論文 / 著書情報
Article / Book Information

題目(和文)	
Title(English)	Low-Temperature Solution-Processed Metal Oxide Transistor for Flexible Electronics
著者(和文)	宮川幹司
Author(English)	Masashi Miyakawa
出典(和文)	学位:博士(工学), 学位授与機関:東京工業大学, 報告番号:甲第11600号, 授与年月日:2020年9月25日, 学位の種別:課程博士, 審査員:飯野 裕明,間中 孝彰,菅原 聡,大見 俊一郎,神谷 利夫
Citation(English)	Degree:Doctor (Engineering), Conferring organization: Tokyo Institute of Technology, Report number:甲第11600号, Conferred date:2020/9/25, Degree Type:Course doctor, Examiner:,,,,
学位種別(和文)	博士論文
Category(English)	Doctoral Thesis
種別(和文)	論文要旨
Type(English)	Summary

（博士課程）
Doctoral Program

論 文 要 旨

THESIS SUMMARY

系・コース： Department of, Graduate major in	電気電子 電気電子	系 コース	
学生氏名： Student's Name	宮川 幹司		

申請学位（専攻分野）： Academic Degree Requested	博士 Doctor of （ 工学 ）
指導教員（主）： Academic Supervisor(main)	飯野 裕明
指導教員（副）： Academic Supervisor(sub)	

要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

Recent rapid growth of digital technology requires various human interactive electronics such as information displays and sensors in area of information society. One of the primary components is thin-film transistors (TFTs). Simple and facile solution-processed metal oxide TFTs are promising device and have various advantages such as low cost, large-area fabrication, and process simplicity. However, the current substandard performance limits its wide range of practical applications. In this thesis, the general methods to improve the low-temperature solution-processed metal oxide TFTs in terms of electrical performance and process simplification were presented to enhance the overall performance for the large demands of flexible electronics.

The processing approach by hydrogen injection and oxidation (HIO) methods are demonstrated for low-temperature solution-processed metal oxide semiconductors using zinc tin oxide (ZTO) by organic precursor and indium gallium zinc oxide (IGZO) by aqueous precursor. The HIO method enables an efficient elimination of a large amount of residual species as well as film densification upon sequential oxidation. By detailed chemical analyses including X-ray photoelectron spectroscopy (XPS), Fourier transform infrared spectroscopy (FT-IR), secondary ion mass spectrometry (SIMS), and thermal desorption spectroscopy (TDS), the mechanisms of HIO methods were carefully investigated. Furthermore, the improvement in the TFT characteristics was confirmed in terms of mobility and electrical stability. The aqueous IGZO TFT with HIO method exhibit very stable characteristics even at 250˚C processing temperature. Furthermore, the compatibility of HIO method for flexible electronics is also demonstrated by the TFT arrays, which exhibit almost same performance as the TFT on silicon substrate. Therefore, the effectiveness of HIO method were clearly confirmed by enhanced TFT characteristics. The importance of the reduction of residuals insides the films is also clarified.

The material approach by aqueous fluorine-doped IGZO (IGZO:F) precursors demonstrated a high-performance metal-oxide TFTs at a low-temperature processing of 300˚C. The fluorine doping for aqueous precursor was effective to suppress the total impurities from metal ligands. It also enhances the TFT characteristics fabricated with IGZO:F precursor, enhancing the overall TFT performance such as the mobility, better switching characteristics, and reliability. Combining with HIO method, the mobility over 7 cm^2/Vs was achieved for the IGZO:F.

The simple TFTs fabrication techniques using direct patterning were investigated. Simple and reliable direct patterning process for totally carbon-free aqueous precursor was demonstrated with good electrical performance and uniformity by utilizing a photo-oxidation of water molecules and nitrate ligands. The

mechanisms of direct patterning were carefully examined by chemical analyses. The TFT exhibited uniformed mobilities with an average value of 4.3 $cm^2/V{\cdot}s$ and small deviations and good reliability.

Through this thesis, the investigations for low-temperature solution processed metal oxide using the processing and materials approaches demonstrate the routes to improve the TFT performance for flexible electronics. The developed low-temperature technology such as HIO method, fluorine doped aqueous precursor, and direct patterning could show the great potentials to lead the practical applications in the field of various flexible electronics. Current performances by those low-temperature technologies are still needed to be improved its performance compared to the metal oxides by vacuum processing. However, the use of multiple technologies such as HIO with innovative precursors could be essential methods to boost the current performance of solution-processed metal oxide TFTs. Further investigations open the door for obtaining good and reliable performance for low-temperature solution-processed metal oxide TFTs, which leads solution-based electronics.