Minimizing the Total Completion Time for the TFT-Array Factory Scheduling Problem (TAFSP)

A.H.I. Lee, S.H. Chung, and C.Y. Huang

Department of Industrial Engineering and System Management, Chung Hua University, No. 707, Sec.2, Wu Fu Road, Hsinchu, Taiwan, R.O.C.
amylee@chu.edu.tw
Department of Industrial Engineering and Management, National Chiao Tung University, No. 1001, Ta Hsueh Road, Hsinchu, Taiwan, R.O.C.
shchung@mail.nctu.edu.tw
Department of Business Administration, Ching Yun University, No. 229, Chien Hsin Road, Jung Li, Taiwan, R.O.C.
cyhuang@cyu.edu.tw

Abstract. In this paper, we address and solve the scheduling problem for thin film transistor array (TFT-array) factories. The TAFSP is a variation of parallel machine scheduling problem, which involves the characteristics of process window constraint, machine dedication constraint, mask availability constraint, and mask setup and transportation activities. Hence, we propose an integer programming formulation to solve the TAFSP. To increase the applicability of the integer programming model in real environment, depth-search strategy incorporates with the strong branching rule is adopted to increase the solving efficiency. Computational results show that a good-quality feasible solution can be obtained in an acceptable computational time for a real-world case.

1 Introduction

Thin film transistor-liquid crystal display (TFT-LCD) is a capital-intensive and technology-intensive industry which evolves after semiconductor industry. For a sixth-generation factory with the production of 1500mm×1850mm-sized glasses, the investment amount is approximately 2.5 to 3.5 billion US dollars. Manufacturing process of TFT-LCD mainly consists of three stages: TFT-array, LC cell assembly, and module assembly. Among them, TFT-array stage requires the most expensive capital investment (approximately 55%-65% of the total investment). Besides, its production process is very complicated, and its cycle time is considerably long compared to the other two stages. As a result, TFT-array process is the bottleneck among the whole TFT-LCD process flow.

The manufacturing process of TFT-array is very similar to that of semiconductor wafer fabrication, except that a TFT-array factory processes very large glasses, not limit-sized silicon wafers. **Fig. 1** shows the process steps of a TFT-array substrate. Due to the fact that that the processing space for machines is limited in TFT-array process, all machines must be serial-type machines, and only one lot can be processed at a time.

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This is very different from wafer fabrication which have both serial-type and batch-type (i.e. several lots can be processed concurrently at a time) machines. As a result, the cycle time of TFT-array is relatively stabilized.

Steppers in the photolithography area are the most expensive machines in a TFT-array factory and are usually treated as the bottleneck resource in the factory. Based on the fundamental concept of the theory of constraints (TOC), the performance of a system is determined by the bottleneck resource in that system [3]. Consequently, a good arrangement of steppers is essential. To the authors' knowledge, the scheduling problem for the TFT-array factory has not been tackled up to now. The reason is probably because the environments of TFT-array factory and wafer fab are very similar and the scheduling problem of wafers fabs has already been researched extensively [9, 10, 6, 2]. In fact, the TFT-array factory manufactures enormous glasses, and the masks used by steppers are much larger than the ones used in a wafer fab. Therefore, the transportation time and setup time of masks among machines account for quite a remarkable proportion of total process time. Chern and Liu (2003) is the only one that studies the mask resource problem, and has proposed a dispatching rule, named family-based stepper dispatch algorithm (SDA-F), to shorten mask setup time. However, a TAFSP problem not only needs to consider mask setup time, it also needs to consider mask availability constraint, process window constraint, machine dedication constraint and mask transportation characteristics. These characteristics will be covered in Section 2.

The rest of the paper is organized as follows. In section 2, the TFT-array factory scheduling problem (TAFSP) is defined and a demonstrative example is given. In section 3, an integer programming model is proposed to solve the TAFSP problem. Section 4 examines the practicality of the proposed model by solving the demonstrative example to show its usability. In Section 5, a real-world example taken from a TFT-array factory located in the Science-Based Industrial Park in Taiwan is given, and the problem is solved by the proposed model to show its applicability. In the last section, some concluding remarks are made.

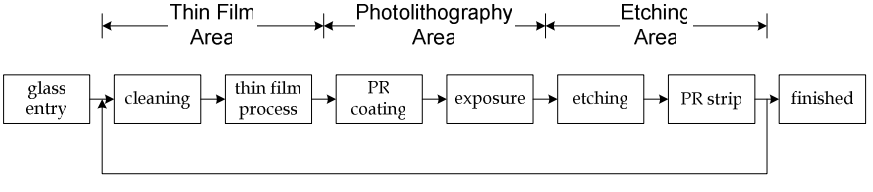

Fig. 1. Process steps of a TFT-array substrate

2 Problem Description

2.1 The TFT-Array Factory Scheduling Problem (TAFSP)

The photolithography process aims to transfer circuit pattern from mask to the surface of glasses so that the functions of final products can be achieved. Different machines