Technological Laboratory of the LMU

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1. Status of the Hot-Lab Facility

During 1996, the laboratory construction has been completed. To obtain the operating license, the technical equipment and the safety devices have to be finally approved by the Bavarian Department of Environmental Affairs. The facility is equiped for the production of thin film targets mostly from actinides, but also from other nuclides like ^{226}Ra or ^{210}Pb up to a specific activity of about 100 mCi/mg. Non γ-emitting isotopes with a specific activity of ≤ 0.25 mCi/mg will be processed by cold crucible electron beam evaporation, resulting in thin films of a high density and smoothness on thin carbon backings. Large samples with areas up to $10 \times 10\,\mathrm{cm}^2$ and a thickness uniformity of $< 5\,\%$ are accessible by this method. Most of the available isotopes of Th, Pa, U, Np, Pu, and Am fall under this category. Isotopes of high specific activity or high purchase price will be processed by micro evaporation sources of low material consumption with collection efficiencies of up to $250\,\mu\mathrm{g\,cm}^{-2}$ per mg of evaporant material. Targets made by this method are typically spots of 2 - 3 mm diameter and up to $2\,\mathrm{mg\,cm}^{-2}$ thickness on carbon backings of sufficient sturdiness. This method allows the preparation of exotic targets like ^{210}Pb, ^{226}Ra, ^{227}Ac, ^{229}Th, or ^{248}Cm. A major ambition for the near future is the development and fabrication of large volume ^{235}Uranium carbide targets for the fission fragment accelerator being set up at the new research reactor FRM II. Special equipment required for this new project is still under construction.

2. Vacuum Metallization of Thin Polypropylene Foils

Vacuum metallization of thin, hot-stretched polypropylene foils [1] was studied in some detail with respect to the fabrication of optical filters to be used in the focal plane PN CCD Camera of ESA's X-ray Multi Mirror (XMM) astronomy satellite. These filters are designed to consist of a $30\,\mu\mathrm{g\,cm}^{-2}$ polypropylene carrier foil without any support structure, coated on both sides with a $17.5\,\mu\mathrm{g\,cm}^{-2}$ Al layer and on one side with an additional $25\,\mu\mathrm{g\,cm}^{-2}$ Sn layer. Due to its low temperature stability polypropylene has to be protected against excessive heat load during processing. Since the source to substrate distance was limited to 26 cm by the chamber size, both Al and Sn were evaporated from W boats requiring a power input of only 300 W, and radiation cooling was applied to the substrate by mounting a polished Al disk at a distance of 0.5 mm behind the foil. The sticking coefficient of Al on polypropylene was found to be rather low compared, e.g., to a glass substrate. Early attempts of Al deposition with a hand-operated power supply resulted in "cloudy" films of inhomogeneous structure. Coatings of satisfactory uniformity, however, were obtained when using rate controlled film deposition techniques. For the Al films, a deposition rate of $0.15\,\mu\mathrm{g\,cm}^{-2}\,\mathrm{s}^{-1}$ was chosen to minimize thermal stress to the polypropylene carrier, while the Sn films were condensed at a higher rate of $1.0\,\mu\mathrm{g\,cm}^{-2}\,\mathrm{s}^{-1}$ [2]. A clean environment is required to achieve pinhole free coatings. For this purpose, a dust free cabinet was built around the evaporation plant, inside which a laminar flow box maintains a density of less than 50 dust particles per cubic foot. Filters with an effective aperture of 73 mm diameter have been prepared. Scans of the local homogeneity of the individual layers across the filter were carried out by soft x-ray transmission measurements with synchroton radiation from the SX-700 facility at the PTB in Berlin, using x-ray energies below and above the Al-K edge, the C-K edge and the Sn-M 4,5 edge, respectively. The overall uniformity was found to be better than $\leq 2\,\%$ for each layer [3]. Moreover, the filters passed environmental tests simulating vibrational and acoustic noise loads representatively related to the ARIANE 5 launch [4], proving, among other things, the excellent adherence of the deposited metal films to the polypropylene carrier foil.

3. Target Thickness Measurement by Soft X-ray Attenuation

Soft x-ray attenuation provides an ideal approach to determine the thickness of self supporting thin film targets. The quantity to be measured is the transmission

$$T = I/I_0 = e^{-\mu d},$$

where $\mu\,[\mathrm{cm}^2\mathrm{g}^{-1}]$ is the mass absorption coefficient of the thin film material and d $[\mathrm{g\,cm}^{-2}]$ the film thickness. Using mass attenuation coefficients published, e.g., in [5], the absolute thickness of a sample can be calculated. Table 1 gives an impression of the versatility of this method. The whole range of target thicknesses encountered in nuclear physics is accessible by chosing a proper x-ray energy. Compared to the widely used α-energy loss method, x-ray attenuation allows routine thickness determination even for very thin free standing and supported target foils with high precision. Following these considerations, an x-ray