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# 안티퓨즈 소자의 하층 전극으로 사용될 TiW실리사이드의 제조
# (Formation of TiWsilicide as bottom electrode of antifuse)

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Antifuses have been widely used in field programmable gate arrays(FPGA's). Antifuses serve as electronic switches that are normally open(off-state) and can be switched to a conducting state(on-state) only once by breaking down the insulator.

Recently, extensive research has been conducted on metal-electrode antifuses like metal-insulator-metal(MIM) structure. The use of thin insulator film is advantageous to low on-resistance because of short distance between electrodes. However, it is difficult to obtain highly reliable thin insulator film on the metallic electrode, due to local electric field intensification caused by the roughness of metal surface, especially by the sharp protrusions.

The barrier metals such as TiW and TiN are usually used as bottom electrode, and the amorphous Si and $SiO_2$ as intermetallic insulator. However in oxide/bottom metal system an unexpected metallic oxide layer could be created at the interface, which degrades the performance of the antifuse device.

In this paper for the purpose of obtaining a smooth surface as well as suppressing metallic oxide formation at the interface, about 100Å amorphous Si was deposited on as-deposited TiW(10at.% Ti) and then layers were annealed by various two-step anneal methods. The TiWsilicide formed at three different first anneal temperatures of 350, 450, and 550℃ along with a fixed second anneal temperature of 700℃ were shown in Fig. 1, and those formed at fixed first anneal temperature of 500℃ along with three different second anneal temperature of 800, 850, and 900℃ were shown in Fig. 2. It was shown that 350℃ first anneal process could not create TiWsilicide, no matter how next high temperature second anneal was applied.

Both TiSi and $(Ti_{0.6}W_{0.4})Si_2$ types of silicides were created at the same time after first step anneal about 450℃ and these were stabilized through the second step anneal near 800℃. However very thin unreacted residual Si layer still exists on the surface of the film, which is revealed from XPS analysis. It is believed that this residual layer plays an important role in suppressing the formation of metallic oxide, especially $TiO_x$, when $SiO_2$ is deposited on the top of the film. As shown in fig. 3, the surface roughness of the film before depositing $SiO_2$ layer, measured by AFM, was about 11 Å, which was as smooth as the as-deposited TiW surface. As a result, introducing TiWsilicide by two-step anneal, the interface of insulator/bottom metal could become stable and smooth which is important in fabricating a reliable antifuse device.

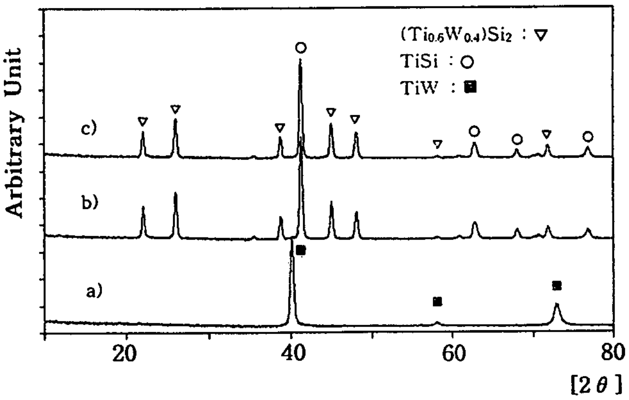

Fig. 1. XRD patterns for TiW silicide formed at three different first anneal temperature of 350℃(a), 450℃(b), and 550℃(c) with a fixed second anneal temperature of 700℃

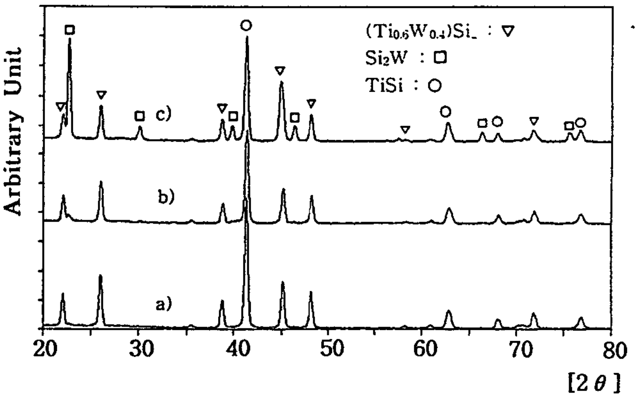

Fig. 2. XRD patterns for TiW silicide formed at fixed first anneal temperature of 500℃ with three different anneal temperature of 800℃(a), 850℃(b), and 900℃(c)

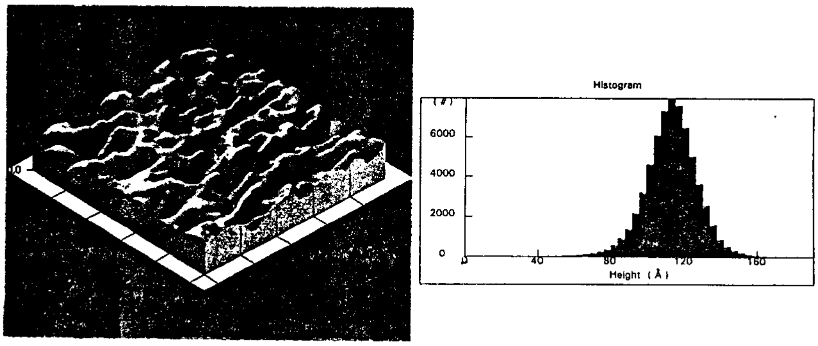

Fig. 3. Surface AFM analysis for the manufactured TiWsilicide film