New oxide group-9 transition metal superconductors in the filled-Ti_2Ni type structure

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The Ti_2Ni and the related eta-carbide-type structures are known to exhibit various interesting physical properties. The Ti_2Ni structure is surprisingly complex for an intermetallic structure-type crystallizing in the space group Fd-3m with a unit cell containing of 96 metal atoms [1, 2]. The related eta-carbide-type compounds of the general formula A_4B_2X or A_3B_3X correspond to filled version of the Ti_2Ni structure [2]. The role of the void filling light atom X, which can be carbon, oxygen, or nitrogen, has so far been unclear for the overall physical properties of these materials. Herein, we have successfully synthesized single crystals of Ti_2Co with the Ti_2Ni-type structure and singe crystals of eta-carbide-type oxide Ti_4Co_2O. We show that while Ti_2Co is a semiconductor, while its filled-version Ti_4Co_2O is a bulk superconductor with a critical temperature of 2.7 K. We find that the interstitial oxygen plays an crucial role for the overall physical properties. By extending this concept to the other group 9 transition metals, we have successfully synthesized the two new compounds Ti_4Rh_2O and Ti_4Ir_2O. We, furthermore, show that both are new bulk type-II superconductors with superconducting transitions at 2.8 K and 5.3 K, respectively. We present detailed measurements on all three superconductors, showing that all three have remarkably high upper critical field in comparison with their critical temperature. Most noteworthy Ti_4Ir_2O has an upper critical field of 16.06 T, which is exceeding by far the weak-coupling BCS Pauli paramagnetic limit of 9.86 T.

[1] Mackay, Richard, Gordon J. Miller, and Hugo F. Franzen, "New oxides of the filled-Ti_2Ni type structure", Journal of alloys and compounds 204.1-2 (1994): 109-118.

[2] Ma, KeYuan, Jorge Lago, and Fabian O. von Rohr, "Superconductivity in the eta-carbide-type oxides $Zr_4Rh_2O_x$", Journal of Alloys and Compounds 796 (2019): 287-292.