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Silicon Loss from Patterned Tantalum Silicide Heated near 900°C in Low Partial Pressures of Oxygen

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Tantalum silicide used in VLSI metallizations can deteriorate by loss of Si near 900C under certain processing conditions. We show how to analyze this deterioration, propose a SiO vaporization mechanism, and describe methods for preventing it.

Tantalum silicide (Ta-Si) deposited on polycrystalline Si (polycide) has been used in VLSI metallizations. In order to control important silicide properties such as defect density, stress, and resistivity, the stability of the silicide under common processing conditions must be known. We investigated the reactivity of Ta-Si in low partial pressures of oxygen containing gas, under conditions simulating actual device processing. Optical and SEM examinations revealed that, after patterning, sintering (to stabilize the polycide), and oxidation (to passivate it), the polycide reproducibly developed one type of defect under certain processing conditions. A series of distinct surface textures, which we called wrinkled, smooth, concave, and reacted, were identified optically along patterned polycide lines; this series represents progressive stages of polycide deterioration. SEM and Auger analyses correlated this deterioration with progressive loss of Si from the polycide. Exposed oxide areas adjacent to patterned polycide were also discolored; Auger and Nanospec analyses revealed a local increase in oxide thickness. We propose that the Si loss is caused by vaporization of SiO, and the oxide growth is caused by the redeposition and oxidation of this SiO. Vaporization occurs during silicide sintering, and can proceed only if the oxygen partial pressure is sufficiently low. At higher partial pressures of oxygen containing gas, a passivating layer of oxide forms and the reaction stops. If the partial pressure of oxygen is still higher, the oxygen can interfere with proper sintering and cause the silicide resistivity to increase. Successfully sintered polycide can be oxidized to grow a passivating oxide without significant increase in resistivity. However, regions of polycide that had lost different amounts of Si during sinter oxidize differently. In particular, regions that lost all excess Si during sinter (leaving nearly stoichiometric disilicide with no silicon underneath) oxidize completely into a high resistivity oxide. Conclusion: Controlling the partial pressure of oxygen containing gases during sintering is important for producing defect free, low resistivity Ta-polycide.