Properties of ZrC coatings deposited by reactive sputtering on Ni-Ti alloy substrates

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Abstract

Statement of the Problem: Thin ZrC coatings were deposited by reactive magnetron sputtering (RMS) on substrates made of Ni-Ti shape memory alloy in the shape of discs ø 32 mm × 3 mm and on single-crystalline silicon. Tests were carried out on ZrC coatings with different carbon contents, deposited at different acetylene flow rates in the deposition process. Phase composition (XRD) studies of Ni-Ti alloy substrates indicate that the dominant phase is austenite (γ-NiTi). There are also peaks with lower intensity than martensite (m-NiTi). Metallographic tests show a microstructure with an austenite matrix and martensite precipitation in an acicular form. Phase identification using X-ray diffraction (XRD) confirmed the deposition of coatings containing ZrC phase crystallites (Fig. 1). The highest intensity of peaks from the ZrC (111) plane was obtained for coatings produced with acetylene flows in the range of 2.5-4.5 sccm. The dry friction coefficient of coatings against Al_2O_3 reaches low values of 0.1-0.3 and is many times lower than for Ni-Ti substrates (0.96). Coatings produced with an acetylene flow above 3.5 sccm show much lower values of wear rates compared to Ni-Ti substrates, and the wear of Al_2O_3 counterspecimens is 2-3 orders of magnitude lower. The highest hardness of the coatings (26.1 GPa) is over 11 times higher than the hardness of Ni-Ti alloy substrates (2.3 GPa). The residual stresses of the coatings reached values in the range of 0.6-1.9 GPa. The highest values of the critical load L_{C2} = 20.1N and L_{C3} = 33.2N were determined in the scratch test for a coating produced with an acetylene flow of 4.5 sccm. In the Rockwell's test, the coatings deform simultaneously with the substrate and there is no visible damage (HF1-HF2). These tests demonstrate good adhesion of the ZrC coatings to Ni-Ti alloy substrates.

Conclusion: The structure and properties of ZrC coatings produced by reactive magnetron sputtering indicate the possibility of using them to cating, for example, endodontic tools made of Ni-Ti alloy - research in this direction will be continued.

Image

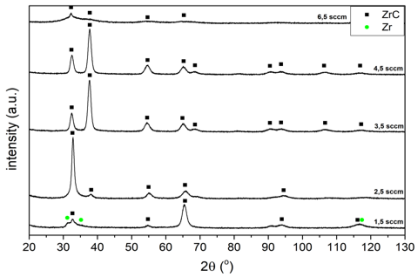

Fig. 1. X-ray diffraction pattern of ZrC coatings depositef at different acetylene flow rates

Recent Publications

1. Staszuk M., Pakuła D., Chladek G., Pawlyta M., Pancielejko M., Czaja P.: Investigation of the structure and properties of PVD coatings and ALD + PVD hybrid coatings deposited on sialon tool ceramics, Vacuum 154 (2018) 272-284. https://doi.org/10.1016/j.vacuum.2018.04.032 ;
2. Lukaszkowicz K., Kubacki J., Balin K., Sondor J., Pancielejko M., Characteristics of CrAlSiN+MoS2 coating deposited by cathodic arc and magnetron sputtering process, Vacuum 163 (2019) 360–367. https://doi.org/10.1016/j.vacuum.2019.02.050;
3. Pancielejko M., Adhesion of PVD and CVD hard coatings as an essential parameter that determines the durability of coated tools, Archives of Materials Science and Engineering, 96/1 (2019) 5-21. https://archivesmse.org/resources/html/article/details?id=189015;
4. Lukaszkowicz K., Sondor J., Paradecka A., Pawlyta M., Chmiela B., Pancielejko M., Szczucka-Lasota B., Węgrzyn T., Tański T., Structure and Tribological Properties of AlCrN + CrCN Coating. Coatings 10 (2020) 1084. https://www.mdpi.com/2079-6412/10/11/1084
5. Ratajski J., Bałasz B., Mydłowska K., Pancielejko M., Laskowska D., Szparaga Ł., Phase transformations in Ni-rich additively manufactured NiTi alloys, Journal of Achievements in Materials and Manufacturing Engineering, Phase transformations in Ni-rich additively manufactured NiTi alloys, Journal of Achievements in Materials and Manufacturing Engineering 121/1 (2023) 118-130. https://doi.org/10.5604/01.3001.0054.3215).

Photograph

Biography

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His work is connected with the current trend related to the modification of tool surfaces with PVD and CVD methods through the deposition of coatings to increase their durability. By using many modern research methods, he was determined the chemical and phase composition as well as the mechanical and tribological properties of coatings e.g. internal stress, microhardness, wear by ball-on-disk method, adhesion by scratch test. He has sought those parameters which characterize the properties of coatings, ones which would permit to effectively/practically assess the performance of coated tools, with an exclusion or limitation of long-term and costly durability tests of tools that are carried out in production conditions. He has participated as a performer in several European, national and university's projects. He has presented of research results at many international and national scientific conferences. His scientific output includes over 70 publications. He reviewed over fifty articles for international journals. He is a member of Polish Vacuum Society in Plasma Surface Engineering Section.

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