High-Quality LaB_6 Films for High-Temperature Surface Plasmon Photonics

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For plasmonic materials in the UV-Vis spectral window, the noble metals are conventionally used owing to their superior properties with respect to strong light-matter interactions and a low-loss nature. In the infrared (IR) region, the performance of noble metals starts to fade and other materials, such as doped transparent oxides, can excel instead. In this context, nitrides [1], carbides and even graphene show potential, and exhibit an excellent thermal stability. Boron compounds also constitute an interesting class of materials, but have been paid little attention so far for optical applications. In particular, lanthanum hexaboride (LaB_6) is a conductive ceramic material well-known as an excellent electron emitter, but it is also a refractory material with melting point above 2700 ℃. In this work, the growth and optical properties of LaB_6 thin films have been investigated. By fabricating the LaB_6 thin film using sputtering and electron beam evaporation (EBE), at varying deposition parameters, insight into its growth and crystallinity is obtained. Both techniques aqcuire good crystallinity. The EBE samples can be grown epitaxially on Si(001), as verified by electron backscatter diffraction (EBSD) experiments. Spectroscopic ellipsometry was utilized to check the dielectric response of the films, and it was clarified to be highly plasmonic with low-loss in the near IR region. The real and imaginary parts exhibit an almost purely Drude behaviour in the infrared region for, thus indicating that LaB_6 is an excellent material for infrared plasmonics. We demonstrate with our epitaxial LaB_6 film, with a distributed Bragg reflector (DBR) structure, a device for ultra-narrowband IR thermal emitter applications.

[1] M. Kaur, S. Ishii, S. L. Shinde, T. Nagao, *Advanced Sustainable Systems* 3, 1800112 (2018)

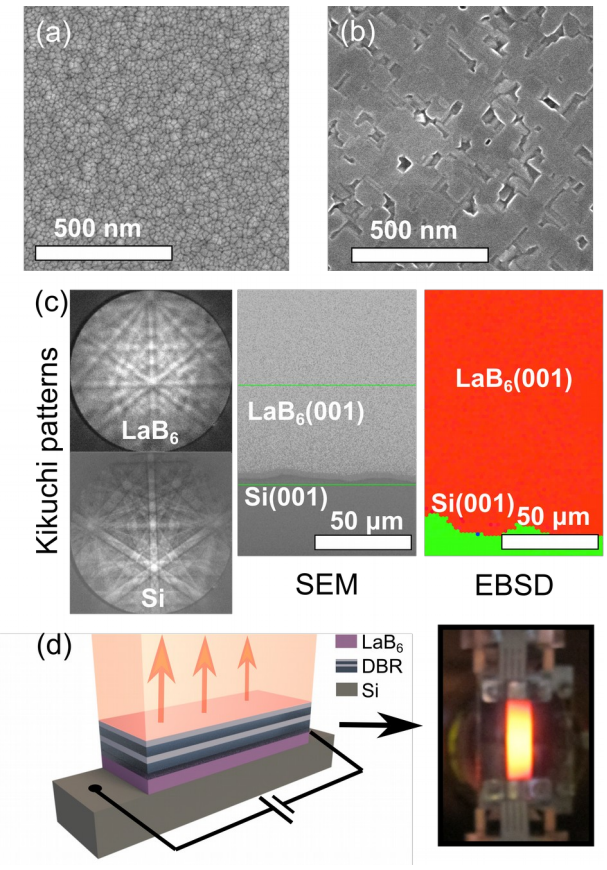

Figure 1. (a) SEM of DC sputtered LaB_6 film. (b) SEM of electron beam evaporated LaB_6 film. (c) Electron backscatter diffraction (EBSD) data showing Kikuchi lines, and crystal orientation of LaB_6 films. (e) Proposed spectral emitter device using LaB_6 combined with a distributed Bragg reflector (DBR) structure.