

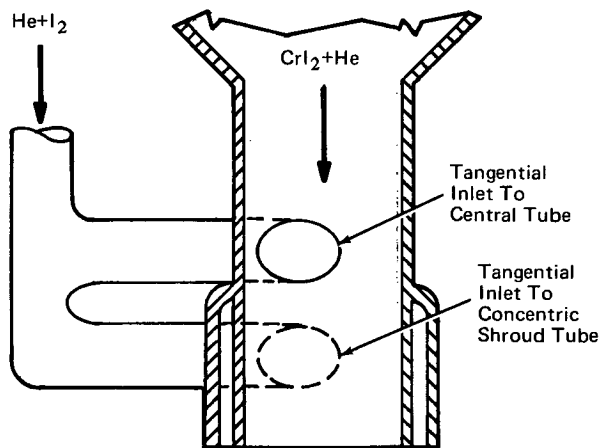
# NASA TECH BRIEF

## Lewis Research Center



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### Dispersion-Strengthened Chromium Alloy



Nozzle Design Used To Inject the  $CrI_2$ -Helium Mixture Into The Hydrogen-Filled Reaction Zone

#### The problem:

To develop a dispersion-strengthened chromium alloy that has high strength and oxidation resistance at elevated temperatures, but also has improved ductility at low temperatures.

#### The solution:

Consolidation of a finely divided powder mixture produced by the chemical vapor deposition of chromium on small  $ThO_2$  particles.

#### How it's done:

Chromous iodide vapor is reduced with hydrogen to give a finely divided chromium powder. Entrainment of finely divided  $ThO_2$  in the hydrogen yields an intimate mixture of chromium and thoria which is amenable to consolidation as a dispersion-strengthened body. Chromous iodide vapor ( $CrI_2$ ), about 2.5 mole percent in a helium carrier gas, is fed downward into a tubular reaction chamber at  $1000^\circ C$  where it meets a counter-current of hydrogen gas. The gases react as  $CrI_2(g) + H_2(g) = Cr(s) + 2HI(g)$  to produce a finely divided high-

purity chromium powder ( $0.1 \mu$  to  $0.4 \mu$ ). When finely divided  $ThO_2$  is entrained in the hydrogen (in amounts approximately 2-5 volume percent of the chromium), a product is obtained in which the chromium and thoria are intimately associated and which can be hot pressed or pressure bonded to give a chromium body with a fine dispersion of  $ThO_2$ .

Tensile tests showed that the  $ThO_2$  particles lowered the ductile-to-brittle transition temperature (DBTT) below that of pure chromium. This was evident both in the as-rolled condition and after the materials had been annealed for one hour at  $1200^\circ C$ . The DBTT values were:

Material	As-Rolled	Annealed
Pure Chromium	$140^\circ C$	$140^\circ C$
Cr- $ThO_2$ Alloy	$15^\circ C$	$50^\circ C$

Both the thermal dissociation of the chromous iodide and the hydrogen reduction reactions (which occur at about  $1000^\circ C$ ) must be taken into account in the design of a nozzle to inject a  $CrI_2$ -He gaseous mixture into a hydrogen-filled chamber. In a successful nozzle design (see the figure), the  $CrI_2$ -He was forced through a centrally located tube at high gas velocities (up to 110 m/sec), while a helium-0.25 mole % iodine shroud gas was injected tangentially through both the centrally located tubular nozzle and the concentric outer shroud tube. The iodine was added to the helium to prevent the thermal decomposition of  $CrI_2$  by dilution with the shroud gas. The design permitted use of sufficiently high gas-flow rates through the nozzle to prevent the back diffusion of hydrogen that could cause reduction of  $CrI_2$  to metal at the nozzle opening (causing the formation of a chromium plug) without adversely affecting the subsequent mixing of the reactants in the hydrogen-filled reaction chamber.

(continued overleaf)

**Notes:**

1. Success in the preparation of chromium powder by this technique suggests that it can be extended to the preparation of other powdered metals, e.g., iron, nickel, cobalt, niobium, tantalum, tungsten, and molybdenum. A number of possible gas-phase reactions can be suggested for each of these metals.
2. The design of the nozzle for injection of CrI<sub>2</sub>-He mixtures into hydrogen should be applicable to other metal-halide reduction processes. The tangential injection of gas within the nozzle enhances mixing of the gaseous reactants.
3. The following documentation may be obtained from:  
National Technical Information Service  
Springfield, Virginia 22151

Reference: NASA CR-72404 (N68-34022),  
Chemical Vapor Deposition of Chromium on  
ThO<sub>2</sub>  
Single document price \$6.00  
(or microfiche \$0.95)

Reference: NASA CR-72901 (N71-35580),  
Development of a Chromium-Thoria Alloy  
Single document price \$3.00  
(or microfiche \$0.95)

4. Technical questions may be directed to:  
Technology Utilization Officer  
Lewis Research Center  
21000 Brookpark Road  
Cleveland, Ohio 44135  
Reference: B72-10378

**Patent status:**

No patent action is contemplated by NASA.

Source: Neil D. Veigel and J. M. Blocker, Jr. of  
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