Effects of Magnetic Field on Copper Films Grown by Electroplating Method

B. N. Park, and S. Y. Choi.

School of electronic and electrical engineering,
Kyungpook national university, Daegu, Korea

In the semiconductor devices, the gravity of RC time delay which is caused by metal line and inter-layer dielectrics has been increasing because the feature size of chip was smaller (see Fig. 1)[1]. Therefore, Copper was proposed for next generation chip wiring. The advantages of Copper, compared with Aluminum are lower electrical resistance, higher allowed current density, and increased scalability etc [2,3]. The Copper has been deposited using a variety of techniques, however, suffer from some problems in depositing Copper. PVD methods, such as thermal evaporation, e-beam evaporation, and sputtering, have difficulty in filling fine pitch trench holes due to the shadow effect [4]. Because of high cost, great film stress, and low deposition speed, the CVD method has no application to the manufacturing processing. Recently, electroplating method which deposits Copper films using Cupric sulfate solution, has been proposed. The electroplating has the advantages of simplicity, safety, low cost, low deposition temperature, high purity, low resistivity, and high capability of gap filling [5].

In this experiment, the seed layer was used a Copper thin film deposited by sputtering method on an unpatterned p-type silicon wafer using Tantalum thin film for diffusion barrier. The thickness of seed and barrier layer were 600 and 400 Å respectively. The electroplating process was performed for 5 min with a cathode current of 2 A, and a electrode distance of 4 cm. The programmable pulse generator and high density solenoid were used for current and magnetic source respectively.

In the pulse current experiment, we obtained uniform film and the biggest grains at high frequency and 2.5 A of reverse amplitude. In the magnetic field experiment, we performed electroplating process for inducing magnetic field or not. When inducing magnetic field, a little improvement in deposition seed and resistance of electromigration was obtained. For all of the processing conditions, pure Copper films were obtained.

And then, we will investigate the effects of direction and variable intensity of magnetic field.

References

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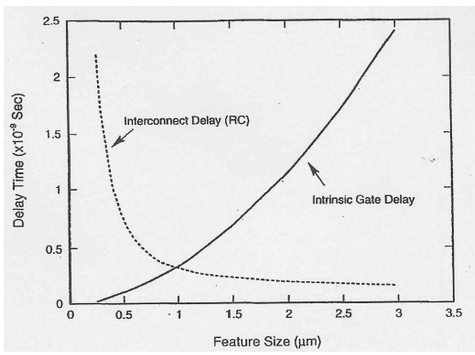
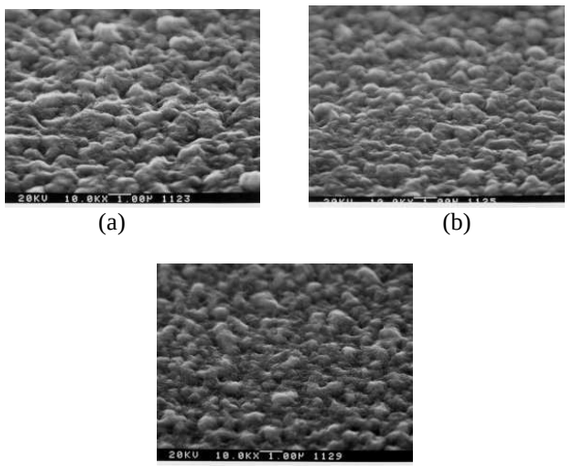


Fig. 1. Comparison of intrinsic gate delay and interconnect delay (RC) as a function of feature size.



(a) (b)

(c)

Fig. 2. The SEM photograph for amplitude ratio of forward and reverse.
(a) forward 2A, reverse 2.5A.
(b) forward 2A, reverse 2A.
(c) forward 2A, reverse 1.5A

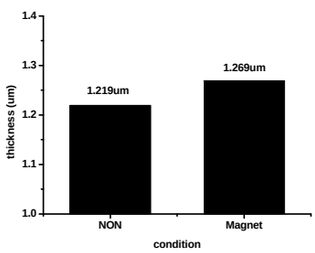


Fig. 3. film thickness vs. each conditions.

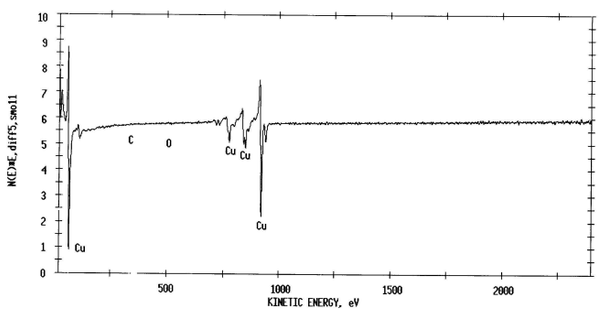


Fig. 4. Auger electron spectrum of the surface.