	Experiment title: High-pressure high-temperature synthesis of novel transition metal nitrides	**Experiment number**: MA-4309
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M. Bykov, S. Chariton, H. Fei, T. Fedotenko, G. Aprilis, A.V. Ponomareva, F. Tasnádi, I.A. Abrikosov, B. Merle, P. Feldner, S. Vogel, W. Schnick, V.B. Prakapenka, E. Greenberg, M. Hanfland, A. Pakhomova, H.-P. Liermann, T. Katsura, N. Dubrovinskaia, L. Dubrovinsky. High-pressure synthesis of ultraincompressible hard rhenium nitride pernitride $Re_2(N_2)(N)_2$ stable at ambient conditions . Nature Communications 10, 2994 (2019)

Abstract:

High-pressure synthesis in diamond anvil cells can yield unique compounds with advanced properties, but often they are either unrecoverable at ambient conditions or produced in quantity insufficient for properties characterization. Here we report the synthesis of metallic, ultraincompressible ($K_0 = 428(10)$ GPa), and very hard (nanoindentation hardness 36.7(8) GPa) rhenium nitride pernitride $Re_2(N_2)(N)_2$. Unlike known transition metals pernitrides $Re_2(N_2)(N)_2$ contains both pernitride N_2^{4-} and discrete N^{3-} anions, which explains its exceptional properties. $Re_2(N_2)(N)_2$ can be obtained via a reaction between rhenium and nitrogen in a diamond anvil cell at pressures from 40 to 90 GPa and is recoverable at ambient conditions. We develop a route to scale up its synthesis through a reaction between rhenium and ammonium azide, NH_4N_3, in

a large-volume press at 33 GPa. Although metallic bonding is typically seen incompatible with intrinsic hardness, $Re_2(N_2)(N)_2$ turned to be at a threshold for superhard materials.