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Collaborated researcher of ILM	Affiliation	ARC, University of Toyama	
	Job title	Professor	
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Title of the joint research	Application of textured DLC coatings to Light Metal Forming		
Joint research Program ※check the box	☐ Program for Joint Usage / Research Centers (JURC) ☒ Program for International JURC ☐ Program for providing samples and materials ☐ Program for using ILM facilities for sample analysis and characterization ☐ Focused themes ☒ Transportation ☒ Biomaterials ☒ Bridge/building materials ☐ Kink strengthening ☐ Independent research theme		
Name of joint usage apparatus	Extrusion testing apparatus, Hydraulic press, Sputtering machine, In-line wear depth observation, EPMA, Raman spectroscopy, Laser texturing machine and other facilities		
Total amount of grant	Travel expense (240,000JPY)		Consumable Fee (60,000JPY)
Research Results ※Please describe following three items briefly. 【The major results】 The nanotextured punches and dies, compared to untextured samples, were studied using micro-extrusion testing. As a result, the textured tools successfully produced greater extrudability of pure Mg rods, obtaining 30% extrusion force reduction and decreasing tool wear. Alternatively, surface coatings for light metal cold rolling applications were investigated. These ceramic-based thermally sprayed coatings have been produced using a plasma spraying technique. Mullite-based nano-fly ash (MMF) composite coatings have exhibited the highest coating integrity among the tested samples, with a porosity of 7.65% and an optimal fracture toughness of 1.40 MPa·m^{0.5}. Incorporating MCrAlY particles into mullite coatings enhanced their mechanical properties, achieving a peak hardness of 638 HV₁. The addition of nano-fly ash significantly improved the adhesion of MMF coatings to the AISI 410 substrate—an essential factor for long-term durability and performance. Notably, the MMF coatings demonstrated a substantial 60% reduction in crystallite size, reaching a refined scale of 47 nm. Dislocation density also increased by 125%, rising to $44.8 \times 10^{-5} \text{ nm}^{-2}$ compared to conventional mullite coatings. Furthermore, the synergistic presence of MCrAlY and nano-fly ash particles improved shear resistance by limiting shear plane mobility, resulting in a maximum adhesion strength of 76 MPa. These findings confirm that the integration of MCrAlY and nano-fly ash into mullite coatings offers significant improvements in hardness, crystallinity, adhesion, and shear resistance. 【Future Prospects】 Aside from textured surfaces displaying good performance, little study has focused on refining the texturing input settings to improve the tribological behavior of dies. Despite substantial advances in surface texturing technologies that reduce friction and wear, metal transfer onto die surfaces remains a persistent challenge, especially for novel coatings meant to avoid galling and surface damage during forming processes. As proven, MMF coatings may be an effective way to address these concerns. Further study is required to develop technologies that successfully reduce friction and wear on die materials in such applications.			

【Concrete results】

<Publication>

- (1) Funazuka, T. et al. Effects of Punch and Die Surface Textures and CoCrMo Die Material on the Micro-Backward Extrudability of Pure Magnesium. J Bio Tribo Corros 11, 11 (2025)
- (2) Nunthavarawong, et al. Effect of Nano-Fly Ash Additive on the Mechanical and Microstructural Properties of Plasma-Sprayed Mullite Coatings. J Therm Spray Tech 33, 2578-2592 (2024)

<International Conference>

Notes

- Please use the form and submit to ILM office (mrc@kumamoto-u.ac.jp) by Friday, May 16, 2025.
- The joint research report will be published in the ILM joint research report (annual report) and will be available on our website. Therefore, please prepare the contents for public release accordingly.
- Please add pages, if needed.