

## Effect of Cooling Rates on Microstructure and Cracking Resistance of Hot-Dipped Zn-12 wt% Al-5 wt% Mg Coatings

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**Abstract** Conventional zinc hot-dip coating utilizes sacrificial protection by preferentially corroding zinc ions over iron due to its higher ionization tendency, thereby acting as a sacrificial barrier to prevent the corrosion of iron. Research on ternary Zn-Al-Mg alloys is actively being conducted to enhance corrosion resistance by incorporating Mg and Al to promote the formation of highly stable and dense corrosion products such as simonkolleite ( $Zn_5(OH)_8Cl_2 \cdot H_2O$ ). This study delved into how different cooling rates affect the microstructure and cracking tendency of Zn-12Al-5Mg (in wt%) coatings. In the case of Zn-12Al-5Mg (wt%, PosMAC Super) developed by POSCO, despite its excellent corrosion resistance, it was found that faster cooling rates lead to a more refined microstructure but also increase the likelihood of cracking, mainly due to the presence of the hard and brittle  $MgZn_2$  phase as primary phase particles. Interestingly, we observed an epitaxial relationship between the primary and binary eutectic  $MgZn_2$  phases, shedding light on their crystallographic orientation and morphology. Additionally, our investigation revealed that cracking susceptibility depends on the crystallographic orientation of  $MgZn_2$  grains relative to the tensile axis. Fiber-like  $MgZn_2$  grains tend to crack along their basal planes, while hexagonal grains crack along other crystallographic planes. This insight into cracking behavior is crucial for designing Zn-Al-Mg alloy coatings with enhanced corrosion resistance and mechanical integrity. Overall, while faster cooling rates refine the microstructure, they also increase cracking susceptibility, emphasizing the need for a balanced approach in optimizing coating properties for different applications.

**Keywords** ZnAlMg coating; cooling rate; microstructure; cracking resistance; electron backscatter diffraction (EBSD)

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## Reference

- [1] M.S. Oh, S.H. Kim, J.S. Kim, J.W. Lee, J.H. Shon, Y.S. Jin, Surface and Cut-edge Corrosion Behavior of Zn-Mg-Al Alloy-Coated Steel Sheets as a Function of the Alloy Coating Microstructure, *Met. Mater. Int.* 22 (2016) 26–33.
- [2] M. Ahmadi, B. Salgin, B.J. Kooi, Y. Pei, The effect of grain refinement on the deformation and cracking resistance in Zn–Al–Mg coatings, *Mater. Sci. Eng. A* 840 (2022) 142995.
- [3] M. Xu, Z. Zheng, D. Han, R. Ma, A. Du, Y. Fan, X. Zhao, X. Cao, Improvement of cracking resistance of hot-dip Zn-Al-Mg coatings by heat treatment, *Mater. Today Commun.* 36 (2023) 106521.
- [4] M. Ahmadi, B. Salgin, M. Ahmadi, B. Kooi, Y. Pei, Cracking behavior and formability of Zn-Al-Mg coatings: Understanding the influence of steel substrates, *Mater. Design.* 212 (2021) 110215.