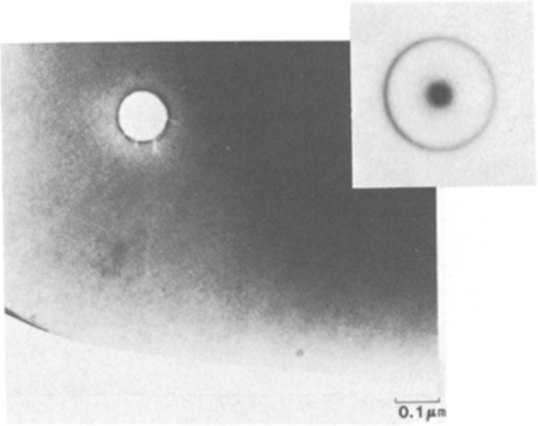

Figure 4 Amorphous thin foil, 90.65 wt% Pd, 4.22% Cu and 5.13 wt% Si alloy.

fraction pattern from a splat-quenched sample of an alloy consisting of 90.65 wt% Pd, 4.22 wt% Cu, and 5.13 wt% Si. The absence of structure within the foil and the diffused nature of the diffraction pattern indicate that a completely amorphous phase was formed as a result of the rapid cooling experienced during splat quenching.

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Fractographic evidence of mixed mode stress corrosion cracking in stainless steel surgical implants

AISI stainless steel 316L is the most widely used alloy for orthopaedic surgical implants and in the majority of the cases the implants are used to hold bone sections while the bone structure reforms. The implants are subjected to significant stresses and are exposed to aqueous body fluids containing about 0.1 M chloride ion. The pH of the body fluid is normally 7.4 but under certain conditions a local variation in the range of 4 to 9 may result.

A significant number of implants fracture in service and the failure is found to occur mostly in plane strain. Upon examination of failed implants, a number of investigators [1–5] identified fatigue and metal defects as the cause of failure but evidence of pitting corrosion [6], crevice corrosion [7, 8] and intergranular corrosion [8] have also been observed on fracture surfaces. A problem faced by the investigators is that the features of interest on the fracture surfaces are frequently obliterated by the repeated impingements of the surfaces during the period after fracture before removal.

Recently, we received a number of failed stainless steel implants (mainly hip prostheses) and in two of these the fracture surfaces appear to be almost intact. Evidence of fatigue and pitting corrosion can be seen on the fracture surfaces of the implants and, moreover, there is evidence of what appears to be stress corrosion cracking (SCC) – both intergranular and transgranular crack propagation. This communication presents fractographic evidence of the mixed mode stress corrosion cracking. Although cases of mixed mode failure in SCC of austenitic stainless steel are reported in the literature, they are mainly limited to failures at the elevated temperatures whereas in the present case, failure took place at a rather low temperature, i.e. body temperature (37° C). It is believed that the fractographs presented are of interest from this point of view.

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Fig. 1 presents the scanning electron micrograph showing mixed mode failure in which transgranular failure has occurred in the lower right grain. Fig. 2 presents the mixed mode failure in another part of the same fracture surface as Fig. 1. In both these figures there is evidence of slip in the grain boundaries indicating a mismatch of the grains. The fracture surface of Fig. 1 has a marked similarity with the mixed mode SCC failure reported by Neilsen ([9] Fig. 16) in an austenitic stainless steel in boiling $MgCl_2$ solution. In Fig. 2 the transcrystalline failure shows additional features inside the grain which possibly represent crystallographic fracture along planes inclined to the main plane of fracture as was reported in the transcrystalline SCC failure of a magnesium alloy [10].

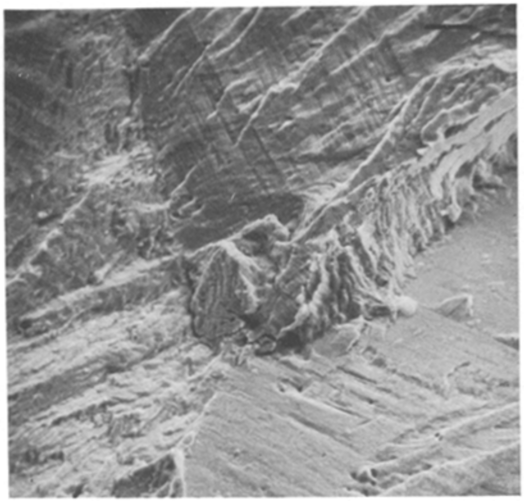

Figure 1 Fracture surface showing mixed mode SCC. Evidence of slip can be seen in the grain boundaries. Scale : 10 μm.

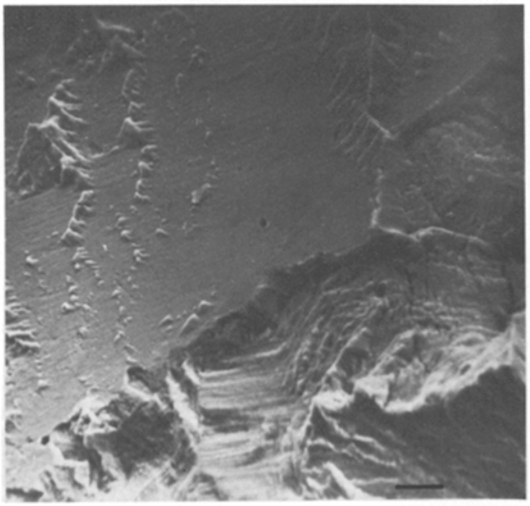

Figure 2 Another example of mixed mode fracture– the transgranular failure also showing crack propagation on planes inclined to the main plane of fracture. Scale : 10 μm.

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