Antireflection Foils with Multilayer Converter for Ultracold Neutron (UCN) Detectors ◇

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For experiments at the ultracold neutron (UCN) source of the new high luminosity neutron source, Forschungsreaktor Mnchen II (FRM II), high efficient detectors are needed. The desired type of detectors utilizes ^{6}Li as neutron converter in the huge cross-section reaction ^{6}Li(n,α)t to detect the 2.06 MeV α-particles or the 2.73 MeV tritons. The high reflectance of UCN at ^{6}Li with its positive optical potential must be compensated by a material with negative optical potential. Besides the expensive ^{62}Ni material natural Ti can be chosen. It was demonstrated that neither ^{6}Li metal nor Ti metal can be deposited in a high vacuum evaporation plant without creating a positive optical potential and thus increasing the reflectivity for the UCN due to oxygen impurities coming from the H_2O partial pressure in the high vacuum system. To overcome these problems a new UHV evaporation plant was proposed at the DFG (Deutsche Forschungsgemeinschaft) and was funded in 2002 with 358000 Euro in the frame of HBFG (Hochschulbaufrderung). This UHV plant was developed to reach a vacuum in the 10^{-10} Pa range. Such a good vacuum can be obtained only when annealing the vacuum system up to 470 K. At such high annealing temperature the silicon detectors for the α and t particles might suffer and reduce their energy resolution. Therefore the multilayer system of ^{6}Li and ^{nat}Ti will not be deposited directly on the silicon detector but a thin rolled Ti foil (450 μg/cm^2) is applied as backing. Ti has a negative optical potential, thus the UCN will not be reflected on it. 250 pairs of thin ^{6}Li and Ti layers will be deposited on this Ti foil in the new UHV evaporation plant. These multilayer pairs will be covered by a ^{58}Ni layer (80 μg/cm^2) which combines two tasks. Firstly, it is needed to reflect the UCN which were not converted on the ^{6}Li just offering a second chance for conversion on the way back. Secondly, the Ni film protects the mean ^{6}Li metal layers against oxidation. After finishing the evaporation, the complete foils is transported via a lock chamber into an argon glove box. There the edge between the Ti foil and the multi layers is painted with a two component lacquer to prevent corrosion of the ^{6}Li layers starting at the periphery. After drying of the lacquer the multilayer foil will be mounted with its ^{58}Ni face onto the front electrode of the Si-PIN diode detector. Fig. 1 shows schematically the setup of the UHV chamber with the three main gate valves, each equipped with a special refrigerator cryopump. The recipient is built by PINK. The middle, smaller cryopump with a pumping speed of 4000 l/s for water vapor is mainly used until the vacuum reaches the 10^{-6} Pa range during baking (470 K). Then its gate valve is closed and one of the two large cryopumps is used to pump down to the 10^{-10} Pa range. For the evaporations the gate valve of the second large cryopump is opened to offer sufficient pumping speed for outgassing of the evaporants and during evaporation-condensation. Each of these large cryopumps offers a pumping speed of 10500 l/s for water vapor. They were designed by LEYBOLD especially for our UHV needs. Each cold head has 5 W power at the second stage which is sufficient for the gas amounts to be pumped in the UHV range. At the first stage 100 W power guarantees that the heat load during baking can be tolerated. The gate valves were especially constructed for our needs by VAT.

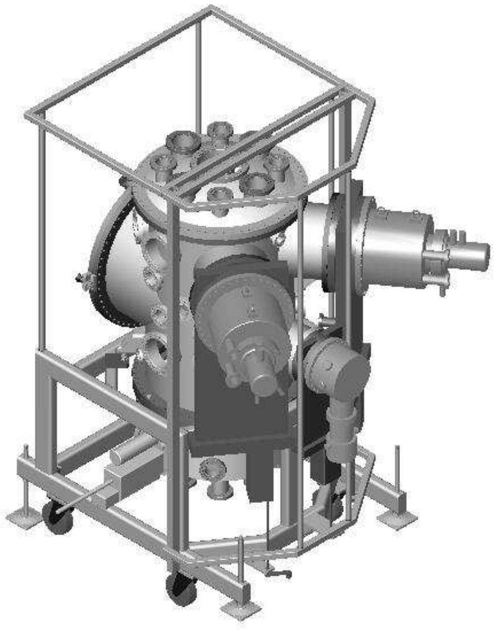

Fig. 1: Schematic setup of the UHV evaporation plant.

Completely metal sealed gate valves are only available up to a size of DN 200, and even those are too expensive for this project. In the standard UHV gate valves the viton O-ring for sealing is in a grove. This construction allows an upper baking temperature of 420 K in the closed position. Since a baking temperature of 470 K is required, VAT was convinced by us to develop a vulcanized Viton sealing, this withstands 470 K. The same viton problem occurs with the O-rings required for the sealing of the main port with 63 cm inner diameter. Here we solved the problem by mounting the two O-rings, separated by the volume for the partition vacuum, in floating trapezoidal groves. The main evaporator is an electron beam source equipped with an eight positions bellows sealed evaporation hearth. This protrudes of the left rectangle of the rack for the recipient as is schematically shown in Fig. 1. The frame rods are for the tent construction needed during baking and can be dismantled. This UHV evaporation plant will be set up in 2003. Since additional designs are required, first evaporation-condensation will be performed not before 2004.

◇ supported by MLL