Self-assembled $NiSi_2$ nanocrystals for nanoscale non-volatile memory application

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Recently, memory-cell structure using discrete traps as the charge storage media has received much attention as a promising candidate to replace conventional flash memory for future high speed and low power non-volatile memory devices[1]. To increase charge density per trap, metallic nanocrystals are being studied due to their higher density of states compared to Si nanocrystals. Nickel silicide is considered to be one of the most suitable materials for deep submicron, self-aligned silicide (salicide) applications because nickel silicide films have lower morphological and thermal instability.

In this study, we investigated the charge storage capability of self-assembled monolayer of $NiSi_2$ nanocrystals embedded in SiO_2 layers[2]. The $NiSi_2$ films with thickness of few nanometers (from 3nm to 5nm) were deposited onto oxidized Si substrates using RF sputtering method. By subjecting the sputtered $NiSi_2$ thin-film to rapid thermal annealing (RTA) a monolayer of $NiSi_2$ nanocrystals were formed. The morphologies of the $NiSi_2$ nanocrystals were characterized by scanning electron microscope (SEM) and atomic force microscope (AFM) for various RTA time durations (from 1 min to 5 min) at 800 °C in N_2 ambient (Fig.1). The mean size and aerial density of the $NiSi_2$ nanocrystals were ~18nm and $1X10^8/cm^2$, respectively. The capacitance-voltage (C-V) measurements were performed to study the electron charging and the discharging effects of the self-assembled monolayer of $NiSi_2$ nanocrystals embedded in SiO_2 (Fig.2). We observed a threshold voltage shift of more than 4 V when the bias voltage was swept between $\pm$9 V. The gate oxide was 3 nm thick with a 20 nm control oxide deposited on top of the $NiSi_2$ nanocrystal layer. The results clearly demonstrates that the self-assembled $NiSi_2$ nanocrystals formed by RTA maybe applicable to future nanoscale-floating gate memory devices.

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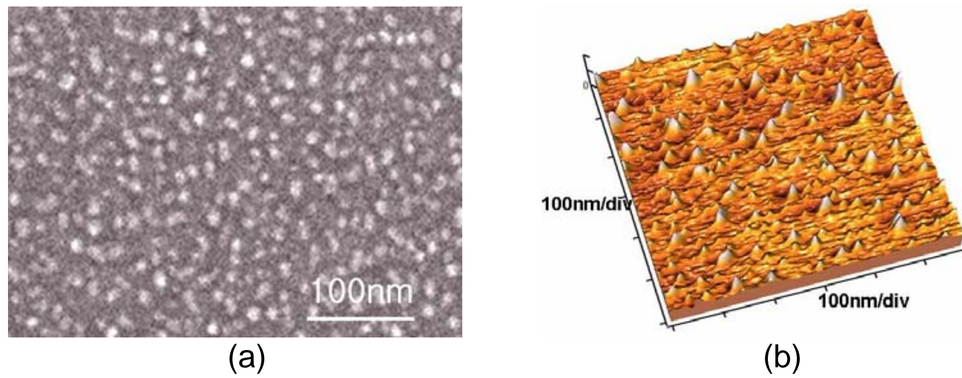
[1] Z. Liu, C. Lee, V. Narayanan, G. Pei, and E. C. Kan, IEEE Trans. Electron Devices 49, 1606 (2002).

[2] P. H. Yeh, C. H. Yu, and L. J. Chen, H. H. Wu, P. T. Liu, T. C. Chang, Appl. Phys. Lett. 87, 193504 (2005).



(a) (b)

Fig 1. Surface morphologies of self-assembled monolayer of $NiSi_2$ nanocrystals. (a) SEM image and (b) AFM image

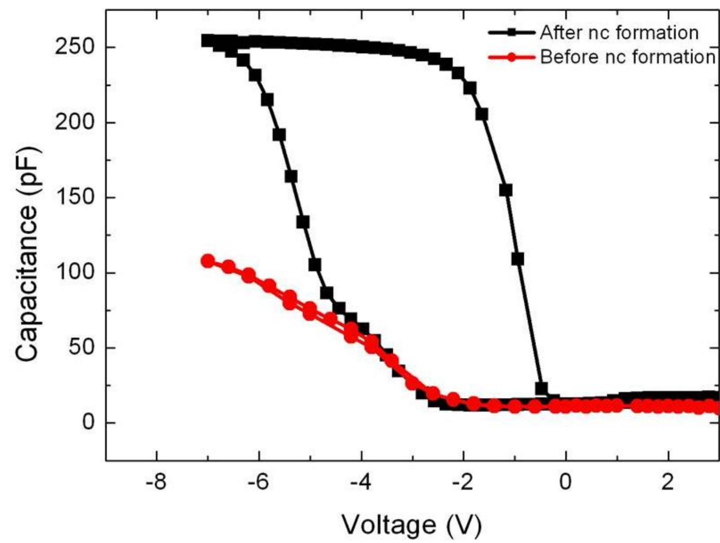


Fig 2. The C-V characteristics of 4nm $NiSi_2$ film before and after self assembled nanocrystals formation measured at room temperature.