ELECTROMIGRATION FAILURE OF METAL LINES

H. Abé
Professor Emeritus, Tohoku University, Japan Member,
Council for Science and Technology Policy, Government of Japan

ABSTRACT

The integration microcircuits progresses in semiconductor devices, and interconnecting metal lines get finer and finer. With the scaling down process, the density of electric current in the metal line increases, and the temperature of the device itself rises. From the trends of the operating conditions such as high current density and high temperature, it is anticipated that the issue of the metal line failure due to electromigration becomes more serious now and in the future. Electromigration is a phenomenon that metallic atoms constructing the line are transported by electron wind. The damage induced by electromigration appears as the formation of voids and hillocks. The growth of voids in the metal lines ultimately results in electrical discontinuity. Therefore, it is required from the viewpoint of ensuring the reliability of semiconductor integrated circuits that the lifetime of metal line is predicted accurately. Then, our research group has attempted to identify a governing parameter for electromigration damage in metal lines, in order to clarify the electromigration failure and to contribute to a circuit design. The governing parameter is formulated based on the divergence of the atomic flux by electromigration, and is denoted by *AFD*. The prediction method for the electromigration failure has been developed by using *AFD*. The *AFD*-based method makes it possible to predict the lifetime and failure site in universal and accurate way. In the actual devices, the metal lines used in the integrated circuit products are covered with a passivation layer, and the ends of the line are connected with large pads or vias for current input and output. Also, the microstructure of metal line distinguishes the so-called bamboo structured line from polycrystalline line depending on the size of metallic grains relative to the line width. Considering the damage mechanisms depending on such line constitution, see Fig. 1, our research group has made a series of studies on the development of the prediction method (Sasagawa et al. [1-7]). This article is dedicated to make a survey of some recent achievements for realizing reliable circuit design against electromigration failure.

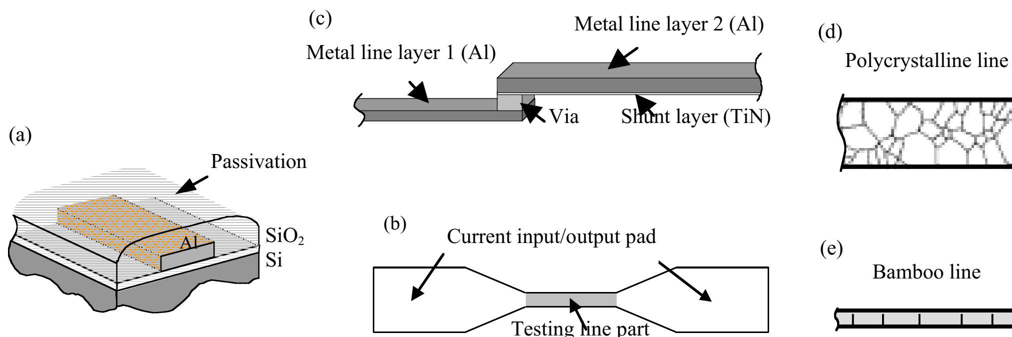

Figure 1: Line constitution treated by the AFD-based prediction method for electromigration failure.

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