MACROSCOPIC AND MICROSCOPIC INVESTIGATIONS ON THE LPCVD FABRICATION OF SILICON NANODOTS ON OXIDIZED SILICON WAFERS

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In the semiconductor industry, device scaling is becoming limited by the fundamental material properties and traditional technologies. Non-conventional Complementary Metal-Oxide-Silicon technologies including new devices such as Single-Electron transistors (SET) are emerging. To fulfill physical requirements, room temperature application is achieved with the realization of nanometer-sized (2-5 nm), polycrystalline fine silicon grains (quantum dots), located on insulating substrates with an uniform high density. Growing Si nanodots with controlled size, density and spatial correlation constitutes a challenging task, due to the complexity of intrinsic formation aspects (1).

We present macroscopic and microscopic investigations of the Low Pressure Chemical Vapor Deposition process from silane used to fabricate silicon dots on oxidized silicon substrates. The objective is to describe and understand the effects of CVD deposition time, local gas phase composition and substrate structure.

Analyses by CFD simulation are made to determine the transient behavior of hydrodynamics and gas phase chemical reactions. It is shown that silane transport inside the interwafer region is not achieved after 10s in typical reactor and conditions. This result suggests that most of the deposition process operates in unsteady state conditions.

Since 3D growth mainly proceeds from substrate/precursors interactions, Monte Carlo simulations are used to describe the first growth events on crystalline surfaces. It appears that both surface nature and gaseous precursor have an important impact on the film growth. The simulation clearly shows the interconnected effects of the density of surface dangling bonds and reactivity of gaseous molecules.

Experimental investigation of the effect of the oxide thickness is carried out. Using the same optimized conditions (LPCVD from silane), silicon dots have been elaborated on two substrates with different ultra thin oxides layers, 1.2 nm and 0.6 nm. From TEM and GISAXS analyses, it is found significant differences for the dot distribution and shape. This can be related to the structural differences observed between the “0.6 nm” and “1.2 nm” oxide layers with the presence of a crystalline layer at the oxide/substrate interface in the “1.2 nm”.

1. T. Baron, F. Martin, P. Mur, C. Wyon, and M. Dupuy, *J. Cryst. Growth*, **209** 1004 (2000).