Pressure Induced Evaporation Dynamics of Gold Nanoparticles on Oxide Substrate

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Here we report thermal evaporation dynamics of Au nanoparticles on single crystal oxide substrates, including MgO, SrTiO$_3$ and Al$_2$O$_3$. The size reduction rate of Au nanoparticles via thermal treatments is strongly dependent on not only a temperature but also a pressure. Lowering a pressure of inert Ar gas from $10^5$ Pa to 10 Pa increases the size reduction rate over 30 times under the temperature range 800-950 °C. The temperature dependence is solely due to the variation of saturated vapor pressure of Au, whereas the pressure dependence of surrounding inert gas can be interpreted in terms of a pressure dependence on a gas-phase diffusion of evaporated Au atoms into surroundings. We present a simplified model to explain an evaporation dynamics, which well describes the pressure dependence on a size reduction rate of Au nanoparticles. By utilizing this useful pressure induced evaporation dynamics, we succeeded in manipulating a size reduction of Au nanoparticle arrays down to -10 nm diameter range from -300 nm initial size by programming sequentially a surrounding pressure.