In-situ Observation of the Growth of Nanodots on Ga Implanted SiO_2 by LEEM

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The fabrication of nanodots has been an area of great interest in recent years due to the promises of new functionalities and improved performance from nanostructure based electronic, photonic, and other applications. One recent interesting growth method of nanostructures is the formation of site controlled surface nanodots of Ga on SiO_2 by locally ion implanting Ga ions into a 60nm SiO_2 film followed by vacuum annealing [1]. While this method allows the fabrication of metallic nanodots with spatial and size control, the growth process is not well understood. As LEEM is well suited to observe in-situ processes, Ga implanted SiO_2 samples were annealed while being observed using LEEM (Elmitec LEEMIII) to more fully understand the Ga nanodot growth process in this case.

Due to strong charge-up of the insulating surface, LEEM observations were not possible as the trapped surface charges effectively prevented incident electrons from reaching the surface. However under mirror electron microscope (MEM) mode the main features of the topology such as surface Ga dots, SiO_2 capped dots and bare insulator surface could all be easily distinguished. During annealing it was observed that the nanodots first formed as SiO_2 capped dots just below the insulator surface which then quickly transitioned to surface nanodots as the increased annealing temperature caused the nanodots to further grow. As a result of this capped-surface transition we believe that a portion of the surface Ga nanodots remains imbedded in the substrate leading to the lack of mobility observed from the Ga nanodots even after continued annealing.

Interestingly, the growth temperature needed to cause Ga migration to the surface and segregation was only 300ºC during the LEEM experiments. This is much lower than previous ex-situ experiment results that found a 600ºC critical annealing temperature needed for nanodot nucleation and growth. This is the result of strong electric fields caused by surface charge-up and external LEEM field enhancing the mobility of implanted Ga.

[1] R. Buckmaster, T. Hanada, Y. Kawazoe, M.W. Cho, T. Yao, N. Urushihara, and A. Yamamoto, *Nano Lett.* 5(4), 771 (2005).