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Hard Antibacterial Zr–Cu–N Coatings with Resistance to Cracking

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Antibacterial coatings, which efficiently kill bacteria on their surfaces, are of key importance for applications in hospitals or public transportation. These coatings should also be simultaneously resistant to mechanical damage, especially to cracking in bending or under loading.
The present paper reports on the preparation of hard antibacterial Zr–Cu–N coatings with resistance to cracking. The coatings were deposited by reactive pulsed dc dual magnetron sputtering of two identical circular Zr/Cu targets fixed by Cu rings in Ar+N2 gas mixtures. The effect of the addition of Cu on the structure, antibacterial and mechanical properties, and resistance to cracking was investigated in detail. The content of Cu ranging from ~0.5 at.% to ~16 at.% was controlled by an inner diameter of the Cu rings, partial pressure of nitrogen and negative substrate bias voltage. The resistance to cracking was evaluated from the bending of the coatings deposited on Mo strips around a fixed cylinder and from high-load indentation of the coatings by adiamond indenter. The antibacterial efficiency of killing E. coli bacteria in the daylight was evaluated using a plate counting method for a contact time of 5h.
It was found that the Zr-Cu-N coatings prepared at optimized deposition conditions exhibit a high hardness ranging from ~21 GPa to ~31 GPa and are in compressive macrostress. The coatings also exhibit a high ratio H/E^{*}> 0.1 and a high elastic recovery > 60% in a wide range of the Cu content (from ~0.5 at.% to ~16 at.%), which results in an enhanced resistance to cracking in bending and under high-load indentation. In addition, the coatings with the Cu content > 11 at.% are nanocomposites composed of ZrN and Cu phases and are simultaneously characterized by 100 % efficiency of killing E.coli bacteria on their surfaces. These properties demonstrate that trifunctional hard/antibacterial/flexible Zr–Cu–N coatings can be prepared using reactive magnetron sputtering.

Keywords
Zr-Cu-N coating
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Mechanical properties
Resistance to cracking
Reactive magnetron sputtering