Variation of density of states in a-Si:H thin-film transistors by mechanical strain

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For bendable display, thin-film transistors (TFTs) based on amorphous oxide semiconductors have been researched widely due to their high-performances and suitabilities [1]. Amorphous semiconductors are preferred over polycrystalline ones for active channel layers of TFTs because of their lower processing temperatures and better uniformitiesof device characteristics. Thus, it is essential to understand properties of amorpous semiconductors under mechanical stress for the development of bendable display [2]. For hydrogenated amorpous silicon (a-Si:H) TFTs, although their performances are inferior to amorpous oxide semiconductor TFTs such as a-IGZO TFTs, a deep investigation on defect states in these amorpous silicon TFTs under mechanical strain is a basis for the improvement of amorphous semiconductor TFTs in the application to bendable display [3]. In this study, we examine the variation of density of states in a-Si:H TFTs under mechanical strain.

Unlike crystalline semiconductors, there are a lot of defect states within the bandgap in amorphous semiconductors due to dangling bonds and weak bonds between atoms, as shown in Fig.1. The defect states generate localized band-tail states and mid-gap defect states. Moreover, under mechanical strain, the deformation of defect states can be easily occurred, thereby threshold voltage, subthreshold swing and on/off current of amorpous semiconductor TFTs can be substantially affected. Besides, gate-insulating silicon nitride layers also suffer from charge trapping instabilities under the mechanical strain, leading to a shift of the threshold voltage.

In our study, we investigate the electrical charateristics of bendable a-Si:H TFTs under compressive or tensile strain. Also, based on the experimetal data, our simulation results using the device simulator (Silvaco ATLAS) are analyzed with variation of density of states or the trapped charge in the silicon nitride layers. As a result, we obtain good agreements between the experimental data and simulation results, as shown in Fig.2.

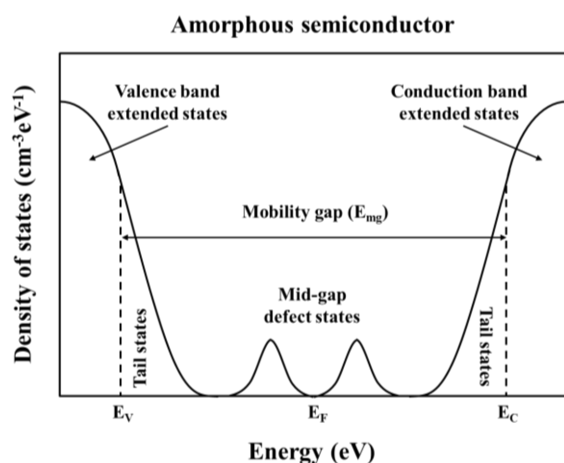

Fig. 1. Schematic scheme of the density of states in amorphous semiconductor

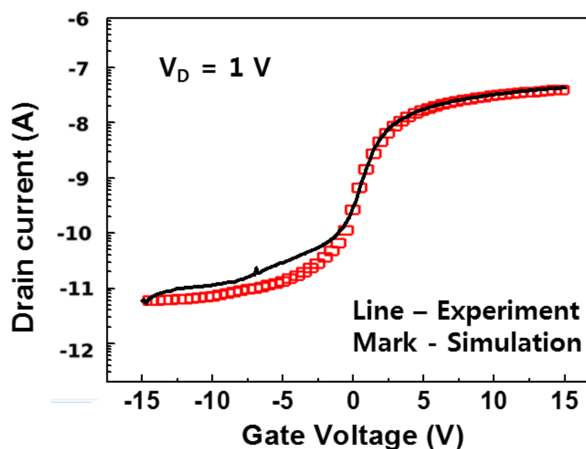

Fig.2. Transfer characteristics of an a-Si:H TFT

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