冷作模具钢等离子渗镀 CrVN 复合涂层摩擦磨损性能研究 *

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摘 要:采用等离子渗镀技术在 DC 53 冷作模具钢表面制备 CrN 和 CrVN 复合涂层,利用 X 射线衍射仪(XRD)、X 射线光电子能谱(XPS)、扫描电镜(SEM)、显微硬度计和摩擦磨损试验机,对比研究了两种涂层的组织结构、力学性能以及摩擦磨损性能。结果表明:所制备的 CrN 和 CrVN 涂层均为面心立方 (fcc) 结构,并呈现 (111) 择优取向,其中 CrVN 涂层形成了以 fcc-CrN 相为基础的 CrVN 固溶体结构。CrN 涂层中掺入 V 抑制了柱状晶生长,涂层结构更加致密,硬度和结合力明显提高,摩擦系数及磨损率降低。CrVN 涂层表面粗糙度较低,并在摩擦过程中生成具有自润滑性的 VO_2,涂层抗粘铝性能得到改善。

关 键 词:冷作模具;CrVN 涂层;微观结构;摩擦磨损;抗粘附性
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Study on Wear Properties of Duplex-Treated CrVN Composite Coatings by Plasma Nitriding and Arc Ion Plating

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Abstract: Duplex-treated CrN and CrVN composite coatings were prepared on DC 53 cold work die steel substrates by plasma nitriding and arc ion plating. The microstructure, mechanical and wear properties of coatings were investigated by X-ray diffraction (XRD), X-ray photoelectron spectroscopy (XPS), scanning electron microscopy (SEM), microhardness tester and tribometer, respectively. The results showed that the as-deposited coatings were fcc structures with a (111) preferred orientation. The CrVN solid solution structure based on the fcc-CrN phase was obtained in CrVN coating. Compared to the CrN coating, the columnar grain growth was suppressed with the addition of V and the CrVN coating became denser. The microhardness and adhesive strength of V-doped CrN coating were obviously improved, while the friction coefficient and wear rate of the coating were reduced. The sticking resistance of aluminium was enhanced for CrVN coating due to the low surface roughness and the formation of self-lubricating VO_2 during the wear process.

Key words: cold work mould; CrVN coatings; microstructure; tribological properties; anti-sticking

随着现代汽车、电子、航天航空等领域的快速发展, 模具产业已成为工业发展的重要基础。表面损伤是模具的主要失效形式,其中相当一部分是由于模具与制件间发生严重的摩擦磨损或粘附问题而导致模具过早失效。单一的模具材料难以满足越来越高的加工性能要求,并且广泛应用的脱模剂等方法没有从根本上解决粘附问题。通过 PVD 硬质涂层提升表面硬度、耐磨和抗粘附性能来改善模具表面状况,已经成为提高模具寿命和效率的重要手段[1-3]。

CrN 基涂层因表面能较低,抗粘附性能优异,同时拥有良好的抗腐蚀性和热稳定性而成为极具研究潜力的模具防护涂层[4,5]。然而,二元 CrN 涂层有限的硬度和较高的摩擦系数难以满足日趋恶劣的工况要求[6],特别是随着铝合金材料使用量的日益增加,提升铝合金成型模具表面抗粘附性能的需求更加迫切。近年来,在传统二元氮化物涂层中加入第三种元素(如 V,Si,C 等)来改善

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