Development of sputter-induced graphite nanoneedle field emitters and their application to electron-beam-pumped light sources

2008

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We have developed novel sputter-induced graphite nanoneedle field emitters and novel Si electron-transparent films for an application to an electron-beam-pumped light source. The sputter-induced graphite nanoneedle field emitters were fabricated by using conventional RF magnetron sputtering equipment. The graphite nanoneedle field emitter was formed at a H_2 pressure of 30 Pa and a RF power of 600 W. The graphite nanoneedle field emitter exhibited an electron emission of 1.1 mA (8.8 mA/cm^2) at an average field of 12 V/μm and a stability of 2.7% at a field of 11 V/μm, which indicated an excellent emission characteristics. The Si electron-transparent film was used to separate a vacuum chamber from a high pressure gas cell. The 1.5-μm-thick Si electron-transparent film was fabricated by dry and wet etching processes of a silicon-on-insulator substrate. The Si electron-transparent films had a honeycomb structure for mechanical strength. The aperture ratio was about 75%. The 1.5-μm-thick Si electron-transparent film achieved an electron transmittance of about 60% at an acceleration voltage of 27 kV, indicating that almost all electrons entering the film penetrated the film at 27 kV. We constructed an electron-beam-pumped light source using the graphite nanoneedle field emitter and Si electron-transparent film, and successfully demonstrated light emission from the excited gases such as N_2, Ne, Ar, Kr, or Xe.