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# Thermoelectric and magnetic properties of double filled $Ce_{1-y}Yb_y(Fe, Co, Ni)_4Sb_{12}$ series

C. Godart, [1], D. Bérardan, [1], E. Alleno[1], M. Puyet, [2], B. Lenoir, [2], H. Scherrer[2], E. Bauer[3], R. Lackner[3], L. Girard, [4], D. Ravot[4], P. Rogl[5]

[1] *CNRS, LCMTR, UPR209, 94320 Thiais, France*
[2] *ENSMN, LPM, UMR7556, 54042 Nancy, France*
[3] *Univ. Tech., Inst. Solid State Phys., A1040- Vienna, Austria*
[4] *Univ. LPCMC, UMR5617, 34095 Montpellier, France*
[5] *Univ. , Inst. f. Phys. Chem.., A1090- Vienna, Austria*

We report on transport, thermal and magnetic properties of $Ce_{y/2}Yb_{y/2}Fe_{4-x}$(Ni, Co)$_x$Sb$_{12}$ series, as well as their potential for thermoelectric power generation. $L_{III}$ absorption edges evidence a trivalent state for the Ce ion and a mixed valence state for the Yb ion, independent of temperature. The valence of Yb decreases when the Yb content increases. All samples in the series $Ce_{1-y}Yb_yFe_4Sb_{12}$ are paramagnetic, and the susceptibility curves are well described by a Curie-Weiss law above 150K. $\theta_p$ decreases linearly with increasing cerium fraction from +55K in $Yb_{0.92}Fe_4Sb_{12}$ to -85K in $Ce_{0.85}Fe_4Sb_{12}$. The effective paramagnetic moment has been separated into three contributions corresponding to the subsystems Yb, Ce and [$Fe_4Sb_{12}$]. We show that the contribution of the [$Fe_4Sb_{12}$] subsystem is constant and equal to $3.2\mu_B$ for the whole series, independently of the valence of the electropositive element. Consequently, the ionic model is not appropriate to describe the magnetic properties of the filled skutterudite $RFe_4Sb_{12}$, and the delocalised nature of the charge carriers must be taken into account. The power factor and the dimensionless figure of merit are significantly improved in double filled skutterudites as compared to single filled ones.

*Keywords :* skutterudites, transport properties, thermoelectricity, paramagnetism