L.2 : Novel laser surface treatment to enhance inter-granular corrosion resistance of type 304 stainless steel

A laser surface melting (LSM) treatment has been developed for enhancing inter-granular corrosion (IGC) resistance of type 304 stainless steel (SS). IGC is the main corrosion problem experienced by austenitic stainless steel components operating in nuclear fuel reprocessing and waste management applications and also, in many chemical industries using nitric acid as the process fluid. The basic cause of IGC of austenitic SS is "sensitization" involving inter-granular precipitation of Cr-rich carbides when exposed to temperature range of 773-1073 K. It is accompanied by development of Cr-depleted zones adjacent to grain boundaries leading to IGC.

The results of the present study, performed in collaboration with BARC and IIT, Mumbai, demonstrated that LSM treatment of type 304 SS sheet brought about significant improvement in its IGC resistance.

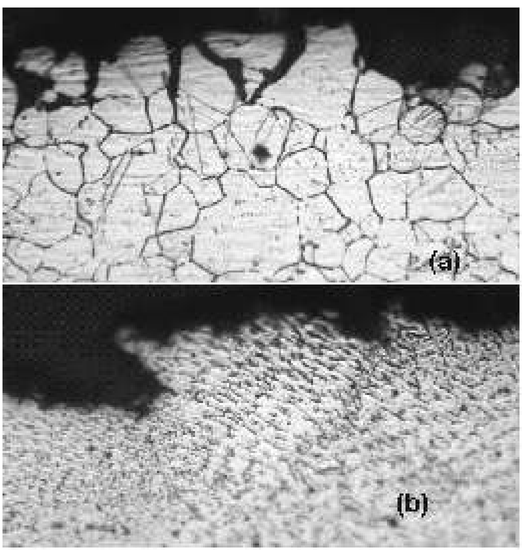

Fig.L.2.1: Comparison of surface microstructures of substrate and laser melted specimens after exposure to sensitization heat treatment & IGC test ASTM A262 Pr. B - (a) substrate with IGC attack and (b) un-attacked laser melted surface.

Figure L.2.1 compares near surface micro-structures of substrate and laser melted specimens after undergoing sensitization heat treatment (923 K / 9 hrs) and IGC test ASTM A262 Pr. B. The results of double loop electrochemical potentio-kinetic reactivation (DL-EPR) test exhibited that laser melted specimens, after undergoing sensitization heat treatment, exhibited significantly lower values of degree of sensitization (DOS, ranging from 0.1-1) than that of the sensitized substrate (4.32). Laser melted surface, even after undergoing sensitization heat treatment, possessed comparable or even lower DOS values than that of the substrate in as-received condition.

Figure L.2.2 compares typical DL-EPR curves of substrate and laser surface melted specimens after exposure to sensitization heat treatment. The factors responsible for enhanced IGC resistance of laser-melted surface are: development of sensitization-resistant microstructure involving (i) high fraction of low angle grain boundaries (increased from 0.04 in the substrate to 0.13-0.19 on laser-melted surface) and (ii) presence of numerous austenite δ-ferrite boundaries. Present work represents a novel approach to engineer surface microstructure of type 304 SS for inducing greater immunity against sensitization & IGC. It has strong potential as an in-situ technique for life enhancement of austenitic SS components operating in corrosive environments.

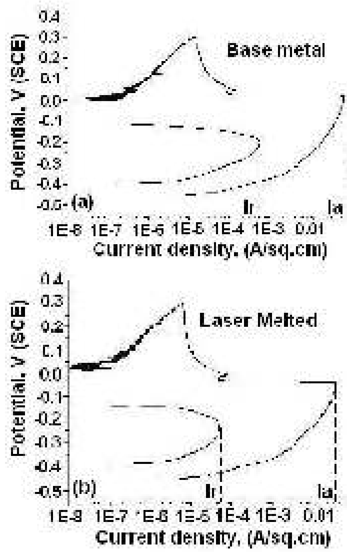

Fig.L.2.2: Comparison of DL-EPR curves for (a) sensitized substrate (DOS = 4.32) & (b) laser melted specimen after exposure to sensitization heat treatment (DOS = 0.106).

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L.3 : Precision processing of silicon with copper vapour laser

Silicon is at the heart of semiconductor, micro-electronics and MEMS technologies. Depending on the nature of the device / sensor, fine structuring (etching, cutting, drilling) varying from few hundreds of nanometers