# 論文 / 著書情報
# Article / Book Information

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# 論 文 要 旨

THESIS SUMMARY

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


Amorphous carbon (a-C) tribological coatings with luminescent wear-sensing capability using luminescent ZnS-based underlayer have been developed in order to achieve a tribological coating with wear-sensing layer. Three types of a-C coating systems have been fabricated and characterised their physical, mechanical, luminescent and tribological properties, and also have demonstrated the wear-sensing capability.

An a-C coating with ZnS:Mn underlayer was initially fabricated. The luminescent ZnS:Mn (5 at.% Mn) layer was fabricated by R.F. magnetron sputtering method and post-annealing at 700°C in Ar atmosphere. ZnS:Mn layer exhibited strong yellowish-orange luminescence at the peak centre 587 nm under irradiated with UV light at 365 nm. Subsequently, a-C films were deposited onto the luminescent ZnS:Mn layer by the same sputtering method for 60 min with a deposition rate of 1.4 nm/min. The obtained a-C/ZnS:Mn coatings showed clear surface without cracks or wrinkles formed on the surface. The luminescence from the ZnS:Mn layer could not be detected, suggesting the a-C film could prevent the luminescence mechanism to be occurred. However, it was found that a-C film peeled off easily during the friction test even though a thin Si intermediate layer was added between a-C and ZnS:Mn layer, indicating the adhesion of a-C film to ZnS:Mn layer was insufficiently strong.

The second a-C coating system was developed with improved adhesion property between a-C film and luminescent underlayer. In this system, epoxy resin coating containing ZnS:Cu phosphor powder (EP/ZnS:Cu) was fabricated as a wear-sensing underlayer. The mixture of epoxy resin and commercial ZnS:Cu powder (5 wt.%) was dropped onto the substrates and covered by polystyrene films to control the smoothness and flatness of the coating. After curing at 40°C for 12 hr and removal of polystyrene film, the EP/ZnS:Cu coatings exhibited clear and flat surface with the thickness of 50 μm. They also exhibited strong green luminescent spectrum with the peak centre at 525 nm under the UV excitation due to the embedded ZnS:Cu powder. The a-C films were deposited onto the EP/ZnS:Cu layer by sublimation of fullerene in electron beam excited plasma (EBEP) and pulsed vacuum arc deposition (VAD) methods. It was found that deposition of a-C films by sublimation of fullerene in EBEP caused the physical degradation to the EP/ZnS:Cu coating due to the strong interaction with Ar plasma during the deposition. In case of a-C films deposited by pulsed VAD, the structure of the films was found to be similar to a typical hard a-C film. The luminescent intensity detected from EP/ZnS:Cu layer was decreased exponentially as the thickness of a-C film increased. As the thickness of a-C film increased to 240 nm, the luminescence from the underlayer was unable to be detected. The friction test results showed that a-C film had an improved adhesion strength to the EP/ZnS:Cu underlayer and had the coefficient of friction as that of typical a-C film. After the friction test, the luminescence from the underlayer could be detected again, suggesting the a-C film has worn out. However, the precise wear monitoring demonstration was difficult to be achieved because of non-uniform wear track and remarkably rough surface of a-C coatings. These were due to the difference in elastic properties of hard a-C film and soft polymer epoxy layer.

Finally, a-C coating with luminescent silica coating containing luminescent CdSe/ZnS quantum dots (silica/QD) was fabricated in order to improve the rigidity of the coating as well as surface smoothness to allow the demonstration of wear monitoring become more precise. The luminescent silica/QD coatings were fabricated by spin coating of the mixture between a liquid polysilazane and a colloid of CdSe/ZnS QD (2.5 vol.%). After curing at 50°C for 3 hr in the high relative humidity atmosphere, the conversion of polysilazane to rigid silica network was occurred. The silica/QD coatings exhibited average surface roughness of 1.1 nm as well as strong luminescence as measured with Raman spectrometer at the excitation wavelength 532 nm. The a-C films were deposited onto the silica/QD layers by R.F. magnetron sputtering method with thin silicon layer (24 nm) as intermediate layer for adhesion improving. It was found that the luminescent intensity was decreased exponentially when the thickness of a-C film increased. As the total thickness of coating reached to 364 nm, the luminescence from the sensing layer was almost unable to be detected. The a-C coating with silica/QD underlayer showed the coefficient of friction of 0.1 during the friction test with a uniform wear track. Wear monitoring of the coating was demonstrated by detecting the luminescent intensity from the wear track of the coating after friction test and the remaining thickness of a-C film was determined by utilising the relationship between luminescent intensity and coating thickness. The results showed that the remaining thickness of coating determined by luminescent spectroscopy coincided well with the result obtained by surface profilometry. This suggested that wear monitoring of a-C films by luminescent spectroscopy was achieved.


備考 ： 論文要旨は、和文 2000 字と英文 300 語を 1 部ずつ提出するか、もしくは英文 800 語を 1 部提出してください。
Note : Thesis Summary should be submitted in either a copy of 2000 Japanese Characters and 300 Words (English) or 1copy of 800 Words (English).