Sequential Lateral Solidification for Present and Future Applications

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Abstract

Sequential lateral solidification has recently become an option for manufacturing LTPS TFT LCDs owing to the availability of production equipment. Compared to the currently established ELA crystallization method, it is characterized by its low running costs and the high quality microstructures that can be obtained. In this presentation, we will review the production-related developments as well as elaborate on recent research activities that deal with a number of crystallization schemes that can be beneficial for future active-matrix display products.

Background

Low-temperature polycrystalline-silicon (LTPS) technology is presently being adopted by the active-matrix liquid-crystal display (AMLCD) industry. The improved TFT characteristics that potentially result from the technology (in comparison to a-Si based technology) hold a promise for the products to become technically more advanced and economically more viable.

Thus far, the production LTPS technology has been synonymous with a particular version of excimer-laser crystallization technique referred to as "ELA". This method, however, is characterized by its high running costs and by a small-grained polycrystalline microstructure, which limit the overall competitiveness of the resulting LTPS products. As a result, there exists a technological driving force to find a new crystallization scheme that can yield more cost-effective production as well as possesses the ability produce more enabling microstructures.

Sequential lateral solidification (SLS) is an alternative crystallization approach that has been investigated for a number of years as a method that can provide such beneficial characteristics.[1] The early research focus was on taking advantage of the flexibility of this process to demonstrate the feasibility of obtaining high-quality crystalline materials for high-performance devices.[2] In the recent years, on the other hand, we have been focusing on the development of manufacturing-optimized SLS schemes for meeting the present and near-future demands of AMLCD industry. Together with a number of research groups and industrial partners, this work has led to the development of a production-type SLS system that is now available from Japan Steel Works, Ltd. (JSW).

In this presentation, we will be reviewing the development of the production SLS processes and systems, as well as summarizing the results of previous research activities. In addition, we will discuss the future development of the SLS method. To this end, we will present recent results from our research activities on the development of SLS schemes to obtain microstructures that are well suited to realize certain future applications, such as location-controlled single-crystal islands for system-on-glass products.

Results

STATUS OF PRODUCTION SLS EQUIPMENT

The most significant aspect of the production-type SLS system that is now available from JSW is that the system was designed and constructed so as to permit optimal implementation of the continuous-scan SLS method.[3] The system can process

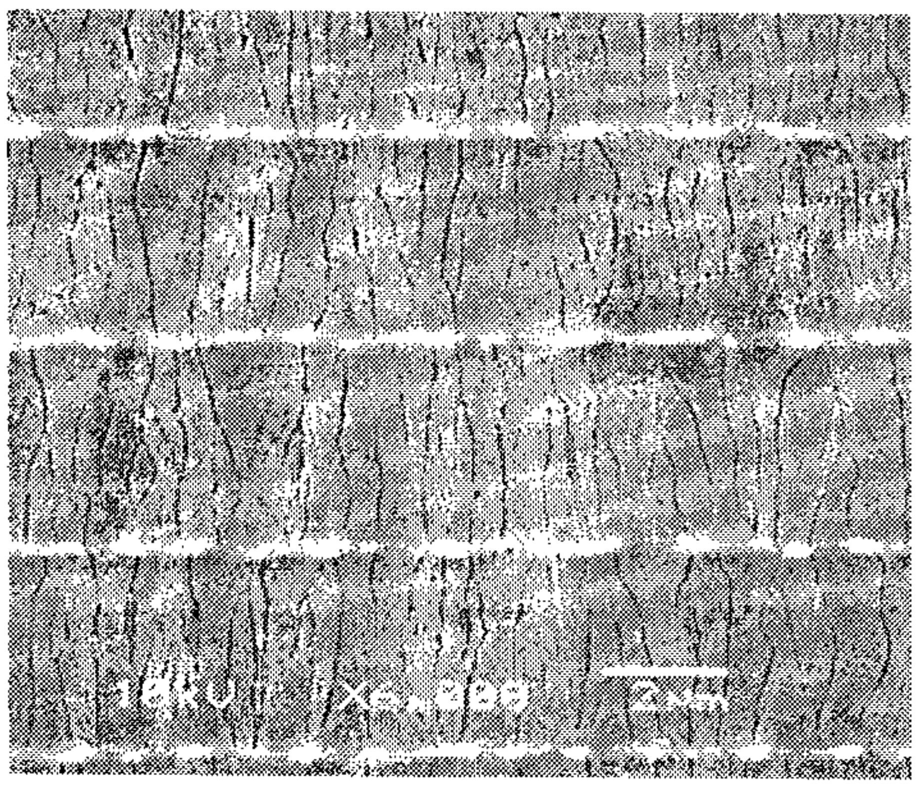

Figure 1. An SEM image of a uniform polycrystalline microstructure obtained with a two-pulse SLS process.

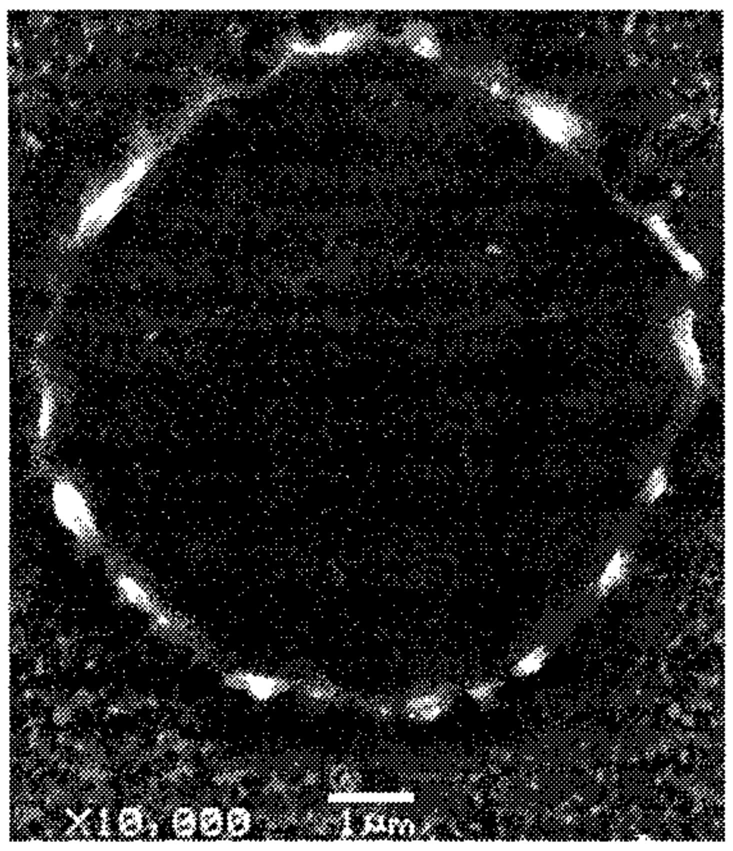

Figure 2. An SEM image of a single-crystal silicon island obtained with a four-pulse dot-SLS process.

various substrate sizes up to the 4th generation glass-substrates (and can be in the future designed to accept gen. 5 or larger substrates). To ensure that the system delivers desired manufacturing performance characteristics, the system is equipped with a number of features such as active focusing, a pulse duration extender, and an ultra-precise translation and rotation stage. As an example, the JSW system is capable of processing 62×75 cm^2 glass panels with a throughput that is 3 to 5 times greater than that achieved using the sate-of-the-art conventional ELA systems. It is estimated that the per-substrate running cost of such an SLS system can be as much as 80% lower than that of the ELA system.

OVERVIEW OF SLS SCHEMES

Figure 1 shows a typical example of one of the several microstructures for which the JSW SLS system has been optimized. This particular polycrystalline material has been obtained through a two-pulse process; it is comprised of large and elongated grains that are periodically and uniformly arranged. The devices fabricated on such a material show improved levels of performance and uniformity over the ELA TFTs.[4]

Figure 2 shows an example of a single-crystal island that was obtained through a four-pulse SLS process. We will present the details of our recent experiments on this particular SLS process (referred to as dot-SLS).[5] As the islands can be created at predetermined positions at high crystallization rates, the method appears to be well suited for the fabrication of high-performance TFTs that are demanded by the future active-matrix display products.

Acknowledgements

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