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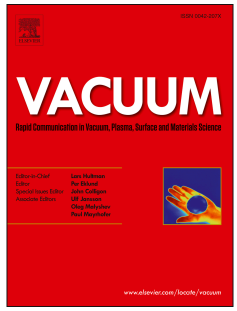

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Rapid synthesis of inorganic $[Ca_{24}Al_{28}O_{64}]^{4+}(e^-)_4$ electride and its performance as an electron thermal emitter

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ABSTRACT

We propose an effective and rapid route for synthesizing polycrystalline mayenite electride (C12A7:e$^-$) in dense bulk. C12A7:e$^-$ bulks with high-density electron doping were obtained via a comprehensive method, which combined Ti powder treatment with spark plasma sintering (SPS) process under a 10^{-2}Pa vacuum. The resulting electride, which exhibits an electron concentration of ~ 2.3×10^{21}cm^{-3}, an electrical conductivity of ~ 1.38×10^3S/cm at 300K, and an absorption peak at 2.5eV, was obtained via SPS process at 1150℃ for 20 minutes. Furthermore, thermionic emission from a flat surface of C12A7 electride was examined at temperatures of 973-1373K and acceleration electrical field of 3000-35000V/cm in a 10^{-5} vacuum. A large current density of 1.68A/cm^2 was obtained in the thermionic emission with an work function (φ_{WF}) of 2.13eV for an applied electric field of 35000V/cm. Moreover, the emission with a current density of 1.68A/cm^2 was stably sustained for 30 h. These results not only suggest an efficient method for fabricating high-quality mayenite electrides but also pave a way for various applications including thermionic emission.

Keywords: mayenite electride; SPS process; thermionic emission.

1. Introduction

C12A7:O^{2-} oxide was first found as a typical phase in alumina cement; chemical formula of the unit cell which contains two molecules of C12A7:O^{2-} can be expressed as $[Ca_{24}Al_{28}O_{64}]^{4+}$+2O^{2-} [1-2]. The unit cell is constructed by a positively charged $[Ca_{24}Al_{28}O_{64}]^{4+}$ lattice framework, which is composed of 12 sub-nanometer-sized cages [3]. These 12 cages are closely connected in three-dimensional space by sharing an open windows which consists of Ca-O-Al-O-Al-O 6-atom annuli [4]. To maintain electrical neutrality, two additional O^{2-} ions randomly distribute in two of these twelve cages [5]. The encaged O^{2-} ions which are loosely bound to Ca^{2+} cations in the cage wall can be replaced by diverse anions such as OH$^-$, H$^-$, Cl$^-$, F$^-$, O$^-$, O_2^- and electrons (e$^-$) without destroying lattice structure. [6-9]. when the free O^{2-} ions are partly or totally substituted by e$^-$, the resultant electride can be expressed by

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