CRYSTALLINITY OF IN-GA-ZN-OXIDE (IGZO) IN CAAC-IGZO VERTICAL FET

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Oxide semiconductor field-effect transistors (OSFETs) are actively developed [1]. In particular, there are many reports on a typical oxide semiconductor, In-Ga-Zn oxide (IGZO) [2]. An OSFET is fabricated with a planar structure in many cases; however, a vertical FET (VFET) with a current path perpendicular to a substrate can be fabricated with an area overhead comparable to one trench hole, and is gathering attention [3]. The VFET structure enables OSFETs to be highly integrated, and also allows the resolution of displays to be higher.

IGZO has a distinctive property of forming a *c*-axis aligned crystalline (CAAC) structure, which is a unique crystal morphology (CAAC-IGZO). In CAAC-IGZO, *c*-axes of crystal grains are aligned in the direction perpendicular to the formation surface and alignment of azimuths of hexagonal lattices in *a*-*b* planes is not observed. A layered structure originating from the CAAC structure is observed with an electronic microscope [4]. Crystalline IGZO surfaces has a higher binding energy with oxygen atoms than amorphous IGZO surfaces, and an oxygen vacancy is less easily formed in IGZO having high crystallinity than in IGZO having low crystallinity. This indicates the high reliability of CAAC-IGZO [5]. With these features, it can be expected that using CAAC-IGZO in an active layer of a VFET will enable both higher integration and improved stability of VFET devices.

It is investigated whether the layered structure can be formed even on a side surface of a trench hole, which is perpendicular to a substrate. An IGZO film was deposited on the side surface of a trench hole for the investigation. As a result, it is shown that the IGZO film has a layered structure that is parallel to the side surface of the trench hole. In this study, we will report on the analysis method and a factor of forming the layered structure.

We are also investigating an appropriate composition ratio of IGZO, aiming at an increase of on-state current of OSFETs. For example, an increase in In content of IGZO is known to increase the carrier mobility and the conductivity [6], but to the best of our knowledge, no study has focused on crystallinity of IGZO with high In content. In this study, we will report the crystallinity of the IGZO film deposited using a target with high In content and a factor of generating the crystalline structure of oxide semiconductor films.

We have examined the device structure and the influence of the film composition upon the crystallinity of the IGZO film, and will propose vertical OSFETs having both high reliability and high on-state current.

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