Novel Phase-Modulator for ELA-Based Lateral Growth of Si

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Excimer-laser annealing (ELA) is a key technology for low-temperature-produced, high-performance poly-Si TFTs used in "system-on-glass", and has been studied by many groups. Phase-modulated ELA (PMELA) is an advanced ELA method featuring long lateral growth due to light intensity modulation on a sample surface by a phase modulator (see Fig.1). The temperature gradient in the Si film induces lateral motion of the melt-solid interface, resulting in lateral growth of Si grains at fixed positions. To grow large Si grains with a high packing efficiency, the light intensity distribution should have a periodic V-shaped form.

We have previously reported the successful growth of 3 μm long Si grains by using a line-and-space phase modulator placed above the surface of a sample, separated by only a small gap, i.e. by the proximity method [1]. For the purposes of mass production, the projection method is preferable; in this method a projection lens plays an important role on the light intensity distribution. This paper presents a novel phase modulator for the projection method.

Figure 2 shows the principle of the newly developed duty phase modulator. It consists of many cells, each having a convex area of a fixed ratio (called the "duty"). If the cell pitch is small enough, only 0th order diffracted light can enter the opening of the imaging optics and higher order light cannot reach the sample surface. This diffraction limit condition prevents the appearance of a fine pattern of dots in the image and ensures the distribution is locally uniform. The light intensity is determined only by the duty and phase retardation caused by height of the cells. The duty varies on the surface for the new modulator; if the duty changes gradually, the light intensity distribution on the sample surface can be given by the local value of duty.

We have designed and fabricated a duty phase modulator for a V-shaped light intensity distribution and measured the distribution on a sample surface[2].

Figure 3(a) shows a photo of the fabricated duty phase modulator with a 180^{o} phase retardation. Figure 3(b) demonstrates that a V-shaped light distribution can be obtained with this modulator. Figure 3(c) shows 5 μm long Si grains grown at high packing efficiency, where crystallization was performed with a modulator with a 60^{o} phase retardation.

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[1] Y. Kimura et al., ECS Proc. PV2002-23, 82(2002)
[2] M. Jyumonji et al., Digest of SID’04 (2004)

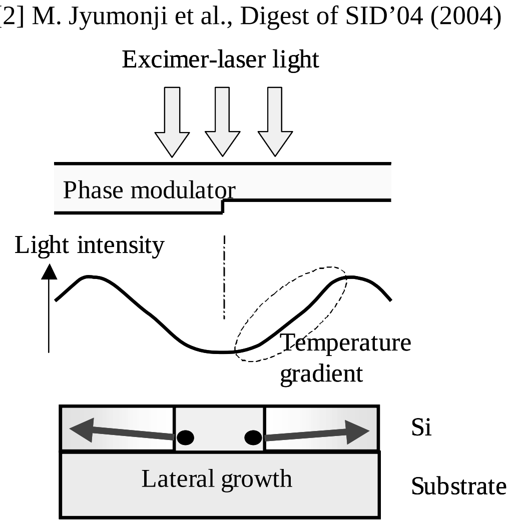

Fig.1 Schematics of PMELA

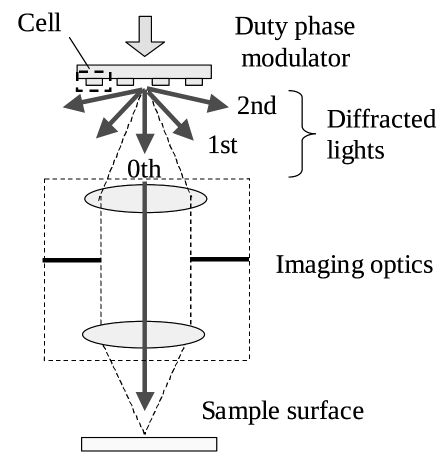

Fig.2 Principle of duty phase modulator

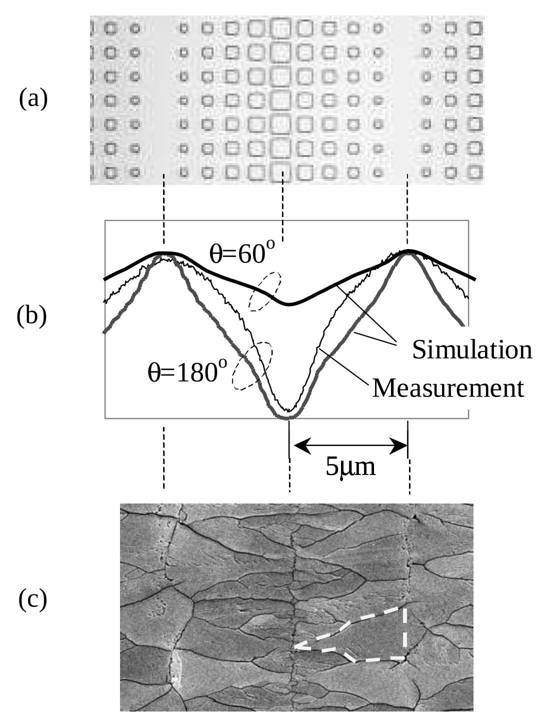

Fig.3
(a) Photo of duty phase modulator
(b) Example light intensity distributions (θ: Phase retardation)
(c) SEM image of Si grains after Secco etching