# 高功率脉冲磁控溅射制备 ZnO 薄膜的研究进展 *

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**摘 要**：氧化锌薄膜材料由于具有高电导率、良好的光学透过率、原料储存丰富、成本低廉的特点，被认为是最具有潜力的透明导电薄膜。特别是其宽禁带（3.37eV）和高达 60meV 的激子束缚能，使其在环境温度制备同质结发光器件、太阳能电池电子传输层具有巨大的应用前景。然而，传统制备方法难以实现薄膜质量的综合调控，存在 p-ZnO 稳定性差、制备的薄膜重复性差、组装的器件效能较低等问题。高功率脉冲磁控溅射（HiPIMS）技术具有溅射材料离化率高的特点，非常适合需要离子反应的各类薄膜。当采用 HiPIMS 制备氧化物、碳化物、氮化物薄膜时，利用其高电离率还可以获得较高的靶离子和掺杂离子，可实现晶格替代、间隙原子等缺陷的形成，制备稳态的材料，如制备稳定 p-型半导体材料。本文综述了近年来 HiPIMS 制备氧化锌薄膜的研究进展，主要是给出 HiPIMS 制备 ZnO 薄膜的放电特性和工艺参数的影响，最后展望了 HiPIMS 制备稳定 p-ZnO 薄膜的发展方向。

**关 键 词**：高功率脉冲磁控溅射；氧化锌薄膜；放电特性；掺杂

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# Review on Semi-Conductive ZnO Thin Film Prepared by HiPIMS

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**Abstract**: Zinc oxide film material is considered to be the most potential transparent conductive film due to its high electrical conductivity, good optical transmittance, abundant raw material storage, and low cost. In particular, its wide band gap(3.37eV)and exciton binding energy up to 60 meV make it possible to prepare homojunction light-emitting devices and solar cell electron transport layers at ambient temperatures with great application prospects. However, it is difficult to achieve comprehensive control of the film quality by the traditional preparation method, and there are problems such as poor stability of p-ZnO, poor repeatability of the as-prepared film, and low efficiency of assembled devices. High-power pulsed magnetron sputtering(HiPIMS) technology has the characteristics of high ionization rate of the sputtering material, which is very suitable for the preparation of complex conductive films such as transparent conductive films and hard films. When HiPIMS is used to deposit oxides, carbides and nitrides, its high ionization rate can be used to obtain higher target ions and doped ions, which can form defects such as element substitution and interstitial atoms, and can be used to prepare stable p-type semiconductor material. In this paper, the research progress of zinc oxide thin films prepared by HiPIMS in recent years is reviewed. In view of the preparation problems of p-ZnO, the discharge characteristics and plasma parameters of ZnO thin films prepared by HiPIMS, undoped ZnO preparation, doped ZnO preparation, and plasma assist ZnO preparation and other aspects are summarized. Finally, the development direction of high-performance, high-quality, high-stability p-ZnO thin film preparation is prospected.

**Key words**: HiPIMS; ZnO thin film; discharge characteristics; doping and p-type

氧化锌（ZnO）是一种 II-VI 族化合物，具有优良的压电、热电和铁电性能。由于这些特性，ZnO 薄膜将应用于众多电子器件中，例如太阳能电池[1]、光电器件[2]、铁电器件[3]。同时氧化锌也是一种新型的宽禁带半导体材料：宽禁带（3.37eV）[4]和高达 60MeV 的激子束缚能[5]，这使得氧化锌薄

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