An Advanced Sample Structure for Excimer Laser Crystallization

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High-performance TFTs for "system on glass" cannot be made without introducing a lateral growth of Si grains by excimer laser annealing [1]-[4]. The optimization of laser light intensity profile by optical modulation, such as a phase-modulated excimer-laser annealing (PMELA) method, is very important to obtain long grains [5]. The sample structure plays also an important role since it determines solidification characteristics under fixed light intensity conditions. We have reported [6] that the optimum thickness of the SiO_2 capping layer is about 200 nm for a 200 nm-thick Si layer/SiO_2 layer structure. The growth length was about 5 µm at the light intensity of 700 mJ/cm^2 and 7 µm at 1000 mJ/cm^2. The grain length is sufficiently large to install several TFTs with 1 µm-long channel in a grain.

It is desirable to decrease the light intensity further at the crystallization. Yeh et al. reported that long grains were grown with SiON capping layer, which is photosensitive for KrF excimer-laser [7]. In the present report, we focused attention on SiOx thin film in the pursuit of good photosensitive layers for wider range of laser wavelength. The optical properties of SiOx film can be changed by changing the value of x from 0 to 2. A SiOx/SiO_2 stacked structure was newly introduced for the capping.

Samples were of a stacked structure with PECVD 250 nm-thick SiOx/30 nm-thick SiO_2 double capping layers, a 200 nm-thick PECVD a-Si layer, and a 1000 nm-thick thermal SiO_2 layer on Si substrate as shown in Fig.1. The total thickness of SiOx/SiO_2 stacked capping layer was chosen to be 280nm so as to minimize the surface reflection by taking the multiple reflection effect into account. The value of absorption coefficient α of the SiOx layer can be changed by varying the SiH_4/N_2O flow rate ratio in the CVD process as shown in Fig.2. We also made a reference sample with a single SiO_2 capping layer. Both samples had the same a-Si thicknesses. The light intensity to irradiate the a-Si layer of the (A) sample can be changed by changing the α value of the SiOx film. There may be the optimum α value. The optimum α value is supposed to be 3000 to 5000 cm^{-1} for this structure. This condition was satisfied at the flow rate ratio ranging from 22 % to 24% for KrF and for 24 to 26% for XeCl lights. Samples were irradiated by a single shot of KrF excimer-laser light pulse after dehydrogenation. Details of the ELA apparatus were reported elsewhere [8]. The micro-structural analyses of the crystallized Si films were performed by means of a SEM after Secco-etching.

The lengths were the same for both samples as shown in Fig.3. since the total heat energy stored was the same for both samples. But the irradiated light intensity reduced from 660 mJ/cm^2 to 480 mJ/cm^2.

In conclusion, we have changed the value of the absorption coefficient α and have obtained a long lateral growth of more than 5µm with reduced light intensity by introducing a SiOx capping layer. The capping layer, consisting of SiOx, is a promising candidate not only for KrF excimer-laser but also for XeCl excimer-laser.

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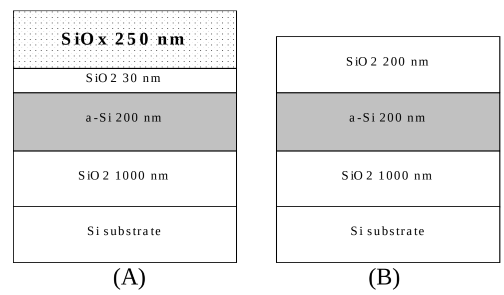

Fig. 1 Schematics of the sample structures
(A) SiOx/SiO_2 double capping layers
(B) SiO_2 capping layer (reference)

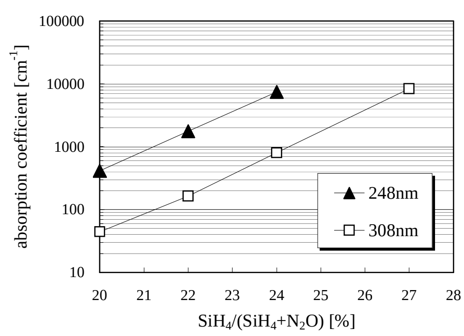

Fig.2 Absorption coefficients of SiOx film versus the flow rate ratio of SiH_4 and N_2O.

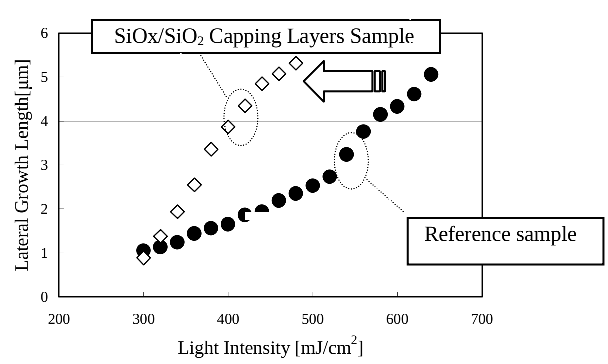

Fig.3 Lateral growth length as a function of light intensity.