NEW TYPE OF CERAMIC COMPOSITE FILMS COATED ON STEEL BY WET PROCESS

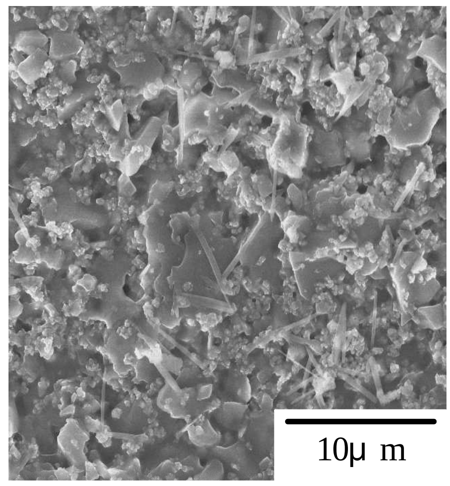
[a]Y. Muroya, [a]A. Motoki,[b]G. Sakai, [b]K. Shimanoe, [b]N. Yamazoe,[c]T. Maeda, [d]Y. Haruta

[a]Department of Materials Science,
Interdisciplinary Graduate School of Engineering Science,
[b]Department of Molecular and Material, Faculty of Engineering Sciences,
Kyushu University, Kasuga-shi, Fukuoka 816-8580, Japan
[c]Kyushu Nissan Paint Co.,Ltd
Shingu-machi, Fukuoka 811-0119, Japan
[d]Baham Co.,Ltd
Shibuya-ku, Tokyo 150-6019, Japan

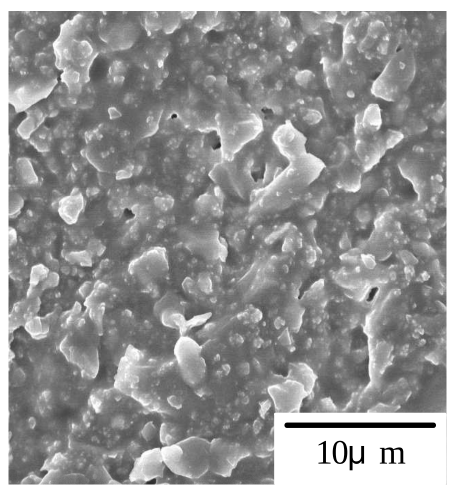
Ceramic coatings on metals have been developed for various industrial applications to protect the metals from corrosion, erosion or abrasion, or to endow the metal works with a decorative color. So far most of the coatings have been carried out by dry processes, which need large-scale equipments and high cost. The wet processes for ceramic coatings on metals, on the other hand, have scarcely been studied well. Probably best known in this category is enamel work, which has long been used for producing enameled metalwares. However, that technology has not always been suited for industrial applications. In this situation, we found a promising way to ceramic composite film coating on metals by a wet process. The composite films (about 100 μm thick) obtained can be stable on heating up to 1100 °C (conditional) or cooling to liquid nitrogen temperature. This paper aims at reporting the coating method and some basic aspects of the resulting films.

The coating slurry was prepared by mixing designated amounts of cristobalite, titania, alumina, kaolinite, sodium carbonate, sodium silicate, and potassium silicate in water. The slurry was applied on steel plates (blasted) with a brush. The coatings as applied were dried overnight at room temperature, pre-calcined at 365 °C for 30 min, and calcined at a temperature up to 1100 °C for 30 min in air or N_2 atmosphere. The coatings were inspected by means of X-ray diffraction (XRD), scanning electron microscope (SEM) and adhesion-test.

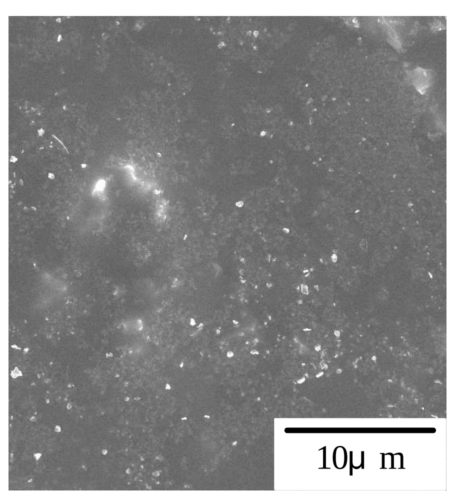
On calcination in air atmosphere, the ceramic coatings were adhered stably to the steel substrates up to 700 °C, while they were exfoliated completely at 800 °C and above. It seems that the pre-calcined coatings contained pinholes and oxygen penetration through the holes causes the substrates to be oxidized at the higher temperatures, resulting in the exfoliation as observed. On calcination in N_2 atmosphere, in contrast, the coatings could remain stable up to 1100 °C, above which the coating began to melt off from the substrate. Moreover, the coating once calcined at 1100 °C in N_2 was stable from exfoliation even when heated at 900 °C in air. Fig. 1 shows SEM images (top view) of ceramic films at several stages of calcination. It is obvious that the film calcined at 365 °C (a) or 700 °C (b) had a rather rough surface with large grains and aggregates and, contained visible pinholes at places. The film calcined at 1100 °C in N_2, on the other hand, had a smooth surface free of pinholes. The elimination of pinholes can be attributed to the melting of alkali silicate as judged from XRD analysis. The ceramic films thus made free of pinholes could be stable under exposure to air at elevated temperature. The films were also stable to cooling down to liquid nitrogen temperature. In conclusion, the present ceramic composite films can stick on steels over a wide temperature range in an inert atmosphere, and the same stability is also attained in air atmosphere if pinholes involved are eliminated by annealing at high temperature.



(a) Pre-calcined at 365℃ in air



(b) Calcined at 700℃ in air



(c) Calcined at 1100℃ in N_2

Figure 1 SEM images of ceramic coatings after the indicated treatments.