Control of self-organised metal nanostructures through the kinetic energy of host species

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Pulsed laser deposition is a versatile technique that allows producing high quality materials at a wide range of deposition rates, gas pressures or geometrical configurations. Alternate ablation of multiple targets gives further access to material configurations such as alloys, multilayers, nanocomposites or doped materials. We have successfully applied this versatility to produce layered nanostructures containing nanoparticles of metals such as Bi,[1] Au,[2] Ag,[3] or combinations of two metals.[4] This approach has been extended to produce a self-organised growth of Ag nano-objects elongated along the growth direction, i.e. nanocolumns oriented perpendicular to the substrate, that gave access to interesting optical and vibration properties.[5,6] The self-organisation process has been achieved by producing alternate ablation of the metal (Ag) and the host (Al_2O_3) targets and reducing the host thickness until metal nanoparticles in consecutive layers get in contact inducing the vertical self assembling due to the coalescence. However, sputtering effects associated to the high kinetic energy species arriving to the substrate have an essential role in the production of the nano-objects[2] and a similar important role is expected to be played in the self-organisation process.

The aim of this work is to understand the role of host species bombardment on the self-organisation process leading to the production of organised metal nanocolumns. We have used the same system, i.e. Ag and Al_2O_3 as metal and host and compared specimens produced in vacuum as in earlier work[5,6] to specimens produced by introducing an helium pressure into the chamber while ablating the Al_2O_3 target to slow down the kinetic energy of the host species arriving to the substrate. The results evidence that self-organisation occurs both in vacuum and helium, but significant differences are observed. The split of the surface plasmon resonance into transverse and longitudinal components evidencing the one-dimensional character of the nanocolumns is correlated to the dimensions of the metal nanocolumns determined by high resolution electron microscopy. The role of the lower host kinetic energy species in helium leading to higher metal contents and thus providing means to produce thicker nanocolumns will finally be discussed.

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