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Crystallization of submicron amorphous hydrogenated silicon films with different hydrogen concentration by nanosecond ruby laser irradiation

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ABSTRACT

Pulse laser annealing remains an actual problem aimed to crystallization of amorphous films on nonrefractive substrates. But, the most previous works studied laser crystallization of relatively thin (<300 nm) a-Si:H films and mainly used excimer lasers. But, excimer lasers are not suitable for crystallization of submicron a-Si:H films due to low penetration depth in a-Si:H at such wavelengths. The problem can be resolved by using lasers with longer wavelengths. The desirable result of crystallization also depends on the choice of proper laser fluence, which is different for films with different hydrogen concentrations. In this work, the processes of a pulsed ruby laser induced crystallization of submicron (0.7 μm) amorphous hydrogenated silicon films with different hydrogen concentrations (2, 12, and 39 at. %) by different laser fluences were investigated. The films were prepared on glass substrates by plasma enhanced chemical vapor deposition technique followed by isothermal annealing in nitrogen atmosphere. The laser annealing (λ = 694 nm) was carried out at a pulse duration of 80 ns (full width at half-maximum) in the fluence range from 0.6 to 2.1 J/cm^2. The laser fluence thresholds for surface area crystallization were found for different hydrogen concentrations in the films. The increase of hydrogen concentration leads to an increase of the threshold energy density (laser fluence) for surface area crystallization due to a decrease of light absorption in the films with a higher hydrogen concentration. Also, it was shown that ruby laser radiation can penetrate and partially crystallize the full depth of the submicron a-Si:H film, but the problem of homogeneity remains.

Key words: laser crystallization, amorphous silicon, Raman scattering, electron microscopy

I. INTRODUCTION

Pulsed laser annealing (PLA) is a known and approbate technique suitable for crystallization of amorphous hydrogenated silicon films.[1,2] Its main advantages are the opportunity of spatial selective crystallization as well as the crystallization of films prepared on nonrefractory substrates. This technique makes it possible to obtain bi-phase (both a-Si/poly-Si and a-Si/nc-Si) films and structures, which are interests for optoelectronic devices produced on wide-format substrates.[3–8]

The choice of proper laser pulse energy density (laser fluence) E_p is crucial factor of success in this technique. The low value of E_p is not enough to crystallize film, and the high one leads to crystallization accompanied by partial film ablation. The restrictions become more strict if goal is to activate