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PII: S0376-7388(16)31092-4  
DOI: <http://dx.doi.org/10.1016/j.memsci.2016.07.046>  
Reference: MEMSCI14631

To appear in: *Journal of Membrane Science*

Received date: 8 May 2016  
Revised date: 10 July 2016  
Accepted date: 25 July 2016

Cite this article as: Tong Liu, Yu Chen, Shumin Fang, Libin Lei, Yao Wang, Cong Ren and Fanglin Chen, A dual-phase bilayer oxygen permeable membrane with hierarchically porous structure fabricated by freeze-drying tape-casting method, *Journal of Membrane Science* <http://dx.doi.org/10.1016/j.memsci.2016.07.046>

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# A dual-phase bilayer oxygen permeable membrane with hierarchically porous structure fabricated by freeze-drying tape-casting method

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## Abstract

A bilayer oxygen permeable membrane consisting of hierarchically porous  $\text{Ce}_{0.9}\text{Gd}_{0.1}\text{O}_{1.95}\text{-(La}_{0.8}\text{Sr}_{0.2})_{0.95}\text{MnO}_{3-\delta}$  (GDC-LSM) support and dense GDC-LSM film has been fabricated by a combined freeze-drying tape-casting and screen-printing method followed by co-sintering. Two dimensional (2D) SEM-BSE and reconstructed three dimensional (3D) XCT images indicated that the porous GDC-LSM support (870- $\mu\text{m}$ -thick) contains graded straight pores with low tortuosity factor, promoting fast gas diffusion in the support, while the dense GDC-LSM film with a thickness of 30  $\mu\text{m}$  provides a short path for the bulk transport of oxygen ions and electrons. However, the oxygen flux of the asymmetric GDC-LSM membrane is only 81% higher than that of the 900- $\mu\text{m}$ -thick dense GDC-LSM symmetric membrane, indicating that the oxygen transport becomes limited by the surface oxygen exchange process for the GDC-LSM asymmetric membrane with a 30- $\mu\text{m}$ -thick dense

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