

Resistance changes in thin metallic films under ion bombardment

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Abstract. Resistance changes in thin films of copper, aluminium and bismuth have been studied under the bombardment of nitrogen, carbon and argon ions. Variations in resistance with implantation dose have been observed upto doses of $\sim 3 \times 10^{17}$ ions/cm² for ion energies in the range 40 to 120 keV. The results are discussed in terms of desorption of gases from the film and a composite action of sputter removal of the film and its structural changes upon ion bombardment. A simple theoretical model is discussed which can qualitatively explain the experimental observations.

Keywords. Ion bombardment; thin films; sheet-resistance; sputtering; implantation dose.

1. Introduction

Considerable work is now in progress to study the changes in conduction processes in thin film resistors after ion implantation. Deery *et al* (1973) studied tantalum films under reactive (N_2^+ , O_2^+) and non-reactive (Ar^+) ion bombardment and observed that in the former case after an initial decrease, there is an increase in the resistance of film with dose, upto doses of $\sim 8 \times 10^{16}$ ions/cm². The resistance invariably shows a decrease with further increase in dose and finally a rapid increase. They attributed the initial decrease to desorption of gases, the latter increase to damage and sputtering effects, the subsequent decrease to formation of compound phases and the final increase to rapid sputtering. The interesting feature of the intermediate decrease, however, could not be confirmed until Wilson *et al* (1976) reported electron microscope observations on an equivalent system. These results indicate that for intermediate doses, there are transformations of chemical phases in the bombarded tantalum films, which are also associated with corresponding sudden changes in the temperature coefficient of resistance of the films.

Later Belson and Wilson (1978) developed a simple theoretical model for the variation of sheet resistivity of metallic films with the ion implantation dose and showed that the resistance-dose curves could be explained without consideration of the sudden chemical changes. They explained the curves in terms of the composite action of sputtering and variation in total ion content of the film. The model, however, does not consider the microscopic changes taking place in the film and hence, may be considered to be at a preliminary stage.

The above studies demonstrate a need for more experimental work for a full understanding of the different processes involved. Experimental studies of ion implanted thin films were therefore undertaken to study different film ion combinations. Since