RAMAN SPECTROSCOPY OF THE LATTICE DYNAMICS AND CRYSTAL FIELD SPLITTING IN $CePt_5$ LAYERS ON Pt(111)

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Ultrathin layers of the binary intermetallic compound $CePt_5$ with thicknesses of few unit cells have found great interest in the field of Kondo physics, originating from the interaction of the localized Ce $4f^1$ electrons with the itinerant electrons [1]. Such $CePt_5$ layers are generated on Pt(111) surfaces in UHV by deposition of elemental Ce and subsequent annealing, resulting in a hexagonal crystalline $CePt_5$ structure, which consists of alternating $CePt_2$ and Pt atomic layers (the latter forming a kagome lattice), and is terminated at the surface by a dense hexagonal Pt layer [2,3]. In this crystal structure a splitting of the Ce 4f electron levels by the crystal electric fields of the neighboring Pt atoms is expected to enable transitions of the 4f electron in the meV range. These transitions should be observable in Raman spectroscopy. Furthermore, the $CePt_5$-layer should give rise to phononic Raman scattering from the lattice.

We report on the determination of the crystal-field-induced 4f level splitting in $CePt_5$ layers with thicknesses between 3.5 and 18 unit cells on Pt(111) surfaces by electronic Raman spectroscopy from crystal field excitations (CFE). For reference we used identically prepared $LaPt_5$ layers, i.e., with the same crystal structure, but without 4f electrons.

In the Raman spectra of $CePt_5$ at $T \approx 20$ K three distinct peaks appear, which are absent for $LaPt_5$. The Raman shifts of these $CePt_5$ peaks range from approximately 15 meV to about 25 meV. Based on the individual dependence of their intensities on the layer thickness, we assign these three peaks to CFE of Ce 4f electrons, located (i) in the $CePt_5$ layer, (ii) at the interface of the $CePt_5$ layer to the Pt(111) substrate, and (iii) at the Pt-terminated surface of the $CePt_5$ layer, respectively.

Besides, up to three additional sharp Raman peaks occur in an almost identical pattern both for $CePt_5$ and for $LaPt_5$. Therefore they are identified as crystal lattice vibrations. For the case of $CePt_5$, one of them is assigned to the $CePt_5$ E_{2g} mode, whose symmetry corresponds to the CFE, the others to vibrations of the uppermost part of the $CePt_5$ layer, which is symmetry-reduced due to surface relaxation [3].

Keywords: Raman; $CePt_5$; Crystal Field Excitations

References

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