Ultrastable Metal Polyhydrides Below 60 GPa

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Abstract

Application of external pressure to a system serves as an additional degree of freedom, expanding our knowledge about stable chemical compounds and chemical reaction pathways under extreme conditions. High-pressure techniques, using diamond anvil cells to reach millions of atmospheres, have revolutionized hydrogen chemistry. For decades, conventional hydrides like LiH, NaH, CaH_2, H_2S or CH_4 were thought to represent the limits of hydrogen content. But this does not exhaust the chemistry of hydrides.

In my talk, I will review a decade of experimental research showing that under pressure near 1 Mbar, elements form extraordinary polyhydrides—such as CsH_7 [1], RbH_9 [1], YH_6 [2], CeH_{10} [3], BaH_{12} [4], and even La(Sc)H_{12} [5,6]—with far more hydrogen atoms per metal atom than previously imagined. I will show the latest results of attempts to reproduce room temperature superconductivity in the La-Sc-H system, and the recent achievement of T_c around 174 K below 100 GPa in the Th-H system. Moreover, by introducing Th into the La-H system, an even higher T_c of up to 230 K can be achieved at the same pressure of about 100 GPa.

I will pay special attention to Th-containing Ce-Th-H ternary polyhydrides (XH_{10}, XH_7, cF80-XH_{6+x}, A15 X_4H_{23}), which exhibit extraordinary stability down to 12 GPa and can be synthesized and characterized without damaging diamond anvils below 65 GPa. The recent trend of decreasing stabilization pressures for hydrogen-rich materials and superconductors [7] opens a realistic pathway toward their application, promising a transformative leap in hydrogen storage technology.

References

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