
Hydrogen Induced Buckling of Gold Films

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Abstract

Depending on the growth stage of the nanocrystalline metallic films which nucleate and grow by the Volmer-Weber mechanism, different stress regimes exist. The films initially have a compressive stress state associated with the grain boundary formation during island coalescence. For atoms with a high atomic mobility such as gold, the tensile stress drops and often becomes compressive until it reaches saturation. Moreover, the dynamics of the coating process in magnetron sputtering is highly dependent on the coating parameters such as the coating speed, the process gas pressure, etc. A typical fingerprint of compressive stress during the coating process is the buckling of the films, occurring as a result of stress relaxation. Another pathway which can result in buckling of the films is the implantation hydrogen ions. Depending on the energy of the ions, buckling can either be localized in a region around the mean penetration depth of implantation or can take place at the coating interface. In this work, 100 nm thick gold films were deposited by the magnetron sputtering technique, which were afterwards treated with an RF driven hydrogen plasma while being kept electrically floating (i.e. low ion impact energies (10-15 eV)). The films initially had a weak residual compressive stress (30 ± 6 MPa) and were free of any kind of plastic deformation. After the plasma treatment, the over-pressurized hydrogen gas at the trap sites of the interface exerted a much higher stress to the films, reaching the critical stress for buckling; thus resulted in partial debonding of the films from the substrate. This buckling of the films was localized at the circular boundary of the delaminated structures and was classified as well-defined circular blisters. This phenomenon was observed for gold coatings prepared on Si (100) wafers and mechanically polished stainless steel and tungsten substrates, however not for rhodium and molybdenum coatings in much harsher plasma conditions. The findings reveal a serious concern for technological applications involving hydrogen plasma treatment of samples containing thin gold films, but in an optimistic perspective, suggest an efficient cleavage technique of such films.

Keywords: Hydrogen plasma, Gold film, Buckling

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