§14. Investigation of Composition Uniformity of $MoSi_x$ Sputtering Films Based on Measurement of Angular Distribution of Sputtered Atoms

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The refractory metal silicide films, used as lead wires in LSI, are usually formed by d.c. magnetron sputtering and it is known that they are non- uniform in composition. The authors pointed out that the non-uiformity was attributed to the difference between the angular distribution of the metal atoms and that of the Si atoms.[1] In this study, in order to demonstrate that the difference between the angular distributions causes the non-uniformity, the authors attempted to measure the angular distributions of Mo and Si atoms. The distribution of $MoSi_x$ film composition was calculated using the measured angular distributions and was compared with the measured composition distribution.

The $MoSi_{2.5}$ target with the diameter of 100 mm was coated with carbon powder and was put on the cathode of d.c. magnetron sputtering apparatus. A small window where carbon powder was not coated was 28 mm far from the target center. Polyimide tape was placed on a round surface of radius 26 mm so that it surrounded the window. Thus, a carbon film containing Mo and Si atoms was deposited on the polyimide tape at a discharge voltage of 500V. The numbers of Mo and Si atoms deposited on several positions on the polyimide tape were measured by RBS method. The angular distribution of the Mo atom and that of the Si atom thus obtained are illustrated in Fig. 1, where it is shown that the Si atoms are more apt to be ejected normally than Mo atoms.

The composition distribution of the $MoSi_x$ film was measured by RBS method. The distributions of n_{Mo} (the number of Mo atoms), n_{Si} (the number of Si atoms) and X (the atomic ratio, n_{Si}/n_{Mo}) are shown in Fig. 2. It shows that the composition is non-uniform. The number of atoms deposited on the substrate can be calculated by suming up the atoms coming from the whole surface of the target. In the calculation, it was assumed that the angular distributions of sputtered atoms were those illustrated in Fig. 1 and that the sputtered atoms were not scattered by Ar gas. The calculated result, which is shown in Fig. 2 by solid curves, nearly agrees with the measured data. Thus, it is concluded that the difference between the angular distribution is the origin of the non-uniformity of the composition of $MoSi_x$ Films.

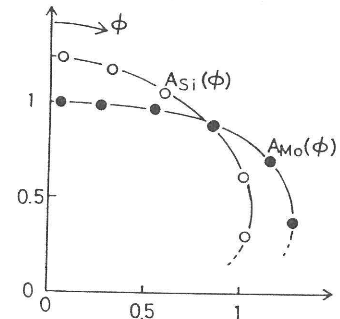

Fig. 1. Angular distribution of sputtered atoms. The discharge voltage was 500V and the Ar pressure was 0.3Pa.

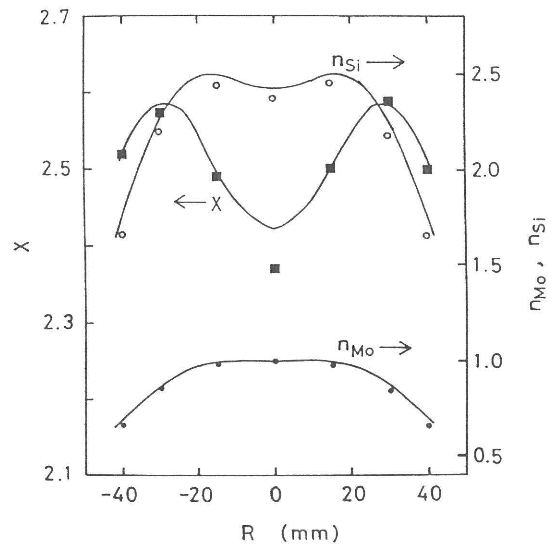

Fig. 2. The number of Mo atoms (n_{Mo}), that of Si atoms (n_{Si}) and the composition X (n_{Si}/n_{Mo}) in $MoSi_x$ films formed at a discharge voltage of 500V and an Ar pressure of 0.3Pa. The value R is the distance from the anode center.

References
1) Yamazaki, T., Matsuda, K., Nakatani, H., Jpn. J. Appl. Phys. 29 (1990) 1304.