Optimised thin-film tantalum coating methods for radio-opaque Nickel-Titanium biomedical implants

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The shape memory alloy Nitinol (nickel titanium) is frequently employed in biomedical implants manufacturing, due to its shape memory properties [1], excellent formability and high radial force on deployment. Crucially, however, nitinol is relatively radio-transparent, limiting its visibility under fluoroscopy and CT scanning. Efforts to address this have often focussed on coating the surface with a radiopaque thin film [2].

Tantalum is considered a promising candidate [3, 4]; more resistant to galvanic corrosion than other metals, non-cytotoxic, and sufficiently radiopaque. However, an ideal Ta coating method remains elusive. While PVD (Physical Vapor Deposition) methods for Ta coatings, such as magnetron sputtering [5], have been refined somewhat, little comparison has been made with methods such as electrodeposition [6] and thermal spray technologies [7]; often considered more economical at an industrial scale. This research aims to perfect Ta-based coatings for nitinol surfaces by comparing these techniques.

To compare the effectiveness of each coating, bonding strength is measured using scratch testing. Nitinol radiopacity is quantified for the coated wires using MicroCT, while measurements of elongation strain before cracking, under tensile loading, is achieved through an in-situ UTM (Universal Testing Machine). Microstructural analysis incorporating simultaneous EDS and EBSD is used to examine interfacial bonding and any grain deformation, non-stoichiometric phase inclusions, and preferred orientation that might facilitate microcracking. Corrosion and fatigue testing is also performed on each sample.

These assays allow for a more effective comparison of deposition techniques based on bonding strength, crack resistance, and ease of production at an industrial scale.

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