Chapter 4

Conclusions

The thesis of “SONOS-Type Memory Devices with High-K Nanocrystals by Sol-Gel Spin Coating Deposition” was proposed. The results of each chapter are summarized as below.

The advantages of using sol-gel spin coating method to deposit high-k thin film as SONOS-type memory charge trapping layer are:

1. Cheaper sources and tools than atomic layer deposition (ALD), physical vapor deposition (PVD), and metal-organic chemical vapor deposition (MOCVD).
2. The solution of precursors can be fabricated under normal ambient.
3. The sol-gel method can be extended to synthesize two or three different high-k materials easily.

In the chapter 2, we use the sol-gel method to synthesize two different high-k precursors, i.e. $HfCl_4$ and $SiCl_4$ together, to deposit binary high-k charge trapping layer. From the TEM image, we can see the nanocrystals existed in the charge trapping layer after 900^{o}C RTA. The composition of the binary high-k thin film is examined from the XPS data. We also measured the electrical performance of this binary high-k thin film SONOS-type memory device. From the electrical data, we have proved this binary high-k charge trapping layer device with good program/erase speed, good data retention ability and good reliability up to 10^5 P/E cycles.

In the chapter 3, we apply our sol-gel spin coating to fabricate SONOS-type memory with co-existed hafnium silicate and zirconium silicate nanocrystals, and the size of one nanocrystal is about 5nm. We have verified the device performance with the P/E speed, charge retention, endurance and disturbance measurement. The quality of the co-existed hafnium silicate and zirconium silicate nanocrystals formed by the sol-gel spin coating method and RTA treatment exhibits better properties in terms of larger Vth shift due to more trapping site existed, long charge retention time (5% loss at 10^4sec), and good endurance (up to 10^5 P/E cycles) with no memory window narrowing.

In brief, we have fabricated high-k nanocrystals in this thesis with sol-gel spin coating method and each of them has good characteristics. Hence, the sol-gel spin coating method is an easy way for high-k charge trapping layer deposition for the next generation SONOS flash memory application.