Phase diagram of the La-Pr-system under pressure

A. Schiwek, F. Porsch and W.B. Holzapfel

Universität-GH Paderborn, FB6-Physik, 33095 Paderborn, Germany

Lanthanum and Praseodymium are considered to be „regular“ lanthanides, which undergo a common series of phase transitions under pressure. Both La and Pr have a hexagonal closed packed structure, dhcp (hP4) at ambient conditions and a closed-packed cubic face centred configuration, fcc (cF4) at higher temperatures and pressures. At about 7 GPa one observes for both elements an (almost) second order phase transition to the „distorted fcc“ structure [1], which is now considered to have rhomboedral structure (hR8). At about 60 GPa La transforms back to a (reentrant) fcc-structure, whereas Pr transforms at 22 GPa to an more open orthorhombic α-uranium configuration (oC4) [2].

The aim of this work concerns the structural behaviour of La-Pr-alloys under pressure. One further interesting feature is the formation of a Cerium-like metal (concerning the average number of f-electrons within the alloy) for comparison with real Ce, which shows a unique series of structures under pressure within the group of the lanthanide metals. These low symmetry structures include more open configurations like monoclinic and tetragonal lattices.

The La-Pr-alloys were prepared by melting of the pure component in an induction oven under argon atmosphere. Because both elements have the same structure there is a continuos series of homogeneous alloys. The alloy compositions were checked by weighing, determination of ambient lattice parameters and evaluation of the fluorescence line intensities.

Figure 1 shows typical energy dispersive x-ray diffraction (EDXD) spectra for different phases of the present alloy $La_{30}Pr_{70}$.

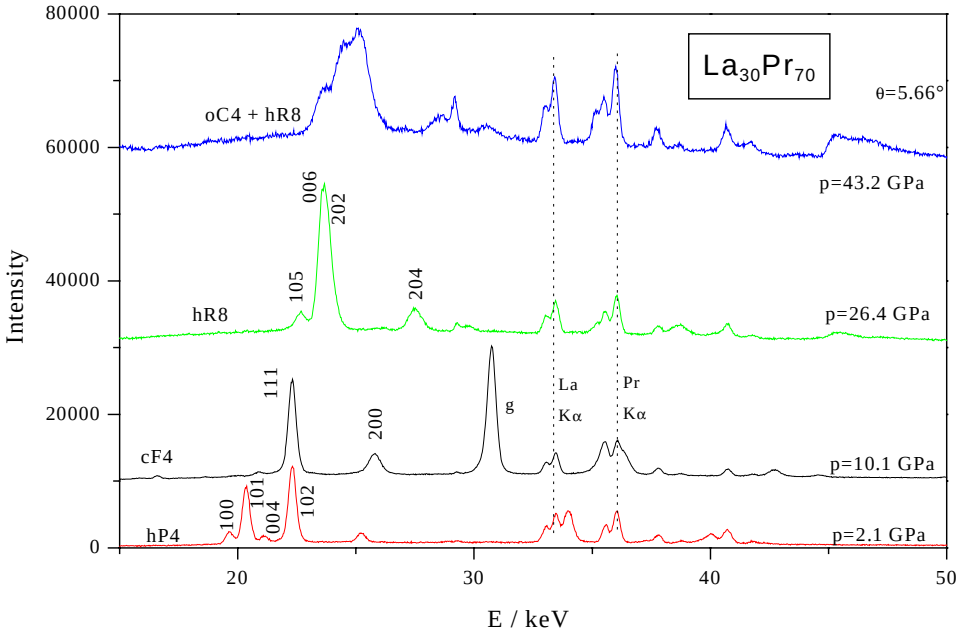

Figure 1: EXDX-Spectra for the different structures in $La_{30}Pr_{70}$ under pressure.
g denotes diffraction lines from the inconel gasket, K denotes fluorescence lines.

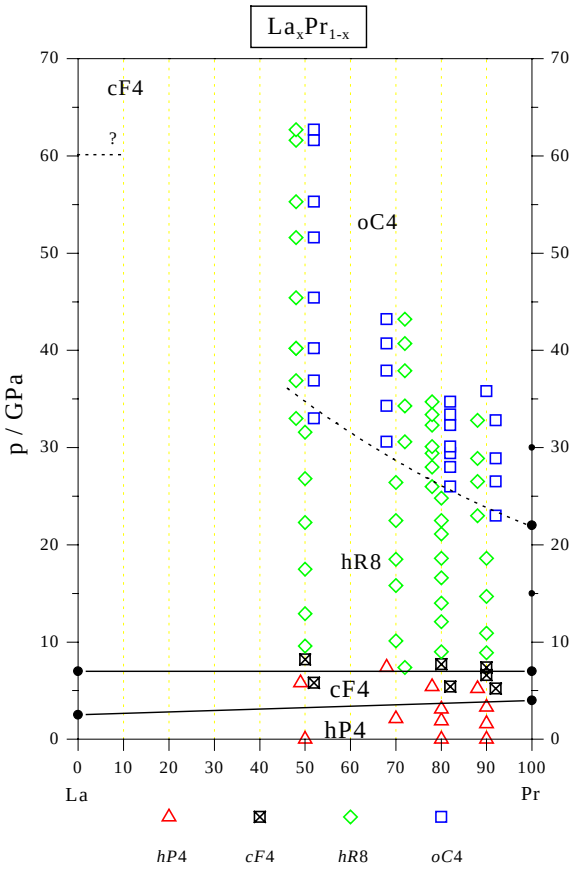

Figure 2: p-x-phase diagram for the $La_{1-x}Pr_x$-system from [3] with additional data points for 50 and 70% Pr from this study.

The homogenous behaviour of the La-Pr-alloy system is illustrated in Fig.2 by the existence of the hP4, cF4, hR8 sequence over the full composition range. I.e. the $La_{50}Pr_{50}$-alloy represents a „Pseudo-Cerium“ with the regular series of phase transitions of the lanthanide at low pressure, but still with the anomalous oC4 phase of Pr at higher pressures. However, with decreasing contents of Pr the transition hR8→oC4 is smeared out over a broad region in pressure. Even at the highest pressures attained a mixed phase state may still be present. This point needs some further studies.

Since La undergoes a reentrant phase transition to the cF4 structure [4-5] and Pr converts to oC4 a triple point cF4-hR8-oC4 is expected at high La concentrations and high pressure.

References

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