TEM study of interface between silicon substrate and platinum films made by electron or ion beam-induced deposition

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Transmission electron microscopy (TEM), energy dispersive X-ray spectroscopy (EDS), electron energy loss spectroscopy (EELS) and Auger electron spectroscopy (AES) has been conducted of the platinum (Pt) films. Pt-films were deposited on silicon wafer by decomposing trimethyl platinum $C_5H_4CH_3Pt$ $(CH_3)_3$ with focused electron or gallium ion beams. In either case, the Pt-films commonly consist of nano crystalline Pt particles embedded in carbon (C) matrix, but with differing Pt-C compositions and differing Pt-particle size. The electron beam deposition of Pt-film is less destructive, while ion-beam deposition produces deep and complex damage layer below the deposition. The damage consists of the three layers below the normal Pt-deposit: another distinct thin Pt-layer enriched in C but reduced in Pt, Si-Pt mixture, amorphous silicon. Here, the thickness of the layers depends on the landing energy of the ion beam, and the Si-Pt mixture exists in amorphous phase. The Pt-depleted thin layer, appearing brighter than the outermost normal Pt-deposit on TEM picture, results from the interaction between four components, which are mobilized silicon atoms from the broken silicon crystal, impinged gallium ion, carbon and platinum atoms from the cracked trimethyl platinum. We discuss the mechanism behind the deposition in detail, based on the acquired information about the structure and composition.

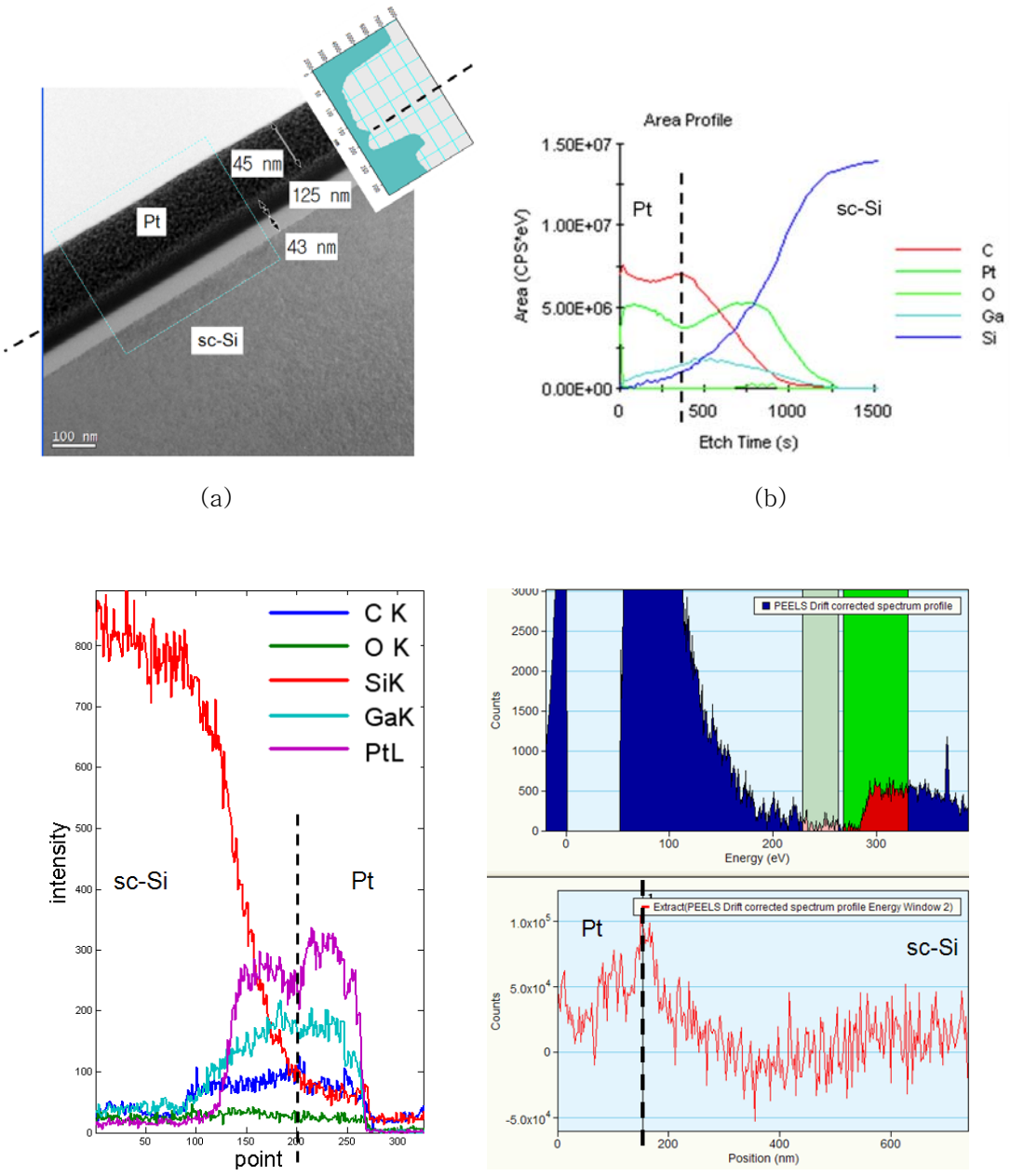

Fig. TEM (a), AES depth profile (b), EDS line (c) and EELS spectra and line profile of carbon (d), for the Ga ion-beam deposited platinum film and the structure below. The landing energy of the Ga ion is 30 keV. AES, EDS and EELS profile were obtained by scanning electron beam normal to the film surface. The black dotted line in each figure indicates the location of the Pt-depleted thin layer, for which all four kinds of data provides consistent information.