The Effect of C, H and O Elements on Etching Ru Thin Films using Inductively Coupled

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***Abstract*:** *In the semiconductor memory device field, for the next generation it is a big challenge to develop a memory device that has fast speed of read and write, high density of memory storage and non-volatility. Nowadays, Magnetic random access memory (MRAM), one of the possible candidates for non-volatile random access memory (NVRAM), has a received great deal of attention due to its several advantages.*

MRAM is composed of magnetic tunnel junction (MTJ) stack and complementary metal-oxide semiconductors (CMOS). MTJ stack is a key parts in MRAM devices and they consist of various magnetic materials, metals, and a tunneling barrier layer. Recently, Ru thin films have been used as an spacer layer in synthetic antiferromagnets (SAF) of MRAM devices that consist of two ferromagnetic layers separated by a non-magnetic coupling space layer because of their low resistivity, good thermal stability and high work function. For the realization of MRAM devices, the etching of Ru films should be developed. Currently the CH_3OH/Ar, CH_4/Ar and CH_4/O_2/Ar chemistry have been known to be good etch gases for the etching of magnetic films and MTJ stack. Therefore, the etching of Ru films also needs to be developed using CH_3OH/Ar, CH_4/Ar and CH_4/O_2/Ar gas mixture.

In this study, inductively coupled plasma reactive ion etching was employed to investigate the etch characteristics of Ru thin films in CH_4/O_2/Ar plasma. The effects of CH_4/Ar and O_2/Ar concentration on the etch rate, etch selectivity, and etch profile were studied. In addition, the influence of O_2 concentration in a CH_4/Ar gas mixture on the etch characteristics was also studied. Optical emission spectroscopy (OES) was utilized to analyze plasma states with different gas ratios in CH_4/O_2/Ar gas mixture. The surface chemistry of etched Ru films was analyzed by X-ray photoelectron microscopy (XPS) to elucidate the etch mechanism.

Keywords: *Inductively coupled plasma reactive ion etching; Ru thin films; Magnetic tunnel junction; CH_4/Ar, CH_4/O_2/ Ar*