

CHROMATE-FREE CERAMIC COATING COMPOSITIONS FOR HOT CORROSION PROTECTION OF SUPERALLOY SUBSTRATES

Figure 1. Schematic of an inorganic overlay coating system of the present invention comprising a basecoat and a topcoat.

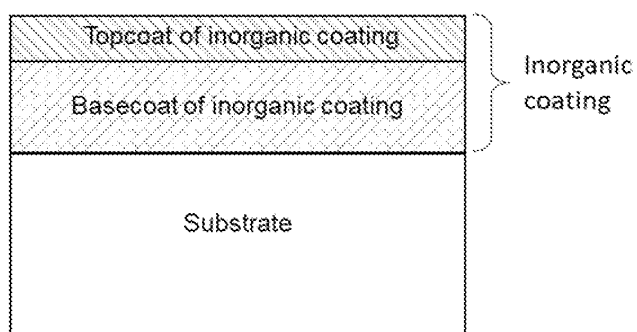


Figure 2. The inorganic coating of the present invention after thermal cycling test at 1500°F (815°C).

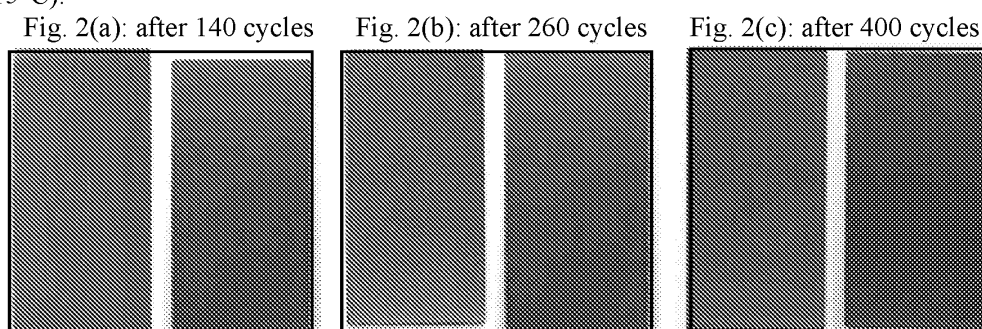


Figure 3. Surface morphology of the inorganic coating of the present invention in thermal cycling test: after 200 cycles in air at 1500°F (815°C).

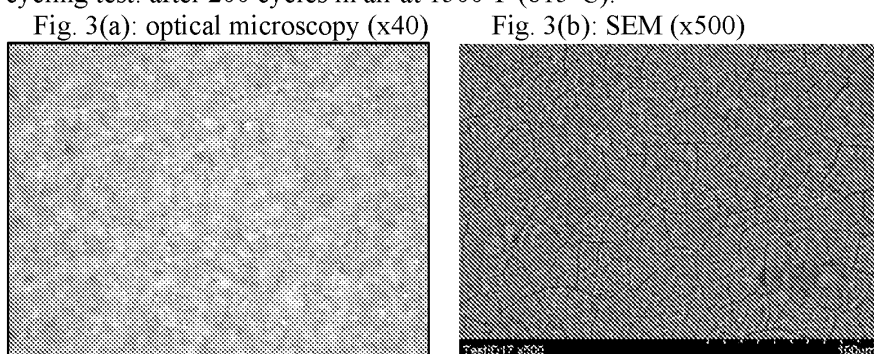


Figure 4. Thermal analysis of Aluminum Phosphate binders with different Al:P molar ratios
 Al:P = 1:3 (stoichiometric $\text{Al}(\text{H}_2\text{PO}_4)_3$); Al: P equals to about 1:2.7; Al: P equals to about 1:2.4.

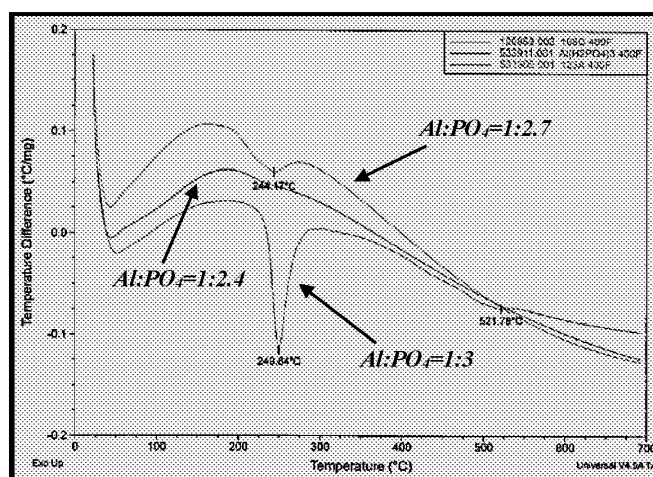


Figure 5. The inorganic coating of the present invention in thermal cycling test in the absence of deposit of corrosive sulfates: Visual appearance before test (a), visual appearance after test (b) of 100 cycles in air at 1310°F (710°C) and after- test cross-sectional SEM (c).

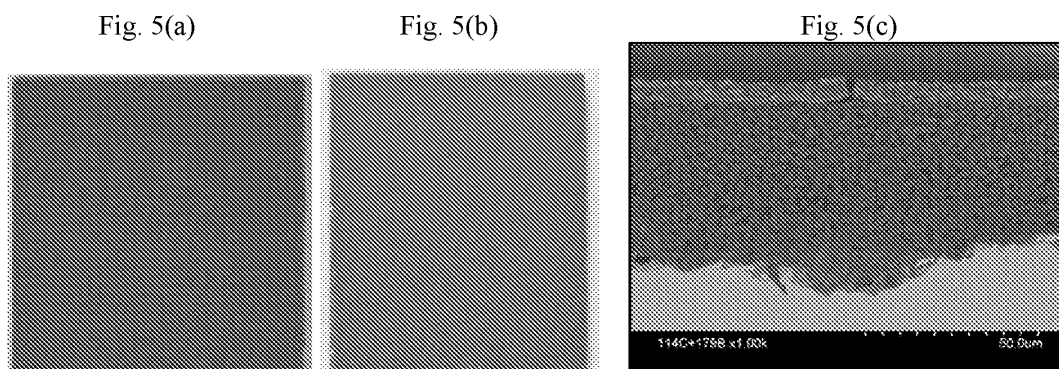


Figure 6. Sulfate attack on bare superalloy substrate, Rene 80: weight loss in Thermal Cycling Test at 1310°F (710°C).

1st Test performed with Mixture A; 2nd Test performed with Mixture B.

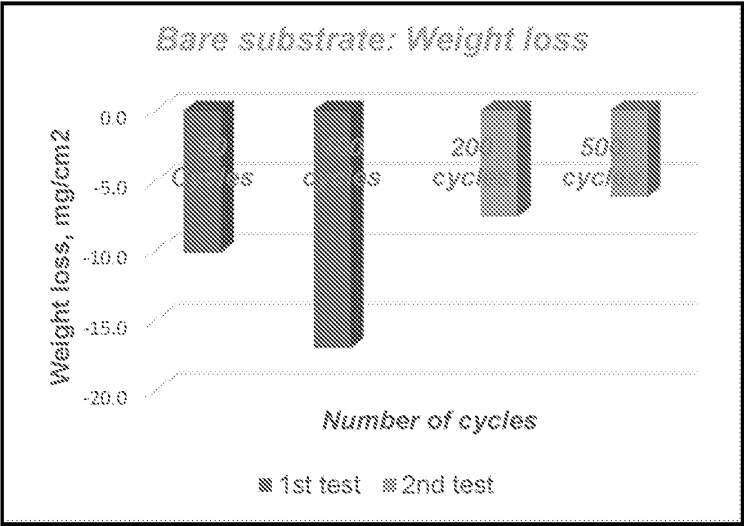


Figure 7 Sulfate attack on bare superalloy substrate, Rene 80: Cross-sectional SEM after Thermal Cycling Test at 1310°F (710°C).

Fig. 7(a). Test with Mixture A: after 100 cycles Fig 7(b). Test with Mixture B: after 500 cycles

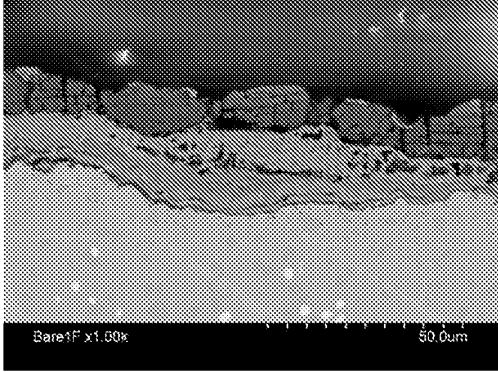
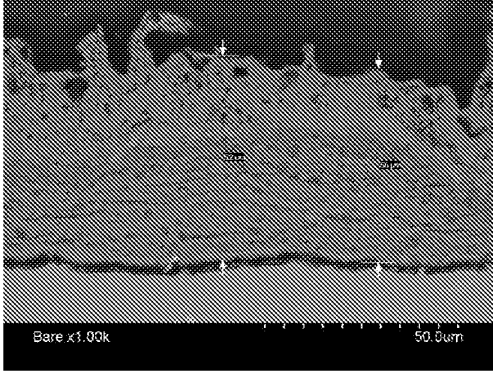


Figure 8. Thermal cycling test in the presence of aggressive Mixture A deposit of corrosive sulfates: Visual appearance of the inorganic coating of the present invention (a) vs. prior art Cr(VI) containing coating system (b) after 100 cycles at 1310°F (710°C).

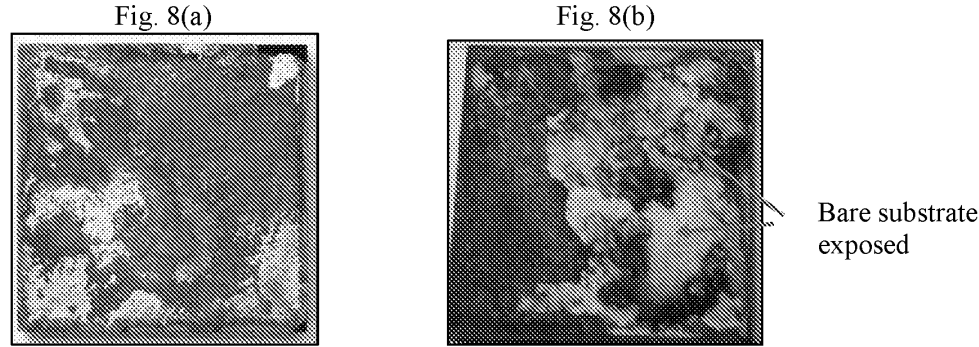


Figure 9. Thermal cycling test in the presence of Mixture A deposit of corrosive sulfates at 1310°F (710°C): Bare substrates vs. substrates coated with the Cr(VI)-free inorganic coating of the present invention.

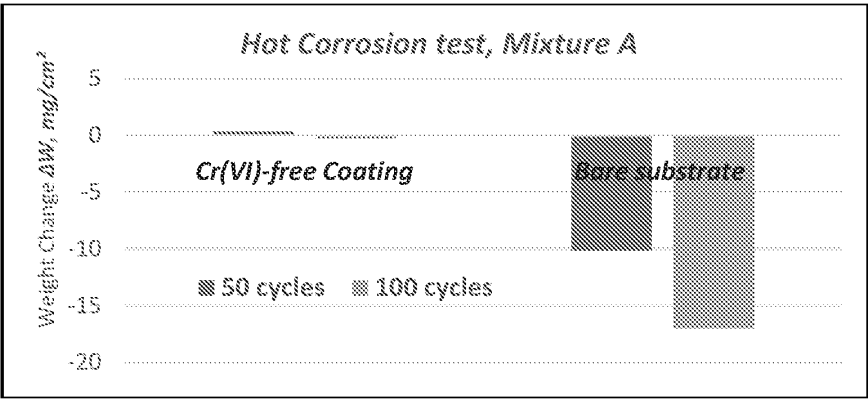


Figure 10, Thermal cycling test of the inorganic coating of the present invention: Cross-sectional SEM after 100 cycles at 1310°F (710°C) without sulfate (a) and with deposit of aggressive Mixture A (b).

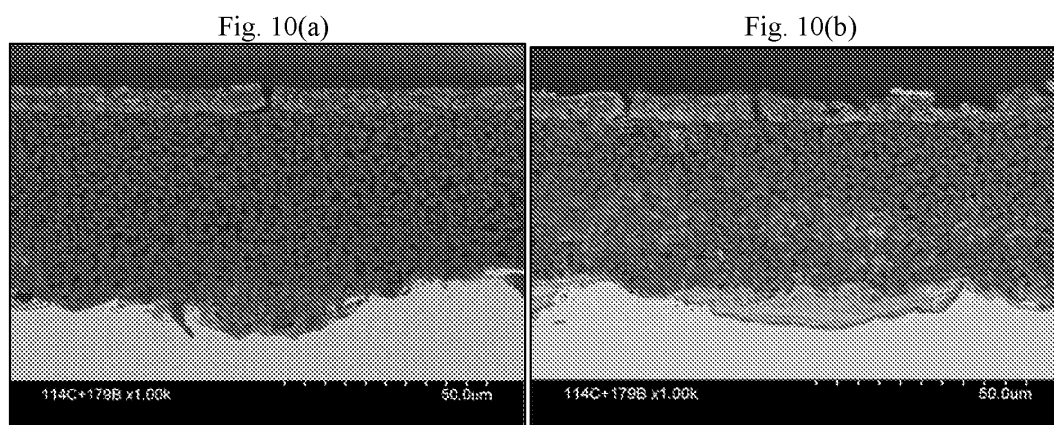


Figure 11. Thermal Cycling Test with Mixture B sulfate deposit at 1310°F (710°C): Cr (VI)-free inorganic coating of the present invention as-prepared (a), after 100 (b) and after 500 cycles (c).

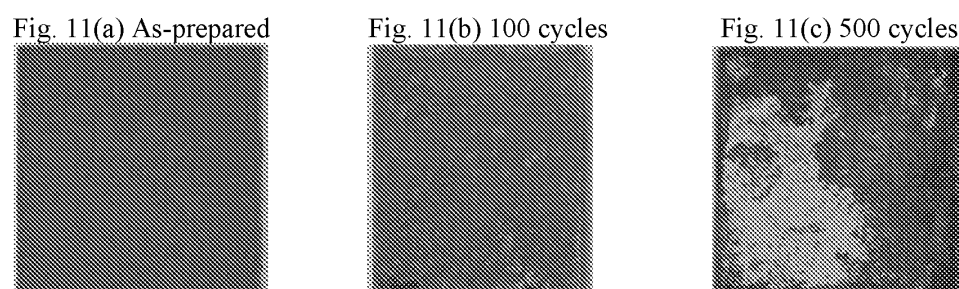
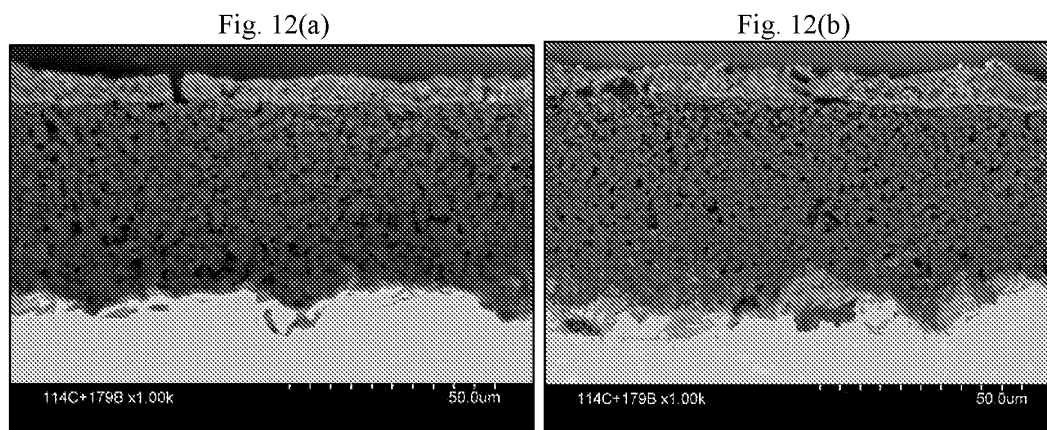


Figure 12. Thermal cycling test of the inorganic coating system of the present invention: Cross-sectional SEM after 100 cycles (a) and after 500 cycles (b) at 1310°F (710°C) with deposit of Mixture B sulfates.



Figures 13(a), 13(b) and 13(c) show a visual appearance of the samples coated with the Cr(VI)-containing system prepared in accordance with U.S. Patent 7,314,674; the samples are shown (a) before testing, (b) after 100 cycles and (c) after 500 cycles of thermal cycling test with Mixture B sulfate deposit at 1310°F (710°C), thus demonstrating an inferior performance of this commercially available coating system, in comparison to the Cr(VI)-free coating system of the present invention, as described in Comparative Example 1.

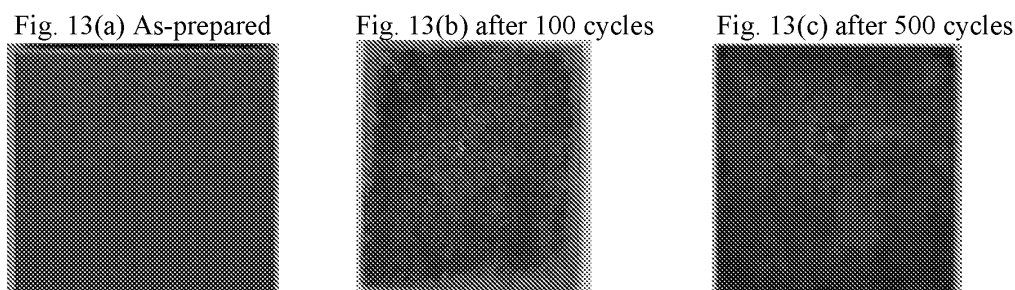


Figure 14. Thermal cycling test with Mixture B sulfate deposit at 1310°F (710°C): Bare substrates vs. substrates coated with the Cr(VI)-free inorganic coating of the invention and Cr(VI)-containing coating system (sample G and H) of the prior art as in Comparative Example 1.

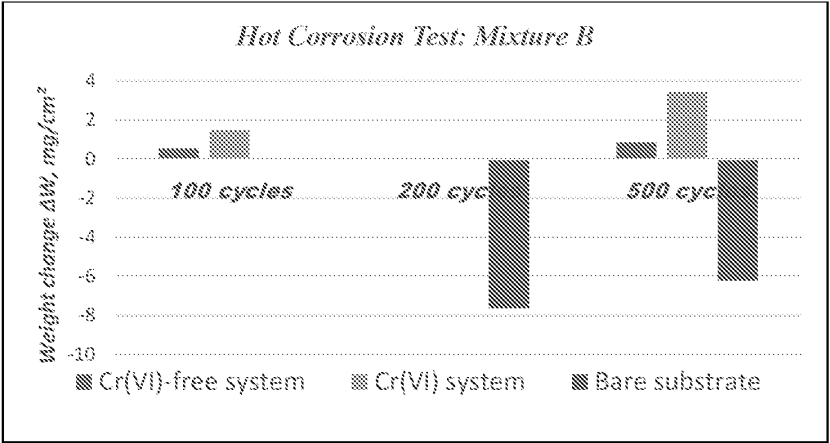


Figure 15. Thermal cycling test with Mixture A sulfates at 1310°F (710°C) for 150 cycles: Bare substrates vs. substrates coated with the Cr(VI)-free inorganic coating system (sample K) of the present invention and Cr(VI)-containing coating systems (sample I and J) of the prior art as in Comparative Example 2

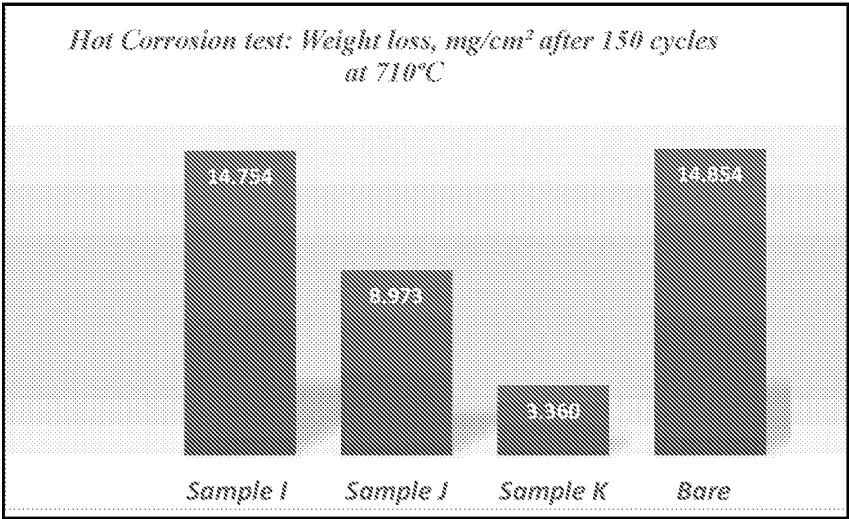


Figure 16. Thermal cycling test with Mixture A sulfates at 1310°F (710°C) for 50 cycles: Substrates coated with the Cr(VI)-free coating System with Li-doped Potassium silicate-based basecoat as in Comparative Example 3.

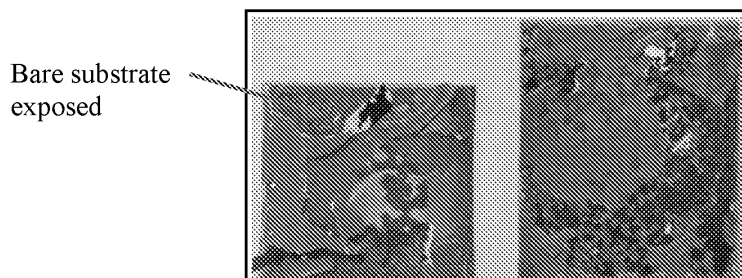


Figure 17. A schematic of a durable multilayer coating system of the present invention comprising a metallic bond coat and an inorganic overlay coating, wherein the inorganic overlay coating comprising a basecoat and a topcoat.

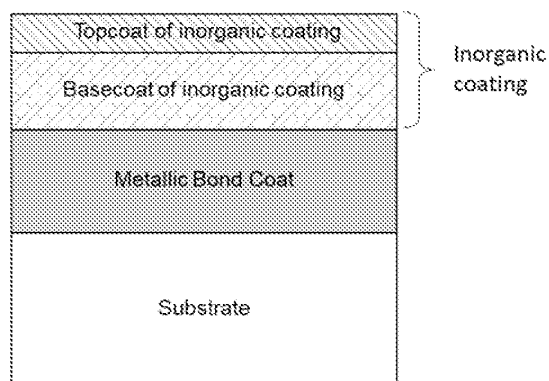


Figure 18. The maximum corrosion pit depth after 200 hour and 500 hour hot corrosion test at 710°C (1310°F) for multilayer coating and inorganic overlay coating of the present inventions in comparison to aluminide coating and uncoated superalloy CMSX-4.

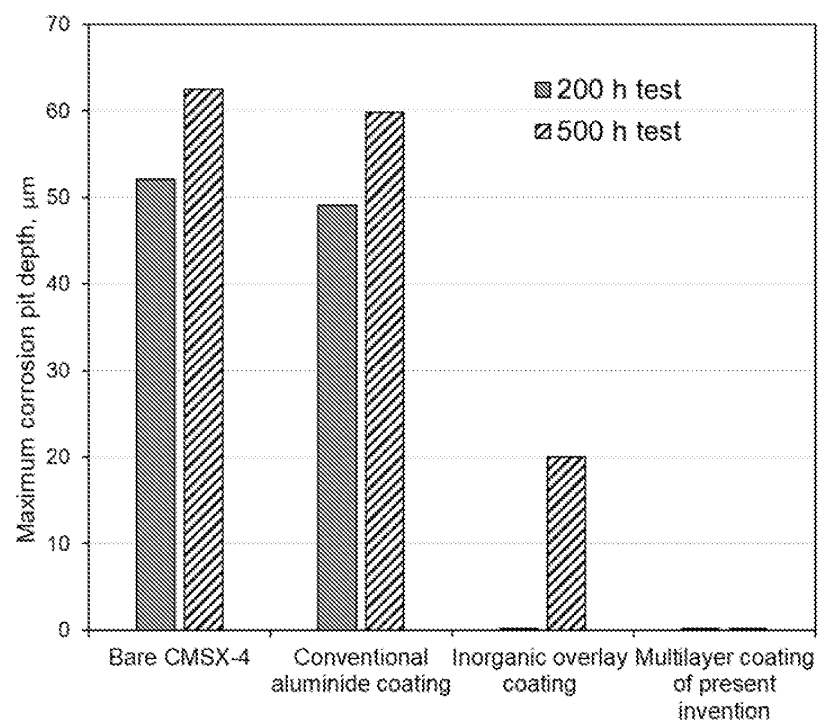


Figure 19. The cross-sectional images show zero corrosion pit for multilayer coating (a) and about 20 micrometer corrosion pit depth of inorganic overlay coating (b) of present invention after 500h corrosion test with mixture A in comparison to about 60 micrometer corrosion pit depth of conventional aluminide coating (c) and uncoated CMSX-4 (d).

