High-performance Silicon-doped Metal Oxide Thin Film Transistor for Next Generation Power-saving Flexible Electronics

Keywords : Low-temperature processable amorphous In-Si-O TFT

Back-ground

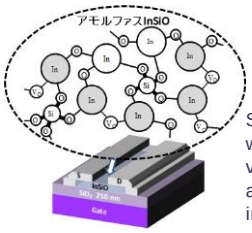
Indium oxide (InO_x)-based semiconductors are particularly attractive for use as switching elements in thin-film transistors (TFTs) for high-definition flat panel displays. This is because InO_x-based semiconductors have a high electron mobility originating from the direct overlap of the isotropic *s* orbitals of In atoms. To stabilize the TFT characteristics by controlling the creation of oxygen vacancy (V_O), an oxygen binding dopant is the crucial in the thin film. Here, we tried to control creation of Vo to realize the high performance TFT.

Aim

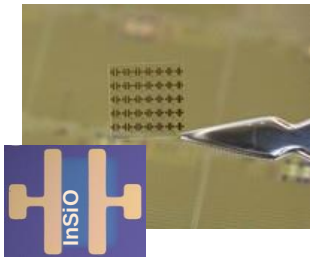
We have developed promising material for oxide thin film transistor to produce a next generation power-saving flat display. Our Si-doped metal oxide TFT (SiM-OxTFT) behaves as a very stable and high-performance TFT with highly suppressed off-state current.

Advanced Research Topics

As for pixel switching TFT in the flat panel display, amorphous silicon or poly-silicon film has been customarily used. But because of serious large off-state current in the current TFTs, a new TFT is strongly desired to realize a low-power consumption system. Furthermore, higher mobility of TFT than the amorphous silicon is needed to present high resolution contents. Amorphous metal oxide thin-film transistor (a-OxTFT) is a possible candidate as the post silicon TFTs. Although the InGaZnO film is one of the candidates of the a-OxTFT, however, the InGaZnO is very unstable film in actual production. The electric property of the film is a very sensitive to oxygen absorption or desorption at the bonding sites adjacent to Zn atoms.
We discovered that the electric stability of the TFT is determined by the bond-dissociation energy of the dopant element in InOx film. By incorporating the dopant with higher bond-dissociation energy, such as Silicon atom, the film suppresses thermal active vacancy in the film. The basic property of our original InSiO-OxTFT has exceeded that of current commercial production TFTs.



Schematic of a-InSiO TFT with schematic image of vacancy suppression in an a-InSiO film by incorporating SiO_2.



Microscope image of TFT array fabricated in our research.

Publications

1) S.Aikawa, P.Darmawan, K.Yanagisawa, T.Nabatame, Y.Abe, K.Tsukagoshi: Applied Physics Letters 102 (2013) 102101.
2) N.Mitoma, S.Aikawa, X.Gao, T.Kizu, M.Shimizu, M.-F. Lin, T.Nabatame, K.Tsukagoshi: Applied Physics Letters 104 (2014) 102103.
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Summary

- Flat panel displays in next generation highly developed information society. High-resolution TV, computer display, smartphone, information panel, etc.
- US20160056409 (Toshihide Nabatame, Kazuhito Tsukagoshi, Shinya Aikawa) .

Research outcome

- Further development of property control of SiM-OxTFT to adjust it into the applications.

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