Xeon Gas Field Ion Source Emitted from a Single-Atom Tip

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The ion beam technology has been widely applied in nanoscience and nanotechnology. Many applications, including secondary ion mass spectrometry (SIMS) and focused ion beam (FIB), rely on high-performance ion sources. The most widely used ion sources are gallium liquid metal ion source (Ga-LMIS) and plasma ion sources. The brightest ion sources are gas field ion sources (GFISs). In 2006, Zeiss announced the first commercial GFIS-FIB, helium ion microscope (HIM)[1]. HIM demonstrated outstanding performance of GFIS-FIB system, a spatial resolution smaller than 0.5 nm with a large depth of focus. However, its pure tungsten emitter can only emit He^+ and Ne^+ ions.

Here we present Xe^+ ion beams emitted from a Ir-covered tungsten single-atom tip (SAT). This type of SAT is thermally stable and chemically inert[2-4]. The tip formation process is simple and the tip can be regenerated through a gentle annealing if the apex of SAT is contaminated[2-4]. The Xe^+ ion emission was analyzed from 150–309 K. The optimal emitter temperature for maximum Xe^+ ion emission was ~150 K. The instability of Xe^+ ion current was 2.12% at 150 K and the ion beam profiles exhibited a half opening angle of ~0.5°. At the Xe gas pressure 1×10^{-4} torr, the reduced brightness of Xe^+ ion beam was estimated as 1.3×10^{8} $A\cdot m^{-2}sr^{-1}V^{-1}$, which is 2-3 orders of magnitude higher than that of Ga-LMIS and 4-5 orders of magnitude higher than that of Xe-ICP ion source[5,6]. The operation temperature of Xe-SAT-GFIS is considerably higher than the cryogenic temperature required for the HIM, which offers significant technical advantages because only simple or no cooling schemes can be adopted. Due to the large atomic mass of Xe, the sputtering yield of Xe is considerably higher than that of He or Ga, therefore a Xe-GFIS-FIB system may become a powerful milling and analysis tool at the nanometer scale.

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