Atom-by-atom Analysis of Field Emission sources by the Scanning Atom Probe

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The scanning atom probe (SAP)[1,2] has been developed as the most capable instrument for the atom-by-atom mass analysis of materials. Utilizing this unique capability, the atomic level analysis of various carbon and silicon emitters such as carbon nano-tubes (CNT), vitreous carbon, graphite, carbon nano-tubes, CVD diamonds graphite, lithographically processed silicon micro tips and mechanically formed silicon pyramids have been analyzed. The study indicates that the mass spectra obtained by the SAP not only show the composition of the analyzed area but also indicate the possibility of revealing the binding states of constituent atoms. Thus the study has been extended for the examination of the surface compositions of various CNT and silicon pyramid arrays made by grooving V-shaped ditches on the [111]-oriented silicon wafer. The study indicates that CNT contains a large amount of hydrogen and the amount of contaminants varies in a wide rage. Although the major contaminants are hydrogen and oxygen, one CNT supplied from an American company contains a large amount of contaminants with masses of 23, 27, 29, 30, 31, 40 and 41. These masses correspond to the impurities such as Al, P, NaO and NaO. The work function of this CNT is also found to be higher than other CNT. Silicon pyramids are fabricated by grooving a [111]-oriented silicon wafer surface in a checker board pattern. The space between the grooves and the depth of the grooves are 10 microns. The grooved specimens are etched by 1 air before the introduction to the vacuum chamber, the mass spectra indicate that the surfaces are unexpectedly clean and few contaminants are detected. However, the mass spectra obtained by analyzing other pyramids of the same specimen exhibit the mass peaks of carbon and oxygen. Furthermore, the broad mass peaks indicate that the surfaces are covered by a large amount of hydrogen. After the field evaporation of the surface layer of a few nanometers, a clean surface is exposed. The Fowler-Nordheim plot (F-N plot) are obtained by measuring field emission current at various negative specimen voltages. The F-N plots indicates that the work functions of the surfaces etched by hydrofluoric acid and ammonium fluoride solutions are nearly equal. The results of further study will be reported.

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