Two-shot SLS of Si film for manufacturing of AMOLED displays

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Abstract

The two-shot SLS method has recently been successfully implemented in volume manufacturing of advanced LTPS-based LCDs. In this presentation, we discuss how the approach is also well suited for being implemented in high-throughput and high-yield manufacturing of large AMOLED displays on large glass substrates.

1. Sequential Lateral Solidification

Sequential lateral solidification (SLS) is a pulsed-laser based melt-mediated crystallization method that can create Si films with a variety of low-defect-density microstructures [1]. The SLS method represents a version of the controlled super-lateral growth (C-SLG) approach [2], which was conceptualized as a consequence of the fundamental findings regarding the melt-mediated transformation scenarios that are manifested in pulsed-laser induced melting and solidification of thin Si films [3,4].

Technically, SLS consists of iteratively executing the following requirements: (1) inducing spatially localized and well-defined complete melting in irradiated regions(s) of the films that subsequently leads to lateral solidification to take place within the region(s); and (2) repositioning and re-irradiating the film in order to induce seeded lateral growth to take place epitaxially from the large grains that resulted via lateral solidification from the previous irradiation. While the definition of the SLS method can be simply defined as stated above, the method can be pointed out as being unusually flexible in that (1) it can be implemented using a number of distinct technical schemes and approaches [2,5], and (2) it can be used to generate a number of microstructurally distinct low-defect-density materials (e.g., uniform-and-large grained polycrystalline films, films with a directionally solidified microstructure, and location-and-orientation-controlled single crystal regions [2,6,7] (see Figure 1)).

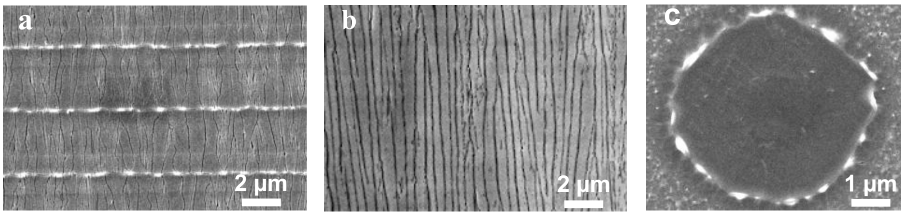

Figure 1. SEM images of microstructures obtainable via various SLS schemes: (a) a uniform large-grained polycrystalline material via 2-shot SLS, (b) a directionally solidified material via line-scan directional SLS, and (c) location-controlled single-crystal regions via dot-SLS.

2. Two-Shot SLS for OLED Displays

Among the various microstructures that can be generated using SLS, the thorough consideration of the OLED product/manufacturing/business-related factors identifies the two-shot SLS material as likely being the best matched material. The two-shot material is noteworthy in that (1) it can be efficiently produced at high throughput rates, (2) it can lead to highly uniform TFT devices that are well suited for OLED displays, (3) its manufacturing attributes have already been demonstrates (i.e., via manufacturing of advanced mobile LCDs), and (4) when optimally executed, it is expected to be easily applicable to large OLED displays (e.g., up to and beyond 60-inch OLED displays) and substrates (e.g., up to and beyond Gen 8 glass substrates).

The microstructure of a two-shot material can be described as consisting of rows of elongated grains that are periodically arranged. As a result, one microstructural feature of the material pertains to the existence of regularly spaced high-angle grain boundaries that run perpendicular to the elongated grains. In utilizing and optimizing such a material, it is important to keep in mind how the periodic and predictable nature of the grains can be beneficially leveraged in order to obtain highly uniform devices by commensurately and optimally engineering the size, shape, and orientation of the TFTs [8].

3. Advanced Two-Shot SLS Capable Manufacturing Systems

The two-shot SLS-processed films can be efficiently realized either by (1) a multiple-beamlet-based SLS approach [9] (e.g., using the manufacturing-implemented "FLX" systems from JSW Ltd. see Fig. 2a), or (2) a line-scan SLS technique [5] using a single line beam (e.g., using the excimer-laser-based "TDX" systems which has been recently developed at TCZ GmbH [10], see Fig. 2b). These manufacturing systems are presently configured to handle Gen. 4 substrates, but the systems that are optimized for processing Gen. 5 (or 5.5) substrates are presently being actively developed.

a

b

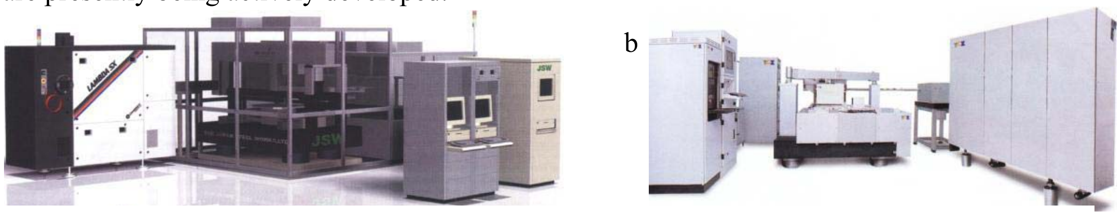

Figure 2. Excimer-laser-based systems: (a) FLX system from Japan Steel Works, Ltd., and (b) TDX system presently being developed at Team Cymer Zeiss GmbH, (b).

4. Conclusion

In summary, we conclude that various manufacturing-relevant and product-related factors point to the two-shot SLS material as corresponding to an optimal manufacturing choice for producing large OLED displays. As such, recent availability of two-shot-SLS-capable manufacturing systems should be viewed with appreciation. When compared to the conventional ELA method, two-shot SLS can be identified as being overwhelmingly better suited, technically as well as economically, for dealing with large OLED displays and glass substrates, and when compared to the other crystallization techniques that are being investigated for making OLED displays, the two-shot SLS method can be identified as being at least cost-competitive, substantially more manufacturing ready/tested, and substantially more road map flexible/compatible.

5. References

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