Experimental Treatments for the Investigation of Nuclear Optical Transition in ^{229}Th

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The increase of the accuracy of optical frequency standards by means of the development of "nuclear clocks", a novel frequency standard based on the nuclear transition to the long-living isomer nuclear state of ^{229}Th with the energy ~7.6 eV, is of great interest. The main problem is the fact that there are no experimental data on the direct measurement of the energy of the isomeric transition, and the above result was obtained only by indirect measurements, and has great uncertainty.

Because of the existing restrictions on the use of radioactive matter in laboratories, all studies are conducted with samples containing only small amounts of ^{229}Th (no more than 1 kBq or ~ 10^{15} atoms). For working with such small amounts of matter it is appropriate to use surface research techniques which are sensitive to the surface concentration at the level of one monolayer (~ 10^{15} cm^{-2}). One of these techniques is low energy ion spectroscopy (LEIS).

LEIS might be used for more precision investigations of the isomeric transition in ^{229}Th. It caused by the fact that LEIS spectra exhibit the fine structure determined by the target surface electronic structure. In the case of low energy nuclear transition it can give the information about the long-living isomer nuclear state of ^{229}Th. To proof this hypothesis it is necessary to prepare high quality samples with a high thorium surface coverage.

An original preparation technique of the thorium films by electrochemical deposition from thorium nitrate solution on different substrate is reported. It was found that electrochemical deposition of thorium on the metal surface provides the formation of adherent continuous films, while the deposition on the semiconductor substrates leads to the formation of thorium island films. The origin of the observed thorium films formation and the results on the investigation of thorium films on Si(111) and polycrystalline Cu surfaces by XPS and LEIS are discussed.