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著者(和文)	LiuYin
Author(English)	Yin Liu
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論 文 要 旨

THESIS SUMMARY

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学生氏名： Student's Name	LIU YIN	指導教員（主）： Academic Supervisor(main)	矢野 哲司 教授
		指導教員（副）： Academic Supervisor(sub)	松下 伸広 教授

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

In this thesis, a room temperature glass coating technique, corrosion-reconstruction bonding, with simple process on metal by using freestanding ultrathin glass film as coating materials and using water as bonding agent is developed. Two points are focused in this thesis: firstly, 45S5 bioactive freestanding ultrathin glass films are prepared and used to develop this glass coating technique, investigate the bonding mechanism, and indicate the potential application; secondly, the effect of glass composition on the bonding behavior, which helps to find the proper glass composition for strong bonding in the corrosion-reconstruction bonding, is investigated.

In chapter 2, a simple glass coating method on metal by using ultrathin glass films as coating materials and water as bonding agent was developed. 45S5 bioactive freestanding ultrathin glass films were prepared by the glass blowing technique. Ultrathin glass films with thickness of 1 to 5 μm could be obtained, and then be bonded on a polished Ti plate at room temperature with a water layer between them. The glass films bonded strongly on Ti plate surface, and the bonding strength increased when the bonded sample is stored in ambient atmosphere at room temperature. The bonding strength was about 370 mJ/m^2 after bonding and increased up to about 900 mJ/m^2 after 9-hours bonding. This result indicates a simple room temperature glass coating technique is successfully developed.

In chapter 3, the bonding mechanism between 45S5 glass films and Ti plate at room temperature shown in chapter 2 was investigated in detail. The 45S5 ultrathin glass films prepared by glass blowing technique were found containing surface Na_2O-rich layer. The bonding mechanism between the 45S5 glass films and Ti plate was clarified by the XPS and TEM results as a corrosion-reconstruction bonding. This mechanism contains four steps: step 1, glass films and Ti plate bonds together by hydrogen bond of water layer; step 2, ion exchange of $Na^{2+} \leftrightarrow H^+$ between glass film and water layer occurs which forms a high pH solution in the bonding interface; step 3, surface of glass films and Ti plate corrodes by the high pH solution to form a bonding interfacial layer; step 4, the formed bonding interfacial layer polymerizes to induce a strong bonding during the storage process of the bonded sample. These steps occur fast after bonding, which is the reason for the much higher bonding strength after bonding (370 mJ/m^2) than the hydrogen bonds (~100 mJ/m^2).

In chapter 4, a 45S5 multi-layer structure was constructed by using the corrosion-reconstruction bonding for potential applications. 45S5 ultrathin glass films could bonded together strongly, their bonding strength also increased when the bonded samples were stored in ambient atmosphere at room temperature. The bonding strength was similar to that of the glass films on Ti plate, which means that the increase of the bonding strength after storage was due to the polymerization of the silicate components in the bonding interfacial layer. These results indicate that multi-layer structure of ultrathin glass films on substrate, in which a multi-function could also be potential by changing glass films, could be constructed by the corrosion-reconstruction bonding method at room temperature for potential applications.

In chapter 5, the effect of glass composition on the surface of ultrathin glass films was investigated. As shown in chapter 3, the surface Na_2O-rich layer on glass films was important for the strong bonding on Ti plate, the observation of glass compositions which could induce this surface Na_2O-rich layer was focused. Several glasses based on the soda-lime-silicate (including a magnesium-lime-silicate glass) and soda-lime-phosphate glasses were chosen, and corresponding ultrathin glass films were also prepared by glass blowing technique. Freestanding ultrathin glass films could be all prepared from these glasses. The surface Na_2O-rich layer was observed in soda-lime-silicate glass films with glass composition of SiO_2<62.5 mol%, CaO<25 mol%, and $Na_2O \geq 25$ mol% within the glass-forming region. The other compositions among the glass-forming region, the magnesium-lime-silicate glass, and the phosphate glasses showed no surface Na_2O-rich layer on glass films. These glass films with surface Na_2O-rich layer

were supposed to have stronger bonding on Ti substrate.

In chapter 6, the freestanding ultrathin glass films prepared in chapter 5 were bonded on Ti plate by the corrosion-reconstruction bonding method at room temperature. These glass films could also bond on Ti plate by using water as bonding agent at room temperature, however, there bonding strength varied. It has been found that glass films with surface Na_2O-rich layer had a higher bonding strength on Ti plate. However, this Na_2O-rich layer was not the necessary condition for high bonding strength, as the phosphate glass and soda-silicate glass films without this layer also had high bonding strength. High solubility in water was investigated to be the condition for strong bonding between glass films and Ti plate based on the experiment results, which was possessed by silicate glasses with low SiO_2 and CaO, high Na_2O content, and phosphate glasses.

Chapter 7 summarized the corrosion-reconstruction bonding method in this thesis. Based on the freestanding ultrathin glass films and the corrosion-reconstruction bonding, various kind of glass coating on substrate with different functions, such as bioactive coating, optical waveguide, protective coatings, et al, has potential to be constructed with simple process at room temperature.