Thermal penetration of gold nanoparticles into silicon oxide

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Metallic nanoparticles (NPs) with diameter smaller than 100 nm are attractive materials due to their original and tunable properties [1]. Among them, size-selected gold NPs in solutions have attract particular attention due to their stability and ease of synthesis. Au NPs have gained applications in various fields of nanotechnology and medicine, including markers and biosensors based on surface plasmon resonance [2], reduction of carbon dioxide for artificial photosynthesis [3], electronic applications [4], as a catalyst for synthesis of nanoporous materials [5] and for the vapor–liquid–solid growth of semiconductor nanowires [6].

At the same time, Au NPs encapsulated in a dielectric matrix attract (e.g. silicon oxide, SiO_xN) sustained interest over several centuries owing to their unusual nonlinear optical and electrical properties. Several approaches, such as the sol–gel process, metal–dielectric co-sputtering deposition, metal-ion implantation into a dielectric, and in situ growth have been used to prepare metal-dielectric nanocomposites. However, assembly of nanoparticles in matrixes, especially those requiring large area coating and equal depth of position is still of major challenging. Vreede and co-workers give an account of the new possibility of nanoparticle to incorporate into silicon oxide [7]. It is known, that Au nanoparticles being deposited on the substrate and being heated in certain conditions could penetrate into substrate surfaces, so Au NPs and its penetration abilities are important both for nanopattering and for nanocomposites fabrication. However, some important unasnwered questions still remain and need to clarify. Therefore, investigation of metal-oxide bonding and the behaviour of Au NPs on substrates at the enhanced temperatures are useful for understanding metal supported systems.

Here we report on studies of Au NPs incorporations into silicon oxide produced by thermal annealing. The investigations were carried out using silicon wafers, having surface covered by the oxide. Colloidal Au NPs were homogeneous deposited from the colloidal solution on Si substrates using surface modification technique based on Ar plasma irradiation. The penetration of Au NPs into SiO_2 was studied at temperatures up to 1000°C under different atmospheric conditions. Cross-sectional shape, diameter, depth and orientation of the formed nanopores characterized by applying the scanning electron microscopy.

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