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P4.3012 Role of Oxygen in nanoparticle structure and composition under various sputtering discharges

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The properties of nanoparticles (NPs) depend on their shape, size, chemical composition, inner structure (atom arrangement) as well as their adhesion forces, the later determining the final state of collected aggregates. It is shown here that there are differences of structure and chemical composition of NPs which are produced from tungsten cathode sputtering in magnetron discharge and conventional sputtering discharge (without magnetic field). These differences mainly due to the presence of oxygen are discussed according to the presence or not of an oxide layer at the cathode surface, the residual oxygen in the device and the device venting. An usual method to remove a cathode oxide layer is the sputtering at low pressure and high input power. After this operation, NPs which are grown from tungsten sputtering in magnetron discharges are of core-shell type when they are analyzed after several days of air exposition. The core is mainly a mono-crystal in the metastable beta-tungsten phase and the shell is made of tungsten oxide. The origin of the metastable phase is attributed to the presence of residual oxygen in the device. Since this phase transforms into the stable alpha-tungsten phase by annealing [1], a standard model on the thermal balance of nanoparticles was used to find the temperature that they can reach under the considered experimental conditions. It is shown that this temperature is significantly higher than the gas one but not high enough to transform the metastable beta-phase during the plasma process.
Similar experiments were performed in sputtering glow discharges. In such a case, to remove the tungsten oxide of the cathode is particularly tricky at low pressure (no plasma breakdown). Hence, the effect of sputtering the oxide layer at a pressure where the nucleation appears is to produce NPs in tungsten oxide (W03) with no control of the oxygen content in the device.

[1] T. Karabacak, P-I. Wang, G-C Wang, T-M Lu, Thin Sol. Films 493, 293 (2005)

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