Communications

The Use of Alkali Metals for Transmission of Hydrostatic Pressure

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HIGH-pressure experiments that use gases or liquids as pressure-transmitting media generally are limited to about 10 to 15 kbar because of the difficulty in maintaining seals or gaskets at higher pressures. Systems that utilize solid pressure-transmitting media (boron nitride, talc, pyrophyllite) are used to obtain higher pressures and elevated temperatures; however, such systems impart nonhydrostatic components of pressure to the specimens.[1,2]

The purpose of this communication is to describe a technique that combines several desirable properties of the liquid and solid systems, *i.e.*, the truly hydrostatic pressures of a liquid pressure-transmitting medium and ease of containment and elevated-temperature capabilities of a solid medium. This is accomplished by surrounding the specimen with an annulus of an alkali metal inside a tantalum capsule. This idea was suggested originally by Fischer.[3] The alkali metals (lithium, sodium, potassium) are used because of their softness in the solid state, low melting temperatures, and low solubilities in other metals. In essence, the technique utilizes a molten pressure-transmitting medium next to the sample material.

A typical specimen cell assembly is shown in Fig. 1.

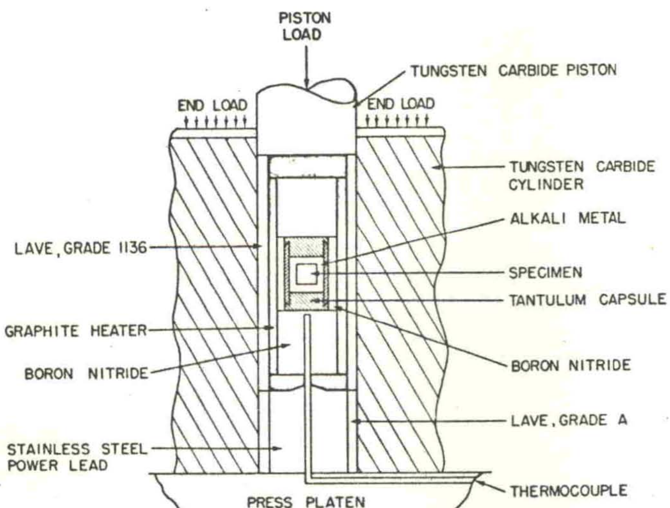

Fig. 1—Specimen cell assembly.

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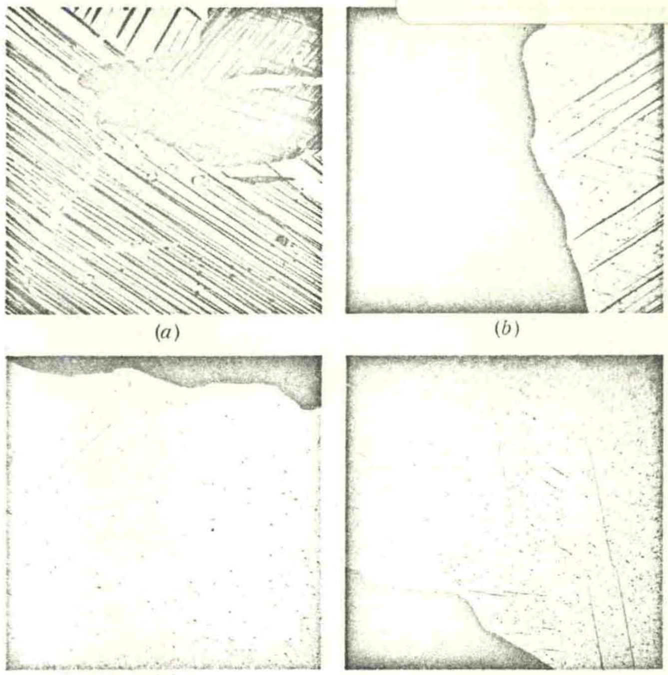

Fig. 2—Microstructures of uranium samples after high pressure and temperature treatments in boron nitride and the alkali metals. All specimens were pressurized to 40 kbar, heated to 900°C and cooled through the γ to α transformations to room temperature, and depressurized. (*a*) Boron nitride; (*b*) lithium; (*c*) sodium; (*d*) potassium. Polarized light, X50. Reduced approximately 17 pct for reproduction.

Pressures up to 45 kbar were generated in a single-stage, piston-cylinder apparatus. Details of similar apparatus and general experimental techniques have been published by Kennedy and Newton.[4] Because of the reactive nature of the alkali metals, all experimental procedures were accomplished in a glovebox with an argon atmosphere. Uranium samples were used, because small shear stresses cause them to deform readily by twinning.[5] The number and shape of the twins were used as a measure of deformation, thus indicating the existence of nonhydrostatic pressures. To eliminate deformation during removal of the samples, alcohol was used to dissolve the alkali metal surrounding the specimen.

Fig. 2 shows the microstructures of uranium specimens cooled from 900°C at 40 kbar. When solid boron nitride was used as a pressure-transmitting medium, Fig. 2(*a*), the samples displayed evidence of appreciable plastic deformation by twinning, verifying the fact that nonhydrostatic pressures were applied to the sample. The specimens shown in Figs. 2(*b*), 2(*c*), and 2(*d*) were surrounded by lithium, sodium, and potassium, respectively, and they show that the amounts of plastic deformation were reduced greatly by treating the samples in liquid alkali metals at high pressure and temperature. The deformations shown in Figs. 2(*b*), 2(*c*), and 2(*d*) probably resulted from interactions at grain boundaries due to the anisotropy of thermal expansion and/or linear compressibility of α uranium.[6,7] When the amount of grain boundary material was minimized, these deformations were minimized also.

[1] H. M. Strong: *Modern Very High Pressure Techniques*, p. 93, Butterworths Inc., Washington D.C., 1962.