

ZnO 나노선과 CdTe 나노입자를 이용한 NFGM 소자의 전기적 특성

윤창준, 염동혁, 강정민, 정동영, 김미현*, 고의관*, 구상모** 김상식
고려대학교 전기공학과, 한국기초과학연구소*, 광운대학교 전자재료공학부**

Electrical characteristics of ZnO nanowire - CdTe nanoparticle nano floating gate memory device

Changjoon Yoon, Donghyuk Yeom, Jeongmin Kang, Dong-Young Jeong, Mihyun Kim*, Eui Kwan Koh*, Sangmo Koo** and
Sangsig Kim

Department of Electrical Engineering, Korea University, Korea Basic Science Institute*, Kwangwoon University**

Abstract : In this study, a single ZnO nanowire - CdTe nanoparticle nano floating gate memory (NFGM) device is successfully fabricated and characterized their memory effects by comparison of electrical characteristics of ZnO nanowire-based field effect transistor (FET) devices with CdTe nanoparticles embedded in the Al_2O_3 gate materials and without the CdTe nanoparticles.

Key Words : ZnO nanowire, CdTe nanoparticle, memory

1. 서 론

The nanomaterials such as nanoparticles and nanowires for nanodevices have received attention in recent years. Especially, due to the outstanding charge confinement effect, nanoparticles were used for charge storage node in memory devices[1]. Nanowires have some advantages to be used as a channel of the nanodevices due to their high crystalline structure, excellent electrical properties and good charge transportation characteristics [2].

Therefore the hybrid nanomaterials, combining the nanowires and nanoparticles, can be to maximize the properties of capability for charge storage node and charge transportation capability. This idea motivates our research of ZnO nanowire-CdTe nanoparticle nano floating gate memory (NFGM) device.

2. 실험

The as-synthesized ZnO nanowires are dispersed on a heavily doped Si substrate capped with a SiO_2 layer having a thickness of 300 nm. Then, source and drain electrodes are patterned on a single ZnO nanowire selected from the dispersed ZnO nanowires by a photolithographic process under an optical microscope. The 5nm thickness of Al_2O_3 layer for tunneling oxide layer was uniformly deposited by atomic layer deposition (ALD) and the diluted water based CdTe nanoparticle solution is spin-coated on the surface of the selected ZnO nanowire. For the formation of a control oxide layer, Al_2O_3 layer having a thickness of 25 nm is deposited by ALD and Ti (70 nm)/Au (30 m) are deposited

on the channel part of the ZnO nanowire - CdTe nanoparticle FET device after the patterning of the gate region between the source and drain electrodes by the photolithographic process. For a comparison, a reference device was also prepared by the same processes described above except the process of CdTe nanoparticles formation.

Figure 1 shows HRTEM image of structure of the ZnO nanowires wrapped CdTe nanoparticles. The average particle size of the wrapped CdTe nanoparticles in the composite ZnO nanowires is 6 ± 2.5 nm. Also, it noted that the CdTe nanoparticles are well dispersed on the surface of the ZnO nanowires without any aggregation.

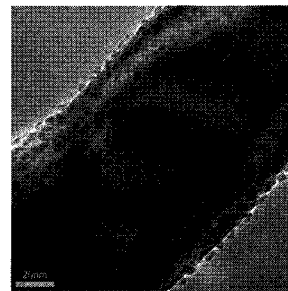


그림 1. HRTEM image of a selected ZnO nanowire - CdTe nanoparticles hybrid nanomaterial.

3. 결과 및 고찰

Figure 2 shows that the $I_{DS} - V_{GS}$ characteristics of ZnO nanowire - CdTe nanoparticle NFGM device and reference sample under multiple drain voltages of 1V, 0.75V and 0.5V. Figure 2(a) exhibits that CdTe nanoparticles have been used as charge storage nodes of NFGM device. CdTe nanoparticles were charged during the gate voltage sweeping, and the charges in the CdTe nanoparticles lead to the

threshold voltage shifts by screening the applied gate voltage.

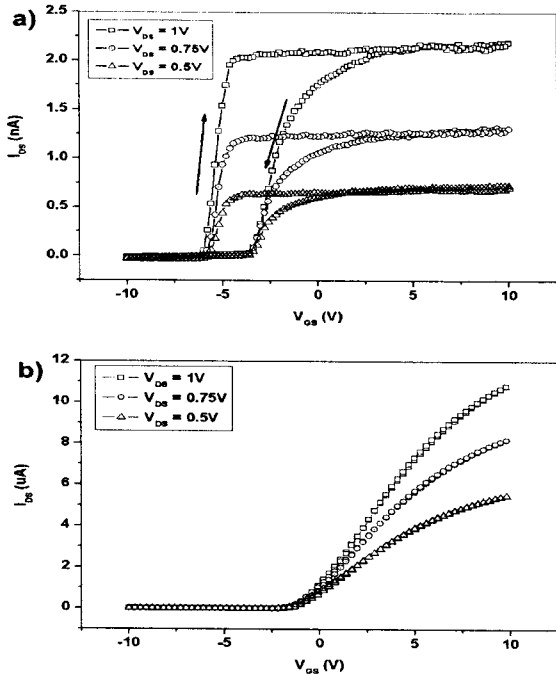


그림 2. $I_{DS} - V_{GS}$ sweep curves of (a) ZnO nanowire - CdTe nanoparticles NFGM device and (b) reference sample

A threshold voltage shift of 3.1V is attained at a sweep gate voltage from -10V to 10V. The hysteresis loops of ZnO nanowire - CdTe nanoparticle NFGM devices are clockwise which result from the charging of the electrons from the ZnO nanowire into the CdTe nanoparticles [4].

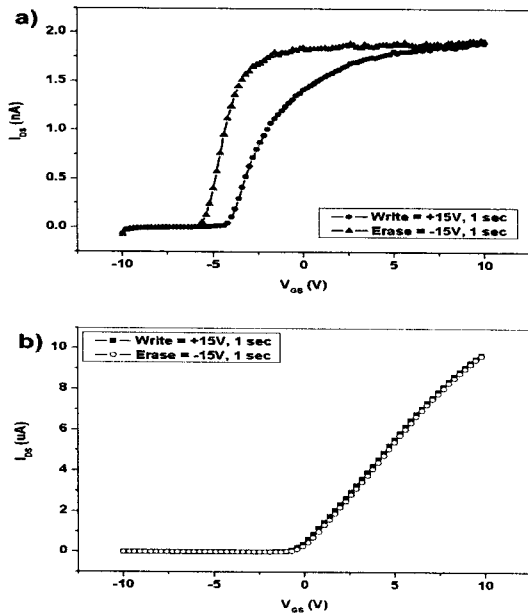


그림 3. $I_{DS} - V_{GS}$ curves of (a) ZnO nanowire - CdTe nanoparticles NFGM device and (b) reference sample when the write (+15 V) and erase (-15 V) voltage were applied for 1 second before measurements.

To address this ZnO nanowire - CdTe nanoparticles NFGM

device can be utilized as nonvolatile memory, we have also characterized the $I_{DS} - V_{GS}$ curves with the gate voltage in the pulse form. To charge electrons from ZnO nanowire to CdTe nanoparticles, +15V is applied to the gate electrode of NFGM device for 1 second and to discharge electrons from CdTe nanoparticles to ZnO nanowire, -15V is applied to the gate electrode of NFGM device for 1 second. Figure 3 (a) shows that the threshold voltage shifts of $\Delta V_{th} = 2$ V about the ZnO nanowire was coated with CdTe nanoparticles for the gate voltage in the pulse. When the +15V pulse is applied to the gate electrode, electrons in the ZnO nanowire channel are moved into CdTe nanoparticles and these charged electrons in the CdTe nanoparticles act as additional negative gate bias. These facts have an effect on the reduction of the drain current. When the -15V pulse is applied to the gate electrode, with the same principle, the drain current increased. The threshold voltage shift is caused by this phenomenon.

4. 결론

Using the nanowire-nanoparticle hybrid nanomaterials, ZnO nanowire - CdTe nanoparticle NFGM device is successfully fabricated by a conventional photolithographic process. From the $I_{DS} - V_{GS}$ curve, clockwise hysteresis loops which caused by tunneling of electrons from the channel to nanoparticles and 3.1V threshold voltage shift are obtained. These results reveal that our ZnO nanowire - CdTe nanoparticle NFGM device has a sufficient substitutability for the conventional memory devices.

감사의 글

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