

On the origin of the effect of yttrium based oxide nano-precipitate on the properties of Oxide dispersion strengthened (ODS) steels.

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Oxide dispersion strengthened (ODS) steels have been strenuously developed as a promising structural material for next generation nuclear energy systems because of their excellent resistance to irradiation damage and high temperature creep (reducing the creep rates by six orders of magnitude at 600-900 °C) as well as extraordinary structural and chemical stability in extremely harsh environments (extremely high stability at high temperature as high as 1,400 °C (this is approximately 0.91  $T_m$  where  $T_m$  is the melting point of the steel) and in an intense neutron irradiation fields). Small Y- or Y-Ti oxide nano-precipitates that are uniformly dispersed in the steel matrix with very high number density are responsible for these extraordinary effects. This unusual stability of the oxide clusters, according to Hirata and co-workers [1], cannot be readily explained by thermodynamics and traditional material theory. The purpose of this work is to investigate the origin of such effects. Because most of the elements involved in these oxide nano-precipitates are transition metals with multiple oxidation states, it will be assumed that these nano-precipitate forms mixed valence compounds [2]. It is known that mixed valence compounds act as a source or sink for electrons during exposure to extremely harsh environment (induce inter valence charge transfer). Thus it is proposed that the mixed valence theory may be the origin of this extraordinary protective effects of the ODS steels.

[1] A. Hirata et al., Nature materials, 23 October, 1-5, (2011)

[2] P. Day, N.S. Hush and J.H.C. Robin, Phil. Trans. R. Soc., 366, 5, (2008)