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CRYSTALLOGRAPHIC AND MAGNETIC PROPERTIES OF $REInAu_2$ INTERMETALLICS

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Structural, thermal and magnetic studies are reported for the $REInAu_2$ series (except Eu). Compounds with La, Ce, Pr and Nd show a phase transition from cubic to tetragonal structure. All compounds have a normal valence state magnetic behaviour, except $YbInAu_2$ which is confirmed to be IV with a ground state with $2J+1 = 8$, and $CeInAu_2$ which despite being magnetic has a strongly enhanced electron specific heat.

Ternary $REMAu_2$ intermetallics (RE = Sc, La, Y; M = Al, Ga, In) with CsCl structure were first described by Matthias et al. [1]. Among these, $YbInAu_2$ was recognised as an IV compound [2]. Recently, Galera et al. [3] investigated the structural and magnetic properties of the $REInAg_2$ series and showed that these compounds crystallise with a cubic Heusler-type structure $L2_1$. We report here about the $REInAu_2$ series with a deeper insight into Ce and Yb compounds.

From X-ray and neutron diffraction, all compounds from Ce to Lu were found to have at room temperature the cubic CsCl (B2) structure. In addition, depending on the sample, some superstructure lines indicative of Heusler-type ordering are present. Thus, in analogy to the $REInAg_2$ series, we think that this kind of order may exist for the whole series. The obtained lattice parameters (indexed on the basis of a cubic cell twice that of the CsCl cell) are given in table I. Except for Yb, the lattice constants show the usual linear correlation with the ionic radii. $LaInAu_2$ has at room temperature a tetragonal structure (table II). X-ray and resistivity studies show that the compounds with La, Ce, Pr and Nd undergo a structural transition from cubic to tetragonal on lowering the temperature (fig. 1). Transformation temperatures T_M and lattice parameters for some temperatures are given in table II. One observes a rapid decrease in T_M and in the magnitude of the resistivity anomaly when going from La to Nd, and also, as $YInAu_2$ retains the cubic structure at low temperature, in the Y-diluted $CeInAu_2$ series (e.g. from 210 K for $CeInAu_2$ to 110 K for $Ce_{0.75}Y_{0.25}InAu_2$). Further, neutron diffraction patterns, taken at low temperature for $CeInAu_2$, reveal additional superstructure lines such as the (001) line.

These transformations appear analogous to the martensitic transformations reported to occur in numerous CsCl-type compounds like for example $LaAg_{1-x}In_x$ [4] or RECd [5]. This structural instability seems to be strongly correlated to the size of the RE as the transition temperatures T_M show an almost regular increase with increasing ionic RE radii. The observed transformations occur without significant volume changes. Unlike the resistivity, where anomalies ranging between 15 and 45% are observed, the phase transition has no observable effect on the magnetic susceptibility.

The $REInAu_2$ compounds are characterised by rather small ordering temperatures (table I). At high temperature all samples excluding La, Lu, Y, Yb and Sm exhibit Curie–Weiss behaviour with effective moments close to that of the free tripositive ions, whereas, especially for the light RE, crystal field effects affect the

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Table I
Lattice parameter a(Å) of the cubic phase at 300 K, effective magnetic moments $\mu_{eff}(\mu_B)$, Weiss parameter Θ_p(K), magnetisation $M(\mu_B)$ at 1.5 K: + 7.5 T, ∘ 15 T, * 3 T.

RE	a	μ_{eff}	Θ_p	Θ_N	M_s
Ce	7.090	2.57	−10		1.05 ∘
Pr	7.055	3.55	−5	<1.5	1.03 +
Nd	7.030	3.70	−8	<1.5	1.78 +
Sm	6.973				0.03 *
Gd	6.940	8.0	−14	11.5	6.8 ∘
Tb	6.913	9.7	−7	8.2	7.4 ∘
Dy	6.885	10.8	−5	6.0	7.8 +
Ho	6.870	10.8	−5	2.6	7.8 +
Er	6.864	9.63	−4	<1.5	6.7 ∘
Tm	6.847	7.06	−35	<1.5	4.5 +
Yb	6.856	no C.W. behaviour $\chi_0 = 4.85 \times 10^{-3}$ cm³/Yb at.			
Lu	6.822				
Y	6.893	$\chi_{300\,K} = 1.5 \times 10^{-4}$ cm³/Y at.			

Table II
Crystallographic transition temperature T_M, lattice constants a and c of the tetragonal phase at some temperatures for $REInAu_2$ (RE = La, Ce, Pr, Nd).

RE	T_M(K)	a(Å)	c(Å)	T(K)
La	355 ± 5	7.048	7.318	300
Ce	210 ± 5	6.988	7.238	152
		6.946	7.197	38
Pr	150 ± 10	6.993	7.184	80
Nd	70 ± 20*	6.902	7.060	20

* Strongly dependent on state and treatment of the sample.

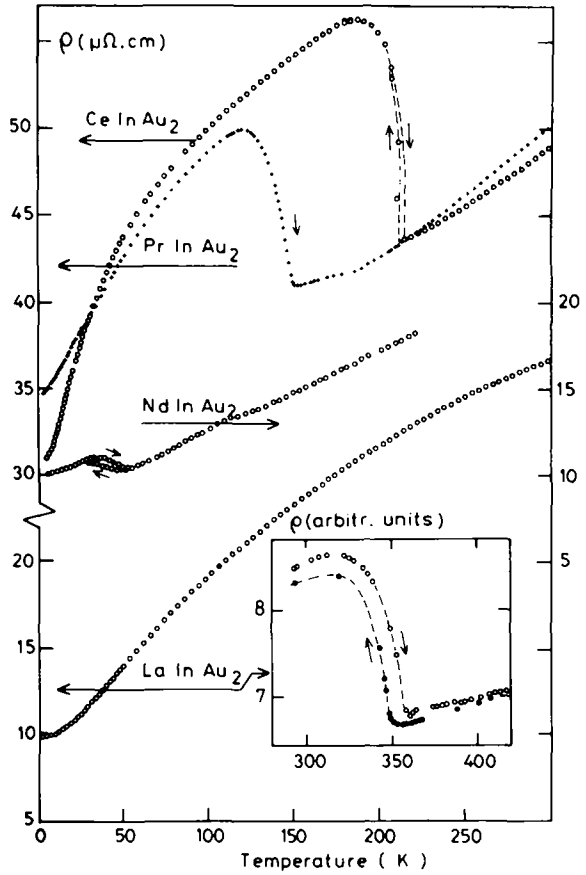

Fig. 1. Resistivity versus temperature for light rare earth $REInAu_2$ compounds.

low temperature susceptibility. Excepting $GdInAu_2$ the magnetic moments (at 1.5 K and in fields up to 15 T) are also reduced compared to the free ion gJ values, mostly at both ends of the series (table I). For $YbInAu_2$ our results ($\chi_0 = 4.85 \times 10^{-3}$ cm³/mol, $T_{max} \approx 80$ K) agree with previous determinations [2]. Relatively large values of ≈20 and 10 $\mu\Omega \times$ cm are found for the magnetic contribution ρ_m to the resistivity in the Yb and Ce compounds.

The heat capacity studies concern the La, Y, Ce and Yb compounds. The electronic contribution γ is ≈2 mJ/K²mol for $LaInAu_2$ and $YInAu_2$. For the IV alloy $YbInAu_2$, it reaches 40 mJ/K²mol what leads for the R ratio, $R = (\pi^2 k_B^2/\mu_{eff}^2)(\chi_0/\gamma)$, to a value of 1.28 close to the theoretical value of $R = 1 + 1/2J = 1.14$ for IV Yb compounds. For $CeInAu_2$ the specific heat shows a large anomaly at ≈1 K, which may reveal magnetic ordering; the entropy associated with this anomaly is $\sim 0.8R \ln 2$ in agreement with a doublet ground state. A large value of 130 mJ/K²mol is tentatively derived from the restricted linear part of the C/T (T^2) variation ($6 \leq T \leq 11$ K). For the dilute alloy $Ce_{0.1}Y_{0.9}InAu_2$, for which the magnetic anomaly

is rejected towards fairly lower temperatures, the electronic contribution is 12 mJ/K^{2}mol, appearing thus roughly proportional to the Ce concentration. Further the study of the magnetic dilution of Ce by Y in the substitution series $Ce_{1-x}Y_xInAu_2$ through high-field magnetisation and susceptibility measurements shows that in the concentration range investigated ($0 < x < 0.9$) the Ce moment remains unaffected, showing thus that Y dilution seems to have no or little influence on the valence state of cerium in this system. L_{III} X-ray absorption spectra on $CeInAu_2$ show the characteristic "white line" of integral valent atoms, what excludes the possibility for the enhanced γ and ρ_m values to be related to a mixed valence state. Thus the low temperature properties of $CeInAu_2$ are not yet fully understood. Further work is in progress.

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