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TITLE

TEM STUDY OF NiAl BRONZE LASER-WELD CLADDINGS

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TEM Study of NiAl Bronze Laser-Weld Claddings

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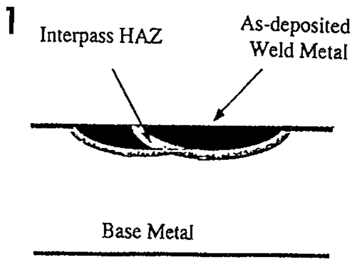
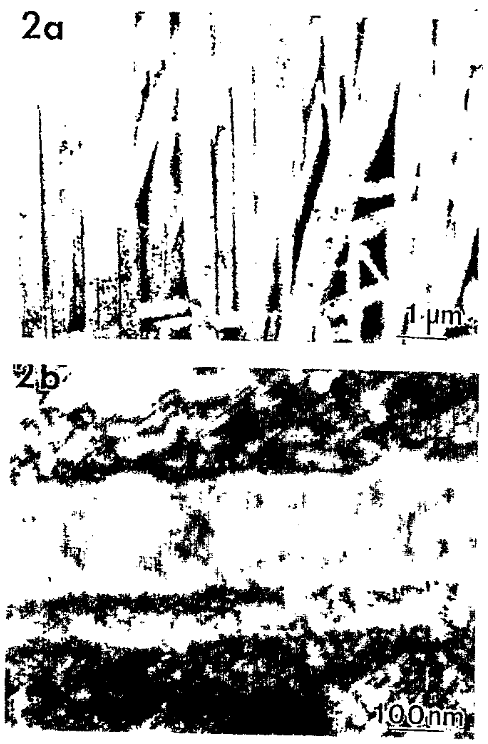
Nickel aluminum bronze (NAB) alloys are widely used to produce components for marine applications due to their excellent sea water corrosion resistance and good mechanical properties. As a result, the microstructure of these alloys has been extensively characterized in both the as-cast and heat treated conditions.[1] Recently, the use of high power lasers for surface melting and cladding of NAB components has stimulated renewed interest in the microstructural development of these alloys.[2,3] Due to the relatively high cooling rates (on the order of 1000 °C per second) associated with laser melting and cladding processes, complex non-equilibrium microstructures are anticipated; however little data is currently available. This paper presents a detailed microstructural characterization of a NAB laser-weld cladding using transmission electron microscopy.

The NAB weldment used for study was provided by DREA and produced by rapidly scanning a laser across the surface of NAB coupon while simultaneously feeding a NAB wire into the melt pool. The coupon and wire compositions were approximately Cu - 9 wt.% Al - 5 wt.% Ni - 4 wt.% Fe - 1 wt.% Mn and the laser beam heat input was 1.2 kJ/cm. The cladding consisted of small overlapping beads as shown schematically in Figure 1. For TEM observations, the samples were back-thinned by mechanical grinding and electropolished to electron transparency. The specimens were examined with a Philips CM20 microscope operated at 200 kV.

Significantly different microstructures are observed in the as-deposited and interpass heat affected zone (HAZ) regions of the clad. In the as-deposited regions (Figure 2a), the microstructure is essentially dual phase consisting of light (more electron transparent) rods separated by irregularly shaped dark plates. In addition, numerous cuboidal precipitates, ranging up to 200 nm in diameter, are distributed throughout both phases. A regularly spaced array of stacking faults is observed in the majority of the light rods found in the as-deposited region (Figure 2b). Fractional shifts of the reflections in electron diffraction patterns from this phase suggest the presence of an interface modulated superstructure based on an ordered stacking of close-packed planes within a fcc subcell The Widmanstatten-like morphology and elevated Al concentration as revealed by EDX measurements, suggests that this stacking superstructure is the product of a bainitic transformation. An identical crystal structure is observed for the dark platelets, however in this case extensive twinning also occurs on the $\{100\}_{fcc}$ planes. This phase presumably corresponds to the 9R stacking superstructure of martensitic origin known to occur in Cu-Al alloys.[4] In the interpass HAZ, the microstructure consists of three phases (plus precipitates): a martensitic phase similar to that described above, a light phase with Widmanstatten morphology (Figure 3a), and a region containing elongated Fe- and Ni-rich particles (Figure 3b). Based on electron diffraction and EDX analysis, these latter two phases are identified as the previously reported proeutectoid α (fcc) phase and (α + κ) eutectoid, respectively. A model relating the observed microstructures to the transformation behaviour of the clads will be presented.





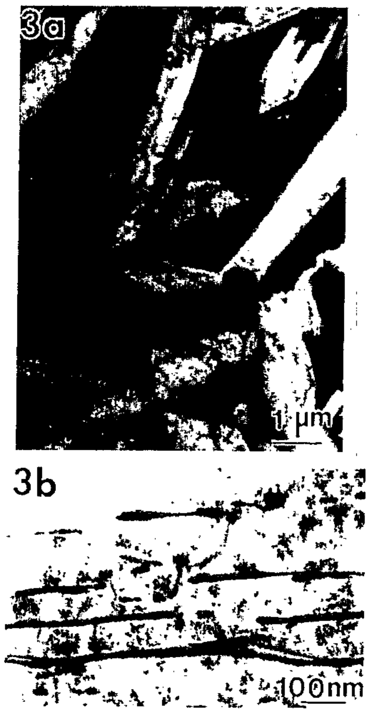


Figure 1: Schematic diagram of cladding.
Figure 2: As-deposited weld metal:
(a) typical region and (b) bainitic phase.
Figure 3: Heat affected zone:
(a) typical region and (b) eutectoid phase.

REFERENCES
1. P. Bezina, *Int. Metals Reviews*, 27(1982)77.
2. C.V. Hyatt and K.H. Magee, *Proc. Advanced Methods of Joining New Materials* II, Amer. Weld. Soc., (1994)111.
3. Y. Liu et al., *Met. and Mat. Trans. A*, 25(1994)37.
4. H. Sato et al., *Acta Metall.* 15(1967)1381.

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