基于系统回归模型的真空镀膜设备液冷加热盘设计方法研究*

李 翔[1],姜小蛟[1],战春鸣[2],刘 昂[1],孙 宁[1],李加平[1]

(1.沈阳富创精密设备股份有限公司,辽宁 沈阳 110015;2.沈阳真空技术研究所有限公司,辽宁 沈阳 110042)

摘 要:晶圆加热盘的设计有两大核心性能指标:工作面温度均匀性和控温能力,晶圆加热盘在设计定型前需要经过多次仿真迭代与测试验证,以确定产品性能满足设计需求。本研究基于有限元计算与系统回归模型,精准预测加热器实际所需长度、功率密度以及对应排布方案,以温度均匀性为优化目标,获取最优设计方案。经不同方案验证,该模型的精度在98%以上,可显著提升加热盘设计效率,为人工智能在加热盘设计领域的应用提供可能性。此外,基于传热学理论,提出了一种加热盘控温能力的设计方法,通过一维计算的方式,为加热盘控温能力的优化设计起到了指导作用。

关 键 词:半导体;真空镀膜设备;晶圆加热盘;水冷;回归模型;控温能力

中图分类号:TB43 **文献标识码**:A **文章编号**:1002-0322(2024)04-0006-06

doi:10.13385/j.cnki.vacuum.2024.04.02

Research on Design Method of Liquid Cooled Heater for Vacuum Coating Equipment Based on System Regression Model

LI Xiang[1], JIANG Xiao-jiao[1], ZHAN Chun-ming[2], LIU Ang[1], SUN Ning[1], LI Jia-ping[1]

(*1.Shenyang Fortune Precision Equipment Co., Ltd., Shenyang 110015, China;*
2.Shenyang Vacuum Technology Institute Co., Ltd., Shenyang 110042, China)

Abstract: The design of wafer heating plate has two core performance indicators: uniformity of working surface temperature and temperature control ability, and the wafer heating plates needs to be verified by multiple simulation iterations and tests before the design is finalized to determine that the product performance meets the design requirements. Based on the finite element calculation and system regression model, this study accurately predicts the actual required length, power density and corresponding layout scheme of the heater, and proposes a method to obtain the optimal solution with temperature uniformity as the goal. The verification results of different schemes show that the accuracy of the model is above 98%, which can greatly improve the design efficiency of heating plate and provide the possibilities for the application of artificial intelligence in the field of heating plate design. In addition, based on the theory of heat transfer, a design method for heating plate temperature control ability is proposed, which guides the design of heating plate temperature control ability through one-dimensional calculation.

Key words: semiconductor; vacuum coating equipment; wafer heater; water cooling; regression model; thermal control

随着我国对第三代半导体材料战略部署的深入,以SiC、GaN为代表的半导体品类对工艺制程的优化升级提出迫切需求[1-2]。在半导体晶圆制备过程中,真空镀膜作为关键环节,所得膜层质量对晶圆的良率起到决定性作用,而高质量膜层的制备需要匹配温度精准且温度均匀的晶圆[3-4]。因此,晶圆加热盘作为实现晶圆温度精准控制的关键设备,其设计要求也在相应提高。真空镀膜是在真空环境下,将金属或非金属膜材转化为气态原子或分子,并使其沉积在基材表面形成薄膜的过程[5-6]。通常,半导体真空镀膜设备可分为PVD(物理气相沉积)、CVD(化学气相沉积)和ALD(原子层沉积),上述设备在工作过程中均需要晶圆温度整体稳定在特定范围内,以

收稿日期:2024-04-11

作者简介:李翔(1991-),男,辽宁省沈阳市人,硕士,工程师。

* **基金项目**:辽宁科技重点项目(2023JH1/11200010)。