

MECHANICAL AND TRIBOLOGICAL CHARACTERISATION TECHNIQUES OF SURFACES AND COATINGS

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1. INTRODUCTION AND OBJECTIVE

The quest for new functionalities in traditional ceramics has led to the exploration of alternatives, such as the application of micrometric coatings of organic, polymeric, or ceramic nature, which provide ceramic substrates with enhanced technical qualities [1]. The obtainment of these new products implicitly entails an upgrading of the capabilities of the company, when it comes to characterising such coatings with the appropriate techniques and methodologies in each case.

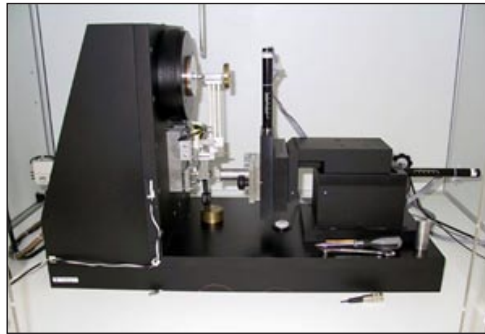


Figure 1 Image of a microindentation tester

One technique that is attaining high levels of application in the characterisation of very thin coatings is dynamic microindentation testing (Figure 1) [2]. The technique consists of continuous measurement of the deformation that a given material undergoes as a function of the applied load, and it allows mechanical properties such as microhardness and the modulus of elasticity of the material to be obtained without needing to measure the residual tracks, as occurs in indentation testing by the conventional method. In addition, it can also be used to determine wear and scratch resistance by applying progressive loads.

This study describes a method of mechanical and tribological surface characterisation that allows micrometric coatings on ceramic tiles to be studied. In the case presented here, a micrometric advanced ceramic coating of diamond-like carbon (DLC) was used, which was deposited by CVD on a ceramic tile with a zirconium white opaque glaze, with a view to characterising this completely by determining its mechanical properties (microhardness and modulus of elasticity), tribological properties (wear resistance and adhesive strength), and surface properties (thickness and surface roughness).

This type of layer was chosen because DLC coatings exhibit high wear resistance and low coefficients of friction. These are characteristics that would provide ceramic tiles with new functionalities, for example for façades and mechanically very aggressive outdoor areas.

2. TEST METHOD AND RAW MATERIALS

A DLC coating, applied by chemical vapour deposition (CVD) with a thickness of about 3 μm on the fired glaze of an earthenware tile, was characterised. Ceramic samples, without and with the DLC coating, are shown in Figure 2. The characterisation of the coating was mainly performed with a microindentation tester, determining mechanical properties such as hardness and modulus of elasticity; tribological properties such as scratch and wear resistance; and finally performing surface analysis by measuring the surface layer thickness and roughness.

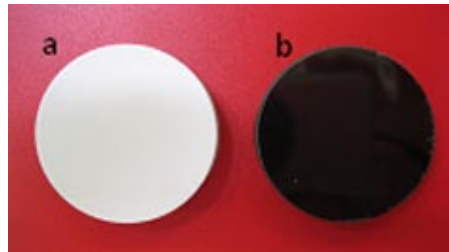


Figure 2 Ceramic sample: a) with and b) without a DLC coating

3. RESULTS AND CONCLUSIONS

The results obtained in the characterisation of the tested samples, without and with the DLC coating, are detailed in Table 1.

Characterisation	Property	Units	Substrate	Coating
Mechanical	Microhardness	GPa	10.6 ± 0.5	14 ± 2
	Modulus of elasticity	GPa	102 ± 8	94 ± 8
Tribological	Critical scratch load	N	Without adhesive failure	Adhesive failure $L_c = 54 \pm 1$
	Specific wear rate	$\mu\text{m}^3/\text{m}\cdot\text{N}$	0.11 ± 0.01	0.06 ± 0.01
Surface analysis	Coating thickness	μm	---	3.06 ± 0.15
	Surface roughness	nm	$S_a = 60 \pm 6$ $S_z = 800 \pm 100$ $S_t = 1100 \pm 200$	$S_a = 66 \pm 5$ $S_z = 650 \pm 80$ $S_t = 1300 \pm 300$

Table 1 Results of the characterisation

The results obtained demonstrate the high sensitivity of the characterisation technique used in differentiating the mechanical and tribological behaviours of advanced coatings applied on to traditional glazes. The following may be particularly noted:

- An improvement in the mechanical properties was observed, since coating hardness increased, while the stiffness of the material hardly changed because the modulus of elasticity was scarcely modified.
- Surface wear decreased considerably, since the surface specific wear rate was practically halved.
- The surface roughness of the material was maintained, since the 3 μm coating thickness was insufficient to modify the surface of the base material.

ACKNOWLEDGEMENTS

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