論文 / 著書情報
Article / Book Information

題目(和文)	
Title(English)	Fabrication of composite coatings by low-pressured cold spray from hybridized particles of functional material and metal
著者(和文)	CHOIJongbeom
Author(English)	Jongbeom Choi
出典(和文)	学位:博士(工学), 学位授与機関:東京工業大学, 報告番号:甲第12074号, 授与年月日:2021年9月24日, 学位の種別:課程博士, 審査員:赤坂 大樹,大竹 尚登,野崎 智洋,平田 敦,山﨑 敬久,青野 祐子
Citation(English)	Degree:Doctor (Engineering), Conferring organization: Tokyo Institute of Technology, Report number:甲第12074号, Conferred date:2021/9/24, Degree Type:Course doctor, Examiner:,,,,,
学位種別(和文)	博士論文
Category(English)	Doctoral Thesis
種別(和文)	論文要旨
Type(English)	Summary

（博士課程）
Doctoral Program

論 文 要 旨

THESIS SUMMARY

系・コース： Department of, Graduate major in	機械 系 機械 コース	申請学位（専攻分野）： Academic Degree Requested	博士 Doctor of （工学）
学生氏名： Student's Name	Choi Jongbeom	指導教員（主）： Academic Supervisor(main)	赤坂 大樹
		指導教員（副）： Academic Supervisor(sub)	大竹 尚登

要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

Cold spray (CS) is one of thermal spray technique, and particle accelerated by supersonic gas collides and adhere to substrate by metallic bonding rather than melted by thermal energy such as traditional thermal sprays. Cold spray is possible to acquire coating with less phase transition, high density, and compressive stress due to its deposition mechanism based plastic deformation at collision by kinetic energy of metal particles. Common particle preparation methods, such as mechanical mixing or ball milling methods, for the fabrication of metal matrix composite coating by CS have been used. However, mechanically embedded functional materials to metal particles result in weak adhesion with metal particle surface. Furthermore, several functional materials experience structural damage during particle mixing process, or aggregated. Thus, new method for particle fabrication with uniformity and less damage has been requested. In this work, two types of strategies for preparation of hybridized particles of functional material directly bonded with metal particle were proposed to solve these problems on CS; one is a direct deposition of functional materials on metal particles to acquire strong adhesion, novel material, or less damage. The other is growth of ductile metal particle on brittle functional material particles for plastic deformation. Fabrication of composite coatings by low-pressured CS using these hybridized particles was conducted, and uniformity, defect density, existence, and contents of functional materials in composite coatings were investigated in four chapters.

In chapter two, composite coating of titanium with hydroxyapatite (HAp) fabricated for uniform HAp distribution and strong adhesion between titanium and HAp was studied. Hydroxyapatite is a bioactive material which induce direct bonding between artificial bond and soft tissue. To induce strong adhesion between HAp and titanium phase, HAp was directly fabricated on titanium particles by the particles immersion to modified simulated body fluid, and HAp-titanium composite coating was obtained from these particles by CS. The HAp in composite coating distributed uniformly with strong adhesion. In addition, osteoblasts cell adhesion induced onto the composite coating was observed due to bioactivity by HAp.

In chapter three, novel metal matrix composite coatings containing of Diamond-like carbon (DLC) film were studied. Diamond-like carbon film has low friction coefficient, high hardness, and chemical inertness. Nevertheless, its μm/h scale deposition rate and compressive stress has limited expansion of application of DLC film. To solve the limits, contained metal matrix composite coating was fabricated from DLC coated metal particles. Copper or titanium particles were coated with DLC by the chemical vapor deposition (CVD), and those coated particles were deposited on Al substrate by CS to avoid structural transition of DLC. The low working gas temperature of CS brought ignorable structural transition of DLC. Moreover,

effect of DLC in composite coating on tribological, anti-corrosion, and mechanical properties were investigated, and it was indicated the function of DLC was introduces to the metal matrix composite coating.

In chapter four, the fabrication of graphene-copper composite coating with less damage in graphene was described. Graphene has extraordinary properties, and has been introduced as a functional material into composites to enhance properties. To avoid structural damaging at mechanical milling graphene was directly deposited on copper particle by thermal CVD and the obtained hybridized particle was applied to CS to obtain composite coatings without structural damage in graphene. Whole fabrication process induced hardly damage because of absence of ball-milling and low working gas. Moreover, particles and composite coating showed no agglomerated graphene due to strong adhesion between graphene and copper. The coefficient of friction was reduced by the introduction of graphene into copper, indicating that the function of graphene could be introduced into metals as composite coating by CS from hybridized particles of graphene coated copper.

In chapter five, fabrication of carbon nanotubes (CNTs)-nickel composite coating with high CNT content by CS was described. Carbon nanotubes have attracted lots of interests as electrodes. However, composite coating with higher CNTs content of 30% by thermal spray from ball-milled particle mixture has not accomplished. To obtain composite coating with high CNTs content, nickel layer was formed on CNTs by electroless nickel plating because ductile nickel plays role of plastic deformation material for deposition by CS instead of brittle CNTs. As a result, this nickel layer on CNTs behaved for the acceleration of nickel coated CNTs and as plastic deformation layer at deposition. The composite coating was composed of two abundant layers; nickel abundant layer with 65 wt.% of carbon at bottom and CNTs abundant layer at upper.

In conclusion, fabrication of composite coatings by low-pressured CS from hybridized particles of the functional materials and metal particles was conducted. The hybridized particles enabled to fabricate the composite coatings with uniform distribution, novel material, less damage, and high contents of functional material. Thus, novel methods of composite coating fabrication from hybridized particles by low-pressured CS was developed.