TEM study of the hardening of Pt 11 at.% V alloy

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Non-Technical Abstract: South Africa is a major producer of platinum in the world contributing 75% of the world supply. Studies show that about half (45%) of the world supply of platinum is consumed by the jewellery industry. But South Africa (SA) produces less than 0.5% of the world jewellery. In order to increase the platinum jewellery output of SA a study was undertaken to research on potentially excellent alloys for this application. Platinum-vanadium was studied focusing on its hardening behaviour. The results showed a significant increase in hardness after heat treatment of deformed alloys.

Technical Abstract: Platinum 11 at.% V undergoes an ordering transformation upon post deformation heat treatment, resulting in the formation of the Pt_8V superlattice. The presence of the ordered phase results in a significant increase in hardness. The hardening mechanism is the hindrance of movement of single dislocations by the dispersed ordered regions.

Glossary of terms

- •Superlattice - ordered crystal lattice
- •Ordering - atoms have a strong preference for specific lattice sites
- •Zone axis - incident direction common to all the planes in the zone
- •fcc_d – disordered face centred cubic
- •fct_o – ordered face centred tetragonal
- •Coherency strains - strains due to mismatch of lattices with different lattice parameters

Objective

Study the effect of heat treatment on hardness

Determine the cause of the hardness increase

Establish the mechanism of hardening

Literature Review

- •Pt 11at.% V orders to form a Pt_8V superlattice[1,2]
- •Pt_8V superlattice is one the eleven experimentally determined A_8B type alloys[3,4]
- •Ordering Pt_8V resulted in change in lattice structure from fcc_d to fct_o
- •Ordering transformations can result in an increase of mechanical properties[5,6] like hardness
- •Different models for the strengthening have been proposed:
  - •Coherency strains between the ordered domains and the disordered matrix[7]
  - •Hindrance of dislocation movements (single or paired) depending on the state of order[8,9]

Experimental procedures

Homogenisation

Isochronal/Isothermal heat treatments

Microhardness tests

Transmission electron microscopy (TEM)

Conclusions

Increase in hardness associated with ordering

Hardening mechanism is hindrance of single dislocation movement by finely dispersed ordered regions

References

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Results

Hardness

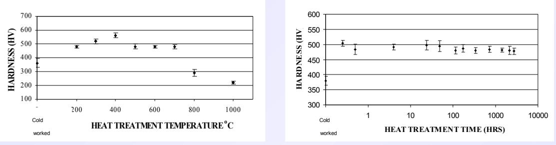

Fig.1: Isochronal (3hrs) and isothermal (400°C) heat treatment vs hardness graphs for Pt 11 at.% V alloy

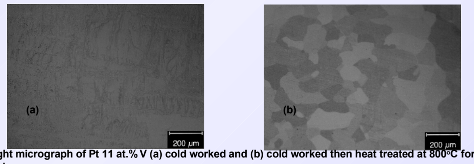

Fig.2: Light micrograph of Pt 11 at.% V (a) cold worked and (b) cold worked then heat treated at 800°C for 3 hours respectively

Transmission electron microscopy

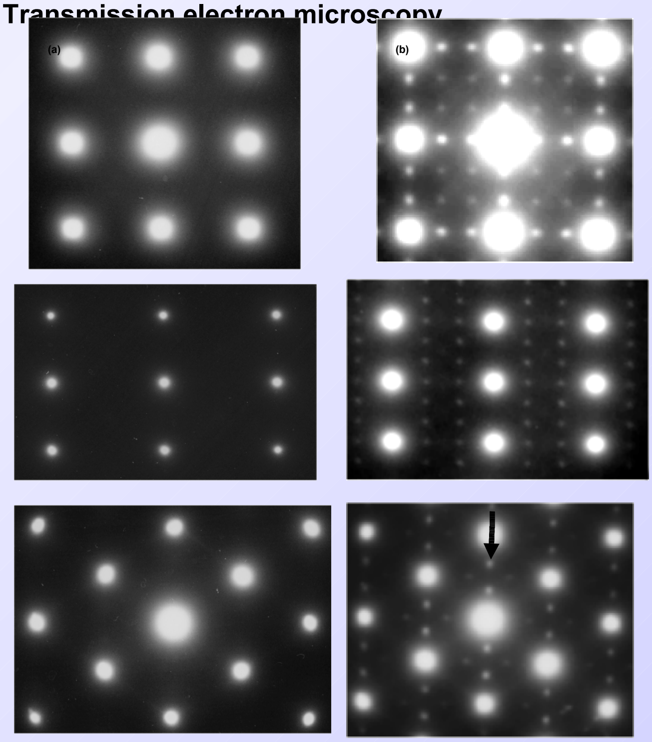

Fig.3: Electron diffraction pattern for Pt 11 at.% V viewed along $[100]_{fcc}$, $[112]_{fcc}$ and $[110]_{fcc}$ zone axes for (a) disordered and (b) ordered alloy respectively

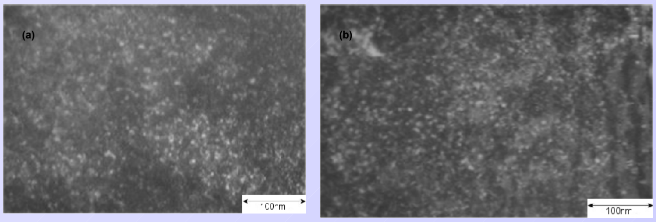

Fig.4: Dark field image of the (a) 0.25hrs and (b) 2736hrs heat treated specimen showing ordered regions due to two crystallographic orientations (shown by arrow)