

衬底温度对脉冲激光沉积法制备的 CuO 薄膜性能的影响

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摘 要: 通过脉冲激光沉积的方法在玻璃衬底上制备 CuO 薄膜, 并研究了衬底温度对薄膜结构, 光学以及电学性能的影响。结果表明: 在不同衬底温度下得到的薄膜均为 CuO, 并且在红外区域, 薄膜的透过率均高于 65%。温度升高到 300℃, 具有较高的结晶质量和红外光透过率, 薄膜的电学性能也随之变好, 出现最低电阻 ($2.33 \times 10^2 \Omega \text{cm}$), 较高的载流子浓度 $5.28 \times 10^{16} \text{1/cm}^3$ 。最重要的是在 500℃ 时氧化铜实现了由 p 型向 n 型的转变。

关 键 词: 氧化铜; 脉冲激光沉积; 衬底温度; 导电类型; 电阻率

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Effect of Substrate Temperature on the Properties of CuO Films Deposited by Pulse Laser Deposition

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Abstract: The CuO thin films were deposited on glass substrates by puls laser deposition and the effects of substrate temperature on the structural, electrical, and optical properties of CuO thin films were investigated. Thin films deposited at different substrate temperature under 8 Pa were all CuO. All CuO thin films exhibited a transmittance higher than 65% in the NIR range. Increasing the substrate temperature to amoderate level (300 in this study) accompanied improved crystalline quality, which yielded the lowest electrical resistivity of $2.33 \times 10^2 \Omega \text{cm}$ with the highest carrier concentration of $5.28 \times 10^{16} \text{1/cm}^3$ and Hall mobility of $1.26 \text{cm}^2/(\text{VS})$. The most important is that CuO achieved from p-type to n-type at above 500℃. The n-type characteristics need to be improved to make these films useful for applications like transparent p-n junction based devices.

Key words: CuO; pulse laser deposition; substrate temperature; conduction type; electrical resistivity

氧化铜(CuO)是一种重要的本征 p 型半导体材料^[1], 禁带宽约为 1.2eV~1.9eV^[2], 具有良好的气敏性和压电性^[3]。而且 CuO 无毒, 制备成本低, 储量丰富, 其 p-n 结太阳能电池的转换效率可以达到 31%, 是一种应用潜力很大的太阳能电池半导体材料^[4]。因此, 寻求能制备出 n 型氧化铜的方法对于氧化铜在电子和光电子器件方面的应用具有非常重要的意义^[5]。

CuO 薄膜制备方法包括热蒸发法^[6-8], 磁控溅射法^[9, 10], 电化学沉积法^[11-13], 脉冲激光沉积法^[14]等。与其他薄膜制备方法相比, 脉冲激光沉积法可以生长和靶材成分一致的多元化合物薄膜, 生长过程中可以原位引入多种气体, 提高薄膜的质

量, 制备的薄膜附着性好, 工艺参数易于控制。脉冲激光沉积法制备的 CuO 薄膜性能主要取决于沉积参数, 例如衬底温度、氧气压强、沉积时间、以及激光能量、频率等。本文采用脉冲激光沉积法制备了 CuO 薄膜, 并研究了衬底温度对薄膜的结构、光学以及电学性能的影响。

1 试验材料与方法

采用脉冲激光沉积方法在玻璃衬底上沉积 CuO 薄膜。沉积前将衬底依次在丙酮、乙醇、去离子水中超声清洗 5 分钟, 用氮气吹干。靶材选用 CuO 靶, 靶材直径为 2cm。所用的激光源为波长 248nm KrF 准分子激光器, 激光参数: 能量模式为