Ti, TiN and TiOx architectured coatings deposited by in-line cathodic sputtering on stainless steel wire: relation between chemical composition, microstructure and properties.

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Abstract: This thesis treats of the functionalization of stainless steel wires with colored Ti-based coatings grown by PVD with a cylindrical magnetron, their chemical and morpho-structural characterization, and the evaluation of the chemico-mechanical durability of the coated wires.

First, the deposition rate and the chemical composition of the films are determined under static conditions. Cathode plasma heterogeneities are demonstrated and related to parameters such as power, pressure and polarization of auxiliary anodes.

Then, Ti, TiN and TiOx monolayer coatings are grown continuously. The relationship between the color of TiN and its chemical composition is established and golden color is obtained for stoichiometric films with low oxygen content (<5% at.). Microstructures are studied with TEM-ASTAR and orientation maps are obtained with a nanometric resolution. While TiN coatings are columnar with <111> texture, Ti grains are rather equiaxed and <0001> oriented. With a 650 °C substrate temperature, substrate elements diffuse into the films which results in Laves phase formation. TiOx is grown in metallic mode, presents interference colors and a composition close to monoxide. TiN coated surfaces display high corrosion resistance similar to 316L stainless steel, unlike Ti and TiOx coated wires. The toughness and the adhesion energy of the coatings are determined by SEM in-situ tensile tests: Ti and TiN are particularly adherent to the substrate in contrast to TiOx.

Finally, coatings are architectured with the addition of a titanium interlayer between the substrate and the ceramic coating. Thus, Ti-TiOx film adhesion is greatly superior compared to the TiOx monolayer coating (5 to 200 J/m2). Finally, microstructural and electrochemical studies show that a key parameter of corrosion resistance is the presence of open porosity in the coatings.