UNIVERSITI TEKNOLOGI MARA

LOW-TEMPERATURE GROWTH OF POLYCRYSTALLINE SI THIN FILM USING RF MAGNETRON SPUTTERING

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ABSTRACT

A study on the growth of polycrystalline silicon (poly-Si) on a glass substrate at low temperature is being studied. The preparation was done by using direct deposition of Radiofrequency (RF) magnetron sputtering method. The physical and crystallinity of thin films was studied and investigated to focus on various deposition parameters such as RF power of 100 W to 300 W, deposition temperature of room temperature to 200 ^{o}C, sputtering pressure of 5 mTorr to 8 mTorr, argon gas flow rate of 40 sccm to 100 sccm and also the influence of substrate bias power of +10 W to +150 W. The physical structures of the thin films were observed by using field emission scanning electron microscope (FESEM), JOEL JSM 7600F, atomic force microscope (AFM) XE-100 Park System AFM and Surface Profiler (SP, KLA Tencor P-6). The crystallinity of the thin films was observed by Raman spectroscopy (Horiba Jobin Yvon). Through the investigation, we found that even giving higher RF power, the thin films start to crystallize but poly-Si thin films still not achieved. To overcome this problem, we explored the role of substrate bias to further enhance the crystallization of the thin films. The substrate bias may provide higher energy during the bombardment and at the same time modifies the arrangement of particles to produce high crystalline quality. The results of the thickness and deposition rate measurements show that substrate bias has influence on the growth of films on the substrate. As the substrate bias increase the deposition rate also increases due to the number of atom collision at the target which lead increasing the particles on the substrate. From Raman spectroscopy result it showed that the Si-Si transverse optical (TO) peak was around 518 cm^{-1} for sample deposited at +30 W which indicates the existence of poly-Si phase. It shows that the thin film crystallized even at room temperature deposition with the influenced of the substrate bias.

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CHAPTER ONE
INTRODUCTION

1.1 RESEARCH MOTIVATION

Tremendous interests have been seen in thin silicon (Si) films on insulating substrates, such as glass and plastics. Researches on fundamental studies of growth and material properties of the films to actual devices have been done. For the applications of the thin Si films we have thin-film transistors (TFTs) and diodes. TFTs have received increasing attention for their use in active matrix liquid crystal displays (AM-LCDs) and active matrix organic light emitting diodes (AMOLED) panel as pixel-switching transistors.

Polycrystalline silicon (poly-Si) is a material composed of independent crystalline grains, which are bounded with the adjacent grains by grain boundary. Poly-Si is different from nanocrystalline silicon (nc-Si) and amorphous silicon (a-Si) which in poly-Si consist no amorphous matrix in it. The poly-Si grain sizes range from tens of nanometers to several micrometers, depending on the deposition and crystallization process conditions.

Since LeComber et al. [1] reported the first hydrogenated amorphous silicon (a-si:H) TFTs, many researchers started the development of an active matrix LCDs using a-si:H TFTs formed on a glass substrate. However, due to the low electron mobility of a-si:H (0.5-1 cm^2/Vs) [2] and the limitation for this technology to n-type TFTs, it made poly-Si is another option to replace a-si:H. Poly-Si has the highest reported electrons and holes mobility of all materials next to single crystalline Si, depending on the selected fabrication process. Using excimer laser annealing (ELA) to form a poly-Si, electron and hole mobility of at least 180 cm^2/Vs and 120 cm^2/Vs can be achieved respectively [3]. The mobility of 41 cm^2/Vs was obtained by Min et al [4] using direct current (DC) magnetron sputtering.

The most common type of substrate is glass because of its low price and availability. This glass substrate is capable of deposition temperature up to 800 ^{o}C. Usually, poly-Si thin films are deposited on glass substrates [5-8], but recently flexible substrate is another alternative to replace the glass substrate [9-10] because its