

**PRELIMINARY OBSERVATIONS OF
SECOND PHASE PARTICLES IN ZIRCALOY-4**

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Zirconium is a nuclear material mainly due its relative transparency to thermal neutrons, good mechanical properties and excellent corrosion resistance. At room temperature it has a hexagonal close-packed (hcp) structure and undergoes an allotropic transformation at 865° C, from hcp phase (α) to body centered cubic phase. (β).

Zircaloy-4 is an important zirconium alloy used as cladding and structural material in PWR reactors. Tin, iron and chromium are the main alloying elements and although the total concentration is less than two percent in weight, they are responsible for improvement of some of the material properties, mainly its corrosion resistance.

The aim of this work is to relate preliminary investigations of the precipitation of second phase particles that happens during thermal- and thermo-mechanical treatments. The observations of morphology, distribution and localization are done by transmission electron microscopy (TEM) in order to characterize these precipitates.

The as-received zircaloy-4 samples (hot-extruded rod) were submitted to different thermal and thermo-mechanical treatments: TT1 (1000°C / 1h + Water Quenched), TT2 (TT1 + 750°C / 8h+W.Q.) and TT3 (TT1 + 40% Cold Rolling + 750°C / 3h +W.Q.).

TEM micrographs (Fig.1a AR, M=5300x; Fig.1b TT2, M=16800x; Fig.1c TT3, M=13400x), show some of these particles. In the literature (1-2) they are classified in three types. Type 1 particles have spherical form with size between 0.1 – 0.4 μm . Some of these show bend contours and appear as single crystal. Generally the type 2 particles occurs at grain boundaries, have larger ovoid form with 0.4 – 0.6 μm size and exhibited structure with twins and stacking faults. The largest ovoid particles with medium size 1 μm are type 3, sometimes are slightly angular. Clusters with two or tree different types of particles are also observed.

(1) Chemelle, P. et al; Journal of Nuclear Materials v.113, p.58 (1981)

(2) Crépin, J. et al; Journal of Materials Science v.32 p.4841 (1997)

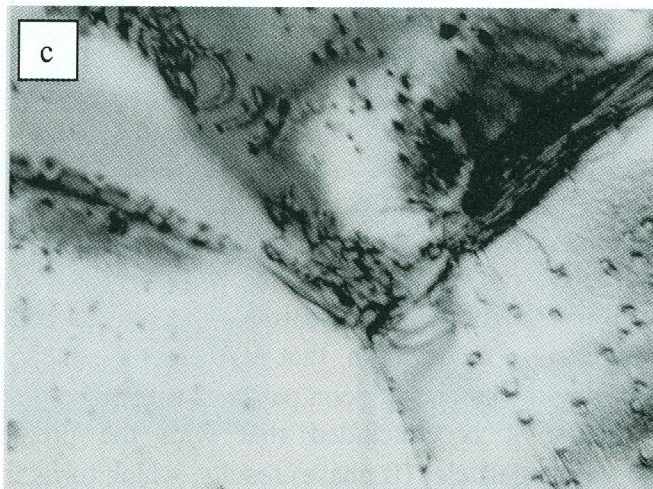
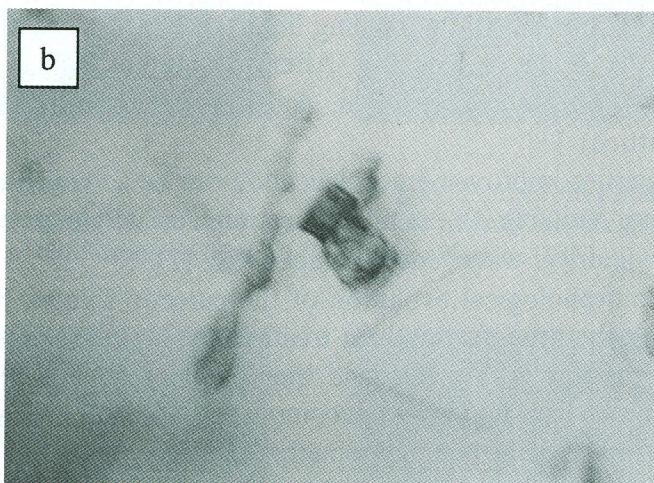


Figure 1. Precipitation particles in Zircaloy-4 (a) As received material $M=5300x$; (b) TT2 material (1000 C/1 h + WQ + 750 C/8 h + WQ) $M=16800x$; (c) TT3 material (1000 C/1h + WQ + 40% cold rolling + 750 C/3h + WQ) $M=13400x$