

Experimental Report

Proposal Code: MA-4318

Synthesis and investigation of novel thorium and lanthanum polyhydrides: $Fm\bar{3}m$ -ThH₁₀ and $P\bar{6}m2$ -LaH₁₆

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Aims:

It was proposed to investigate synthetic paths and crystal structure of thorium and lanthanum polyhydrides (mainly, $Fm\bar{3}m$ -ThH₁₀ and $P\bar{6}m2$ -LaH₁₆) which can be obtained by direct synthesis from metal and hydrogen in DAC with laser heating. Our calculations for ThH₁₀ and LaH₁₆ indicated the possibility of existence of high-temperature superconductivity in these phases with $T_C > 220$ K.

Experimental results:

Four DACs were used for the synthesis of thorium and lanthanum hydrides at pressures from 80 to 205 GPa. The DAC, loaded by La and intended for synthesis of LaH₁₆ at 250 GPa, crashed above 205 GPa during the increase of pressure using a pneumatic piston. However, the equation of state for metallic lanthanum was obtained.

The remaining three DACs were used for the synthesis of thorium hydrides using laser heating (YAG laser $\lambda = 1 \mu\text{m}$, power up to 100 W) implemented at the station ID27. As a result, novel polyhydrides were obtained: $I4/mmm$ -ThH₄, $P\bar{6}_3mc$ -ThH₉ (like CeH₉ found in) and $Fm\bar{3}m$ -ThH₁₀ (see Figures). The limits of stability of these phases and their equation of state were experimentally investigated. The values found are in good agreement with the results of theoretical predictions.

A side product of the experiment is the synthesis of various tantalum hydrides (probably TaH, TaH₃, TaH₆) formed by accidental heating of Au/Ta electrodes in one of the cells. At the moment, the structures of the obtained tantalum hydrides are being established.

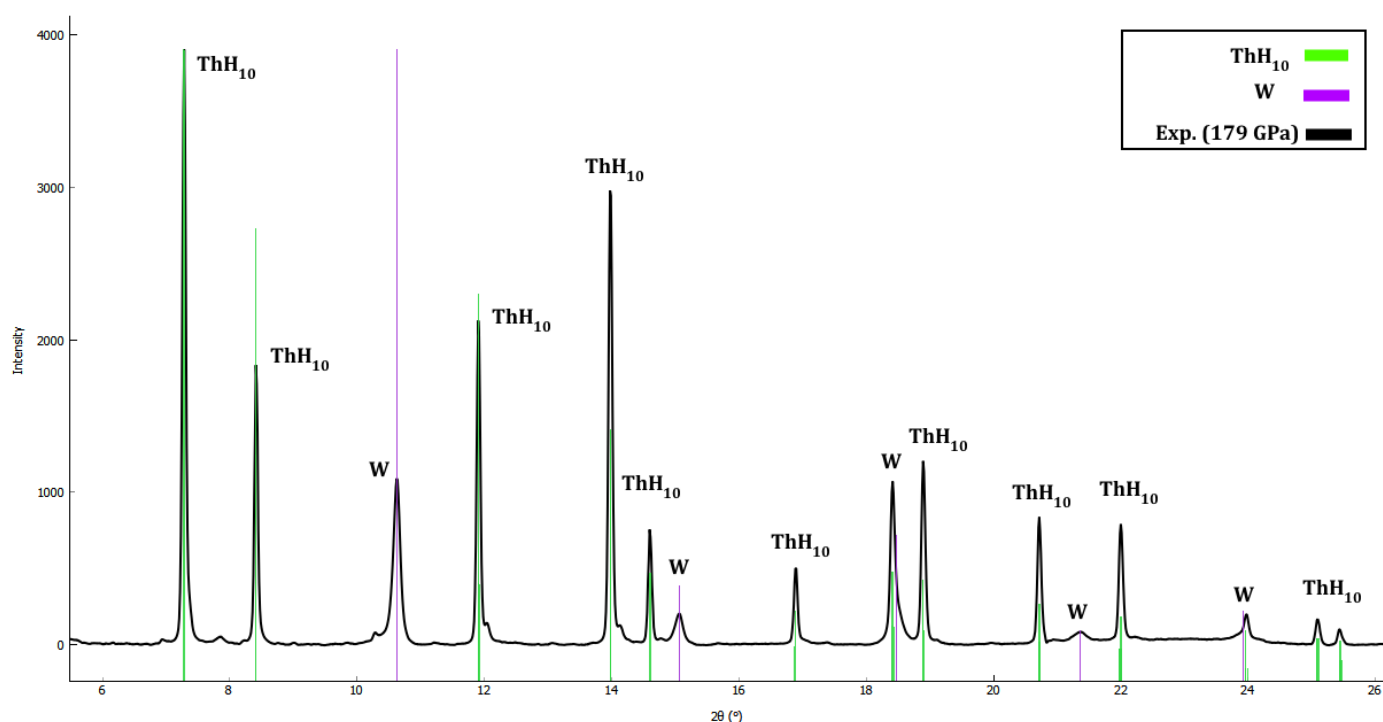


Figure 1. Experimental diffraction pattern and overlay of the predicted phase ($Fm\bar{3}m$ -ThH₁₀) at 179 GPa.

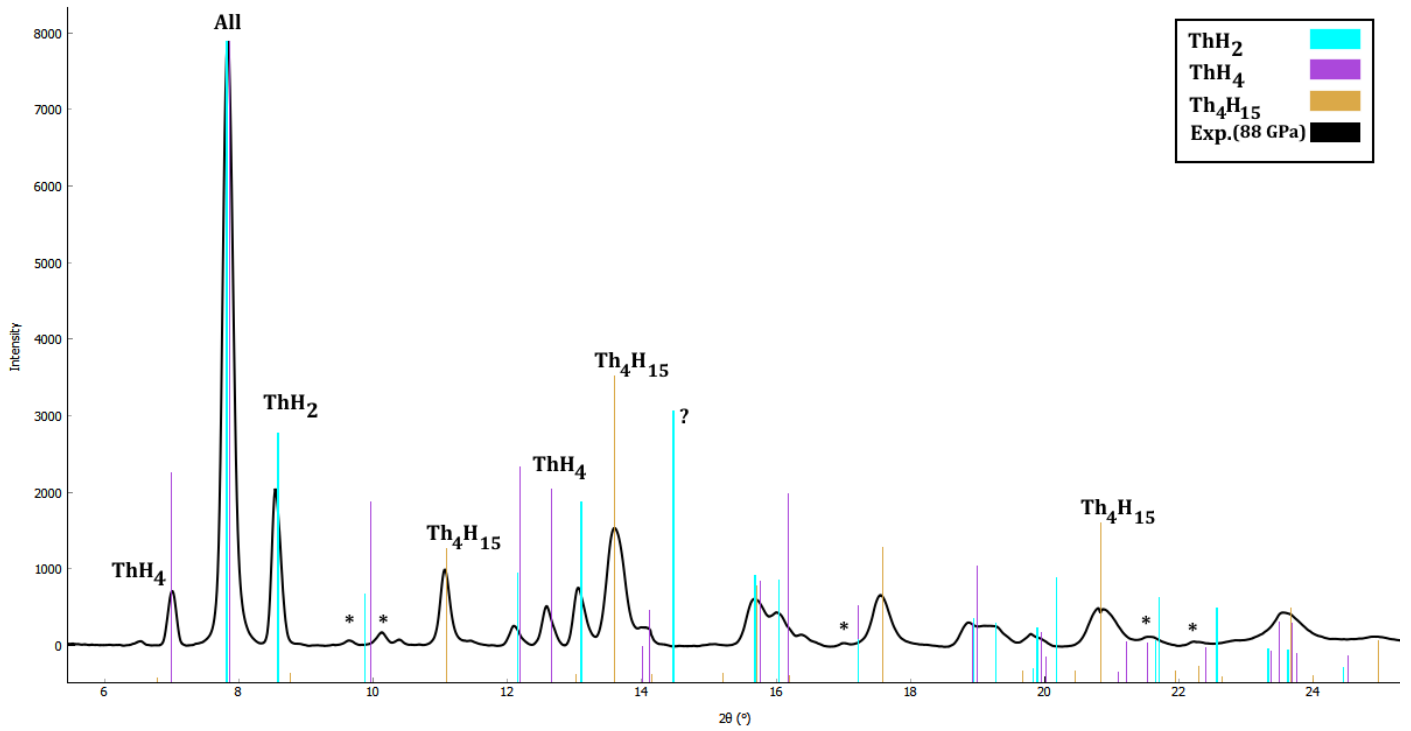


Figure 2. Experimental diffraction pattern and overlay of the predicted phases ($I4/mmm$ -ThH₄, $I\bar{4}3d$ - Th₄H₁₅, $I4/mmm$ -ThH₂) at 88 GPa. Asterisks (*) indicate reflexes that need a small refinement. One of the ThH₂ reflections is absent on the spectrum (?).

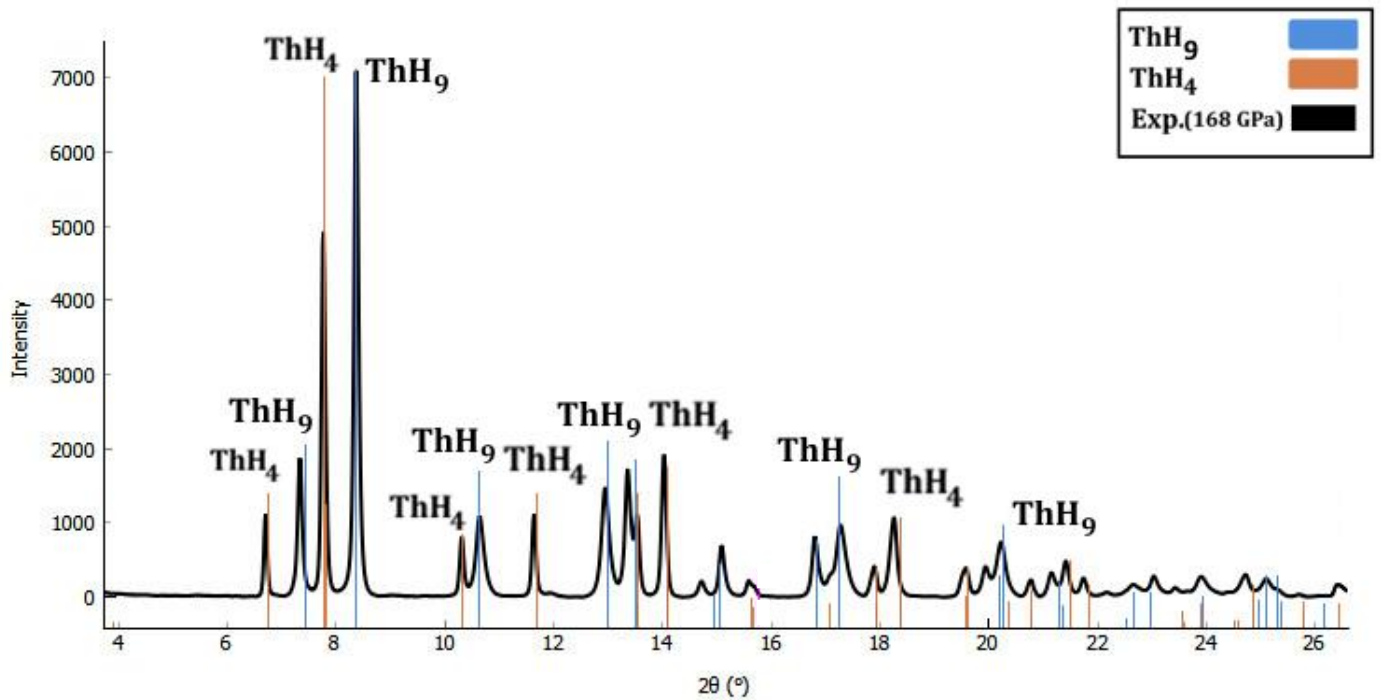


Figure 3. Experimental diffraction pattern and overlay of the predicted phases ($I4/mmm$ -ThH₄, $P6_3mc$ - ThH₉) at 168 GPa before refinement.