Mechanism of haze formation on 193 nm photolithographic reticules: SO_2 contamination on Cr

M. Veillerot, H. Fontaine, J.P. Barnes, G. Demenet, F. Piallat,
S. Cetre, E. Martinez

CEA-Leti, MINATEC Campus,
17 rue des martyrs, 38054 GRENOBLE Cedex 9, France

ABSTRACT

Haze contamination and crystal growth on 193 nm reticules is a widespread problem of advanced semiconductor manufacturing plants. This contamination leads to significant losses caused by wafer yield drop, shortened mask lifetime, etc. These progressive defects appear on all surfaces found on the mask, just as well on the Cr or MoSi pattern-side as on the quartz back-side [1,2]. Haze is created from surface contaminants (cleaning residues, airborne molecular contaminants, …) that photo-chemically evolve under deep UV light and water vapor to form crystals [3,4,5]. Ammonium sulfate haze represents the first concern and, since sulfate-free cleanings are used by mask manufacturers the major root causes is expected to come today from airborne dioxide sulfur (SO_2) and ammonia (NH_3). The growth mechanism as well as the thresholds of air concentration are still undetermined.

In this work an intentional contamination study of Cr surfaces with airborne SO_2 has been carried out. Surfaces were prepared by deposition of Cr metal layers (100nm) by DC-PVD on silicon wafers. XPS and XRR measurements were carried out to confirm that these films were representative of actual Cr mask surfaces. Contamination was performed by exposure of thermally Cr coated-wafers to controlled concentrations of SO_2 in the gas phase generated from dilution with clean wet air. Exposure concentration (from 10ppbv to several hundred ppbv) and time (up to 24h) were varied as experimental parameters. Amounts of SO_2 and other inorganic contaminants deposited on the surface were characterized by Ionic Chromatography. A typical kinetic curve of contamination is given in fig.1. XPS and ToF-SIMS analyses of contaminated Cr surfaces have also been performed in order to determine the chemical composition and spatial distribution of the contamination. Ionic images of Sulfur and co-contaminants are given in fig.2. From this work critical kinetic data and possible chemical mechanisms of SO_2 contamination of Cr surfaces have been identified.

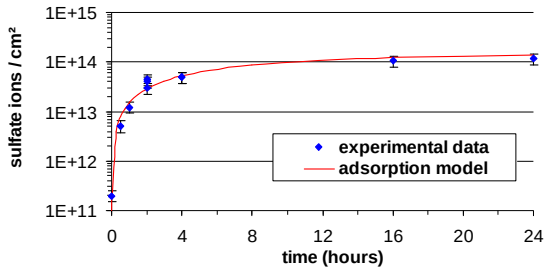

FIG.1: Adsorption kinetic of the SO_2 at 160ppbv on a Cr surface in clean room conditions (21°C -45% RH).

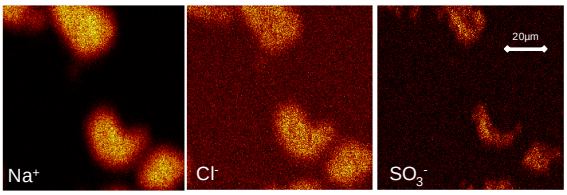

FIG. 2: ToF-SIMS ionic images of contamination crystal grown on the Cr after exposure to SO_2.

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