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SELECTED PAPERS FROM
ICOM'01, ICOM'05 AND
ICOM'08

Editors

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QUALITY OF CU FILM ELECTRODEPOSITED ON SILICON WAFER USING DIFFERENT CURRENT DENSITIES

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ABSTRACT

Copper film was electroplated on silicon wafer surfaces using a H_2SO_4 electrolyte at a current density ranging from 30 to 90 mA/cm². The silicon wafer substrate had a diffusion barrier layer of IMP Ta, IMP TaN, CVD TiN or PVD TiN and a Cu seed layer over the underlying barriers. The influence of current density on the quality of the electroplated Cu film has been investigated in terms of texture, surface morphology and surface roughness. The growth of the Cu film is generally in <111> preferred orientation under all plating conditions. The degree of growth in <111> orientation is higher on both CVD TiN and PVD TiN barrier layers compared to those on IMP Ta and IMP TiN. The film became strongly orientated in <111> direction when electroplated at a current density of 60 mA/cm². Electroplating at a 90 mA/cm² current density produced Cu film textured in <200> direction. The surface roughness reduced significantly by electroplating at an increasing current density. The grains of Cu film were finer after electroplating at a higher current density compared to that plated at a lower current density. The growth of the Cu film was mostly columnar with equiaxed grains near the surface and at the interface.

KEYWORDS:

Copper electroplating, current density, silicon wafer, barrier layer, texture, surface roughness

1. INTRODUCTION

Copper has low bulk electrical resistivity and superior resistance to electromigration. These properties made copper a potential material for metallization of ULSI in comparison to aluminium and its alloys that are currently used in semiconductor industries. Cu metallization can be achieved by many techniques, such as PVD, CVD, sputtering, electrochemical deposition (ECD) and electro-less deposition. Because of low capital cost, high quality film, low processing temperature and good via/trench filling capability, ECD has gained popularity over other deposition techniques. A successful electrodeposition of copper film with resistivity of $2.0\mu\Omega\text{ cm}$ has been demonstrated and shown to have good via-filling capabilities [1-5]. However, Cu reacts rapidly with silicon to form silicide at a temperature as low as 200°C and drifts through the oxide under field acceleration. Any trace of Cu in silicon will create traps that are deleterious to device operation [6]. Therefore a barrier layer between Cu and its underlying layers is a prerequisite for Cu to be used in silicon IC applications.

Texture is the preferred distribution of grains in a particular crystallographic orientation and it is an important structural parameter for bulk materials and coatings. Electrodeposition on a randomly oriented polycrystalline substrate can result in the development of preferred orientation, or texture, in