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Etching Characteristics of Au Film using Capacitively Coupled CF4/Ar Plasma

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Abstract – In this paper, the etching of Au films using photoresist masks on Si substrates was investigated using a capacitively coupled plasma etch reactor. The advantages of plasma etch techniques over current methods for Au metalization include the ability to simplify the metalization process flow with respect to resist lift-off schemes, and the ability to cleanly remove etched material without sidewall redeposition, as is seen in ion milling. The etch properties were measured for different gas mixing ratios of CF4/Ar, and chamber pressures while the other conditions were fixed. According to statistical design of experiment (DOE), etching process of Au films was characterized and also 20 samples were fabricated followed by measuring etch rate, selectivity and etch profile. There is a chemical reaction between CF4 and Au. Au-F is hard to remove from the surface because of its high melting point. The etching products can be sputtered by Ar ion bombardment.

Key words –

I. Introduction

Au (gold) is employed extensively in high performance device fabrication, principally because of its high electrical conductivity and its property of relative chemical inertness. Device makers have used lift-off techniques almost exclusively for patterning Au films[1]. However, the lift-off scheme has a disadvantage which is a considerable complexity to their process flow. The advantages of plasma etch techniques over current methods for Au metalization include the ability to simplify the mentalization process flow with respect to resist lift-off schemes, and the ability to cleanly remove etched material without sidewall redeposition[2]. The objective of this study is to optimize fluoride gases plasma etching process of Au metalization using statistical method. It is expected that this study including experiment designs, analysis approaches, and optimization methods proceeds to advanced attempts in plasma etching process of Au metalization.

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II. Experiment

The advantages of plasma etch techniques over current methods for Au metalization include the ability to simplify the metalization process flow. However, the Au atoms of the Au film react with fluorine make nonvolatile etch by-products such as AuFx, which can be redeposited on the surface[3]. Consequently, the plasma etching of Au film is beyond control. The full factorial design method is performed with several controllable factors and each levels. With etch rate, selectivity and profile characteristic, the analysis is implemented through statistical methods.

The plasma etching of Au film using photoresist masks on silicon substrates is investigated using fluoride gases.

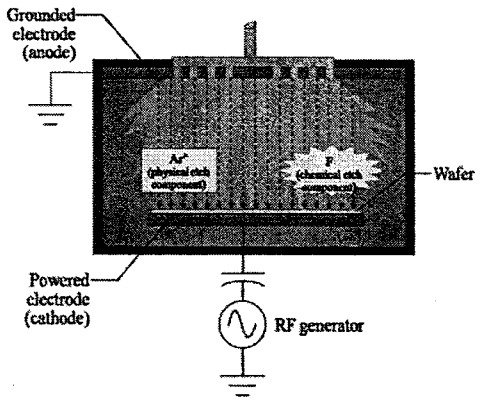

Fig. 1 A schematic of the capacitively coupled plasma (CCP) system.

Process feasibility studies of photoresist masked Au etch are started in the CCP (Capacitively Coupled Plasma) using stacks composed of 4000Å gold over thin Pt over a Ti adhesion layer over SiO2 on Si substrates. To etching process of Au film, the experiments are designed by full factorial method with controllable factors (RF power, pressure, gases mixture). During plasma processing, etch rate, selectivity and profile measure by measuring instruments such as α-step and SEM (Scanning Electron Microscope). Then statistical analysis is quantitatively implemented, i.e. main and interaction effects, analysis of variance, and regression analysis.

III. Result and discussion

In this experiment, lower pressure and more Ar gas ratio, increasing the etch rate of Au films. The pressure condition is a very critical factor for etch rate of Au films.

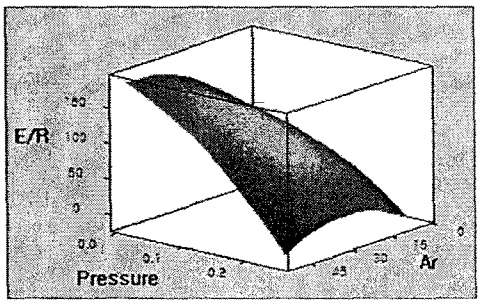

Fig. 2 interaction plot : fixed CF4 gas at 100sccm

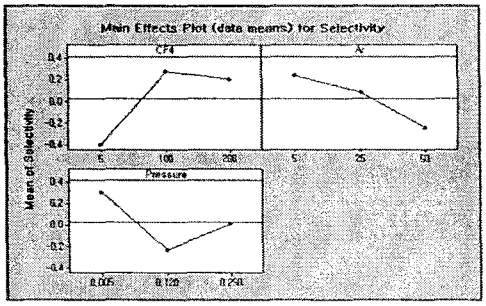

Fig. 3 Main effect plot for selectivity

Fig. 2 shows that interaction effects between pressure and Ar in the etch rate of Au films. Fig. 3 shows main effect of selectivity between Au film and photoresist. It is observed, the more Ar gas ratio, decreasing the selectivity. It was seemed that Ar+ ion bombarded the photoresist mask. In Fig. 4, lower pressure and more Ar gas ratio, increasing the etch profile of Au film. The pressure condition is very critical factor for etch rate of Au films. Fig. 5 is images of the best result obtained in the series of photoresist mask gold etch experiments. The gold etch rate here is 200Å/min, with a platinum etch rate of half that. The etch profile is approximately 108°.

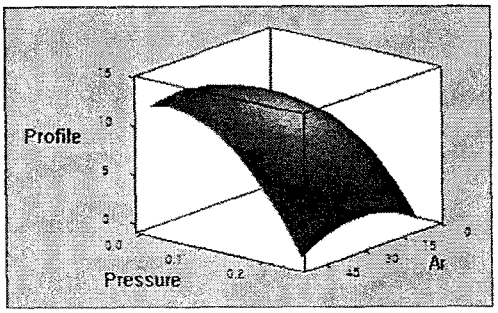

Fig. 4 Response surface plot : fixed CF4 gas at 100sccm

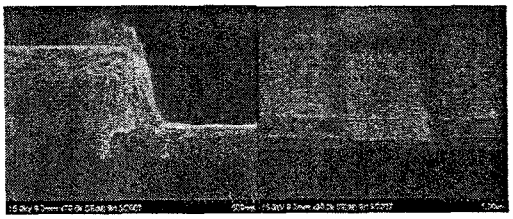

Fig. 5 The best result of Au film etching (cross section and field view)

IV. Conclusion

In this work, we investigated the effects of pressure and gas mixing ratio on both etch characteristics and mechanism of Au films in CF4/Ar capacitively coupled plasma. The optimized etch conditions can be proffered to the plasma etching of Au metal films and other noble metals, like platinum and iridium, which are now finding use in integrated circuit fabrication.

Acknowledgment

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