Contribution ID: **113** Type: 口头报告

脉冲磁场处理对钴基合金相界耐蚀性影响及机理研究

摘要

钴基合金堆焊层的耐腐蚀性对核电材料在严苛环境下的长期可靠性至关重要，特别是相界面处的腐蚀现象，已成为影响其性能的关键因素。本研究探讨了脉冲磁场处理（PMT）对碳化物/基体钴界面耐腐蚀性的影响，并系统地揭示了其潜在机制。研究采用了扫描电子显微镜（SEM）、原位透射电子显微镜（TEM）、原位扫描开尔文探针力显微镜（SKPFM）等表征技术，结合密度泛函理论（DFT）计算分析。研究结果表明，PMT 处理样品未出现界面腐蚀裂纹或碳化物剥落，且腐蚀深度显著减少。TEM 分析进一步显示，相界面处的晶格畸变减小，面心立方（FCC）结构的钴部分转变为六方密堆积（HCP）结构。SKPFM 测量和 DFT 计算结果表明，相界面耐腐蚀性的提高主要归因于电子功函数（EWF）的变化。

关键词

钴基合金堆焊层，脉冲磁场处理，耐蚀性能，相界面，相变，电子功函数

Abstract

The corrosion resistance of cobalt-based alloy cladding layers is crucial for the long-term reliability of materials in the nuclear power industry, where they are exposed to highly aggressive environmental conditions. A major challenge to their performance is the corrosion occurring at phase boundaries under harsh operating conditions. This study investigates the effects of pulsed magnetic field treatment (PMT) on improving corrosion resistance at phase boundaries, specifically at the carbide/matrix Co interface, and seeks to clarify the underlying mechanisms. Advanced characterization techniques, including scanning electron microscopy (SEM), in-situ transmission electron microscopy (TEM), in-situ scanning kelvin probe force microscopy (SKPFM), and density functional theory (DFT) calculations, were employed. PMT samples exhibited no interface corrosion cracking or carbide spalling showed a significant reduction in corrosion depth. TEM analysis revealed reduced lattice distortion at phase boundaries and a partial transformation of face-centered cubic (FCC) Co to hexagonal close-packed (HCP) Co. The enhanced corrosion resistance at phase boundaries is attributed to changes in the electronic work function (EWF), as determined by SKPFM measurements and DFT calculations.

Keywords

Cobalt-based alloy cladding layer, Pulsed magnetic field treatment, Corrosion, Interface, Phase transition, Electronic work function

Authors: 王, 德鑫 (清华大学); Dr 刘, 瞿 (清华大学); Dr 钱, 成凯 (清华大学); Dr 李, 克俭 (清华大学); Dr 蔡, 志鹏 (清华大学); Dr 孙, 立斌 (清华大学)

Presenter: 王, 德鑫 (清华大学)

Session Classification: 环、化、材、技、能源战略

Track Classification: 03 口头报告: 环、化、材、技、能源战略