真空电弧源冷却结构对温度场的影响研究 *

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摘 要:真空电弧离子镀技术是工业界使用最为广泛的表面处理技术之一。在电弧离子镀实际应用过程中,所制备涂层的表面大颗粒仍然是困扰高端制造的一大难题,造成这一现象的根本原因是靶材表面局部过热产生的液滴飞溅。减少液滴产生的有效方法有很多,除降低放电功率密度、提高弧斑运动速度等热端控制技术之外,还包括加强靶材的冷却等。本文将新型冷却结构和弧斑运动引入弧源的数值模型,对弧源内部冷却水的流场和靶材表面的温度场进行模拟分析,研究了不同边界条件下弧源温度场的变化规律。本文的研究结果对真空镀膜机设计与工艺开发具有一定的指导作用。

关 键 词:弧源;冷却结构;温度场;靶面温度
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Influence of Cooling Structure on Vacuum Arc Source Temperature

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Abstract: Vacuum arc ion plating is one of the most extensive surface treatment technologies in use now. However, in the actual industrial application, large surface particle of the prepared coating is still a major problem that plagues the advanced manufacturing. The reason lies on that the target is overheated, and then molten pool is formed to cause solution splash. The effective methods for reducing the occurrence of droplets include reducing the discharge power density, increasing the arc motion speed, as well as enhancing the cooling measures. In this paper, a numerical model was established for the arc source including new cooling structure and arc spot motion. The flow field of the cooling water inside the arc source and the temperature field of the arc source surface were simulated and analyzed, and the variation of the arc source under different boundary conditions was analyzed. The results in this paper may be helpful for the design of vacuum coating machine as well as the process development.

Key words: arc source; cooling structure; temperature field; target surface temperature

真空电弧离子镀是把弧光放电用于蒸发源的一种离子镀膜技术,所以又被称为真空电弧沉积(Vacuum arc deposition, VAD)[1]。其工作原理为冷阴极弧光放电[2-9],物理基础为热场致发射。电弧离子镀的放电主要依靠阴极靶面弧斑放电,以点状的弧斑放电使靶材蒸发沉积在样品表面。弧斑运动是一个或数个不连续的弧斑生成、熄灭、再移位生成、再熄灭的快速过程。弧斑的运动轨迹如果长时间处于同一区域,该区域会聚集很多的能量,热量的持续累积将形成大的熔池液滴,导致膜层表面出现大颗粒污染[10-11]。

造成膜层大颗粒污染的直接原因是弧斑运

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