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CONDENSED MATTER FILM BEHAVIOUR

ELECTROMIGRATION THRESHOLD OF THIN-FILM CONDUCTORS

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The connection between the mechanical properties of a thin film conductor and its electromigration threshold $(jl)_{th}$, where j is the current density and l is the conductor length is analysed. It is assumed that electrodiffusion can lead to elastic strain of the conductor (electrodiffusional stresses). As is shown for aluminium, the electromigration threshold value is determined by the level of compressive stresses at which the electrodiffusional stresses intensively relax via a dislocation glide (at $T \lesssim 470$ K) or high-temperature dislocation creep (at $T \gtrsim 470$ K). Expressions are proposed for estimation of $(jl)_{th}$ for thin film conductors made of various materials.

It is assumed that the value of the electromigration threshold is determined by the parameter $\mu/(Z^*\rho)$, where μ is the shear modulus, Z^* the effective charge, ρ the resistivity of a thin film material. In descending order of $(jl)_{th}$, metals may be arranged into five groups: noble metals (gold, copper, aluminium, silver); IIB group metals (cadmium, zinc); refractory metals (molybdenum, tantalum, tungsten, chromium, titanium); platinum metals (nickel, iridium, rhodium, palladium, platinum) and soft low-melting point metals (indium, tin, lead). Among d-elements $(jl)_{th}$ decreases with the increase of the group number in each period of the periodic table. To increase the electromigration resistance of the conductors of integrated circuit metallization, the dispersion hardened alloys based on metals with a high value of $\mu/(Z^*\rho)$, for example, aluminium, gold, silver or copper should be used.

1. INTRODUCTION

As the complexity of integrated circuits (IC) increases and the IC component sizes are reduced, thin film metallization increasingly becomes a factor determining the reliability and durability of electron devices.

The lifetime of a thin film conductor depends on the mass transport intensity which is largely determined by electrodiffusion and mechanodiffusion[1,2]. The existence of a threshold current density j_{th} implies that long trouble-free operation of the conductor can be achieved if the current density is $j \leqslant j_{th}$. The latter is considered[3–9] to be caused by mutual compensation of the electrodiffusion flow J_e and the mechanodiffusion flow J_s resulting from the mechanical stress gradient $\Delta\sigma/l$

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