Comparative study of NVM elements based on single-walled carbon nanotubes and silicon nanocrystals

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Discrete storage nodes type of NVM (nonvolatile memory) devices have a high potential to improve its properties on the contrary to conventional floating gate memory; due to the absence of adjacent nodes interference further technological scaling becomes reachable. Based on Si nanocrystals (nc-Si) NVM is of considerable interest last decade [1]. One of expected applications of single-walled carbon nanotubes (SWCNTs) is NVM by using it instead of nc–Si as charge storage nodes within, e.g. SiO_2, wide-band dielectric ambient.

There are advantages [2]: 1) compatibility with a standard CMOS process (high thermal stability 1500°C); 2) supplying of a profitable CNT work function (4.8 eV) by via diameter control, chemical doping, and O_2 desorption. SSWCNTs on the SiO_2 surface can be form by various CNT growth methods [3]. The performance of two SWCNT NVM device subtypes was discussed earlier [4]: with embedded into SiO_2 vertically standing SWCNTs and horizontally lying SWCNTs. By extrapolation it was shown that after 10 years at room temperature levels of 60% and 15% stored charges are preserved for S- and L-subtypes respectively. S-subtype shows [4] better program/erase switch and enhanced retention time compared to L-subtype due to high coupling ratio (that relates with increased effective surface of control electrode) and the defect immunity based on the isolated distribution SWCNTs.

Evaluation of SONOS structure retention time gives about 100 years at room temperature condition [5]. Here we estimate the charge retention time for nc–Si NVM as 10–20 years at the 67%-level. The further improving technology and design of NVM based on SSWCNT with high coupling ratio will develop competitive devices compared to devices on nc–Si.

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