CrN/Ag Coatings for Biomedical Implant Applications

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1. Introduction

There have been increasing numbers of biomedical implants used in the human body. However, the rate of failures is high despite the developments in new materials and designs, and the revision surgeries are complex and involve prolonged hospital stays. This is putting a substantial burden on the health services. As many failures are caused by wear of the implant or infections, this project aims to develop bio-tribo-corrosion resistant CrN/Ag coatings that will be used to fabricate biomedical implants. The project concerns the health services, the coating industry, the biomedical industry, etc.

The coatings being developed will have excellent biocompatibility and antibacterial properties. They will extend the life of the implants and therefore lower the number of revision surgeries, benefiting the patients worldwide. Attractive profits will be expected after the project results are put to the market. Benefits can also be realised across multiple applications: coatings for a range of biomedical implants; coatings for food manufacture or aerospace applications where antimicrobial properties or wear and corrosion resistant properties are required.

2. Experimental

The coatings were deposited on M2 tool steel substrates by Tecvac Ltd. using electron beam evaporation in both horizontal and vertical positions (sample numbers: 81, 82, 84 and 85). The baseline CrN coatings were also deposited onto CoCrMo substrates. The coating thicknesses were measured by cross-sectional SEM and ball crater. The coating structure and composition were characterised by scanning electron microscopy (SEM), energy dispersive X-ray spectroscopy and X-ray diffraction (XRD). The hardness of the coatings (H) was measured by nanoindentation, and the tribological properties were evaluated by micro-abrasion wear testing, ball-on-plate impact testing and reciprocating sliding wear testing. Some results are not reported here.

3. Results

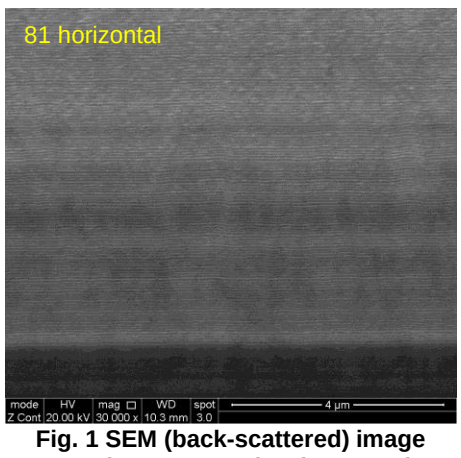

Fig. 1 SEM (back-scattered) image in cross-section (21at%Ag)

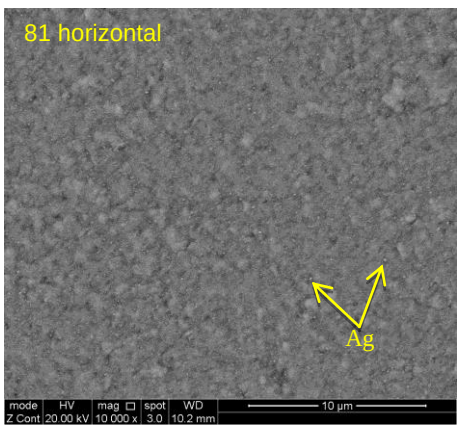

Fig. 2 SEM surface morphology (back-scattered) (21at%Ag)

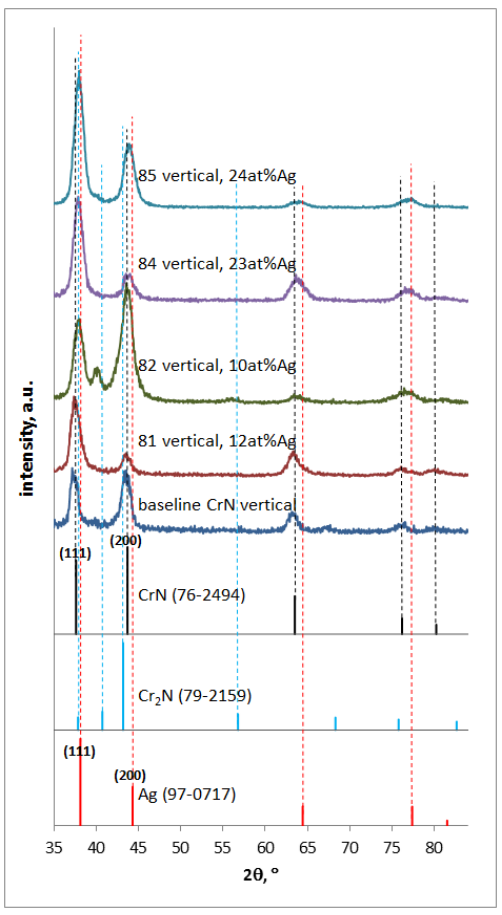

Fig. 3 Glancing-angle XRD patterns for the vertical samples

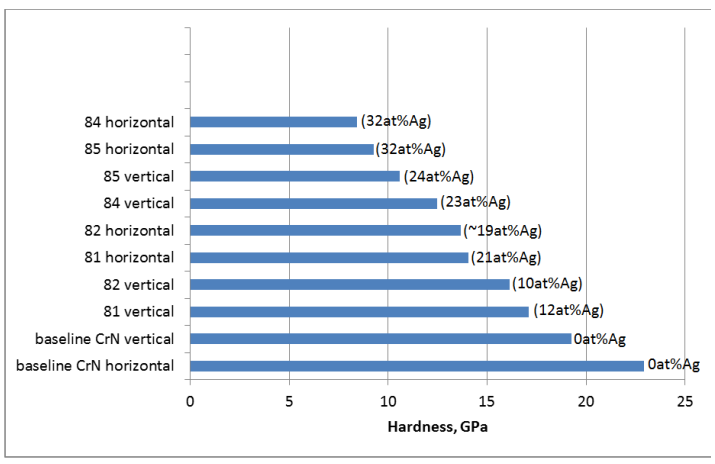

Fig. 4

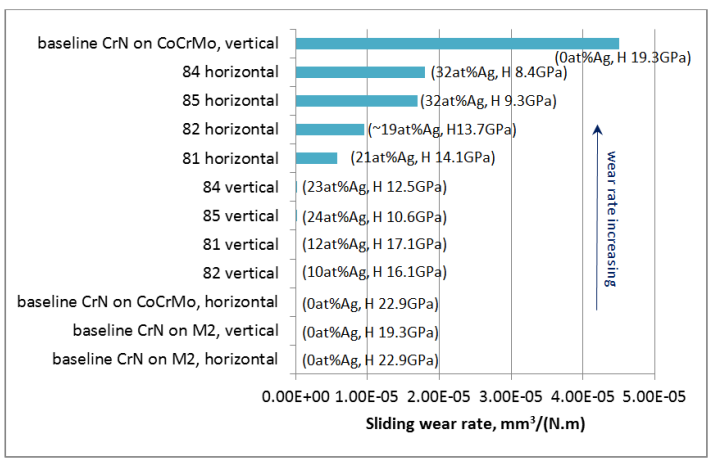

Fig. 5

4. Comments

Figs. 1 and 2: The coatings are dense, without columnar structures. Multilayering effects can clearly be seen in the coatings. The non-uniformity of the multilayering indicates variations in deposition conditions, especially during the initial deposition period. Brighter Ag particles are shown on the back-scattered electron images. Some Ag particles are too small to be observed; a non-uniform and rough coating surface also makes some Ag particles invisible under SEM.

Fig. 3: It is not so clear whether addition of silver promotes CrN (111) texture over (200), due to the overlapping of silver and CrN peaks (both (111) and (200)).

Fig. 4: In general, the hardness of the coatings decreases with increasing silver content. For coatings without added silver, the horizontal samples are slightly harder than the vertical sample (this may be due to the fact that Cr_2N – present in the horizontal samples – is harder than CrN.).

Fig. 5: A variety of factors contribute to the sliding wear performance of the coatings. Amongst all the coatings investigated, the 'baseline CrN' on CoCrMo (vertical) gave the worst sliding wear resistance because of the thin coating and the (relatively soft) CoCrMo substrate. However, to elucidate the role of each factor affecting the wear performance, a systematic study is required, without so many variables.

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