

Crystal structures of actinide elements at high pressures

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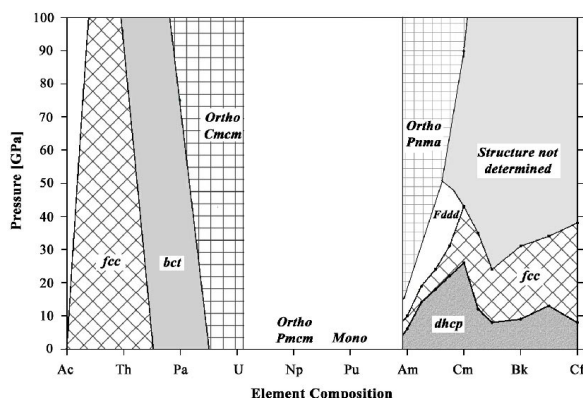
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This review relates to recent high pressure x-ray diffraction studies of the actinide elements Pa [1], U [2] and Am [3,4] up to pressures of 100 GPa (1 Mbar), as well as to studies on Cm and Cf, which are still in progress.

Synchrotron radiation and other experimental advances were used to obtain data of high quality and resolution to resolve the high pressure crystal structures. These investigations contribute to a better understanding of the nature of the 5f electrons, which show pronounced differences compared to the 4f electrons of the lanthanides with regard to their bonding properties. While the spatial extension of the 4f wave functions around the nucleus is small, the 5f wave functions of the actinides are more extended [5]. This favors direct interactions of the 5f electrons with conduction electrons and indirect interactions with 5f electrons of neighboring atoms. In some of the actinide elements such interactions exist already at ambient pressure (in the elements from Protactinium to Plutonium), in other actinide elements such interactions can be induced by reducing the crystal volume, i.e. by applying pressure. This ‘delocalizing’ of the 5f electrons leads to crystal structures with higher density, smaller compressibility and also with lower symmetry. Americium, for instance, displays (in contrast to its neighbor Plutonium) a localized 5f electron character at ambient pressure, but under pressure crystal structures with symmetries typical for delocalized 5f electrons are formed [1,2].

The figure shows a schematic overview of the different structures of the actinide metals as a function of pressure to 100 GPa, deduced from earlier work [6] and from data of our recent experiments.



References

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