates the results of change of deposition rate as well as microstructure with variation of dual power inputs and process parameters. The results are discussed with plasma diagnostic data of silane and hydrogen using optical emission spectroscopy (OES) and Langmuir probe.

Keywords
microcrystalline silicon
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high deposition rate