SUPERTHIN INTERNAL TARGET FOR STORAGE RINGS

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ABSTRACT

The construction, operation of the superthin micropowder spray target for storage rings as well as testing results are presented. The "dust beam" is created by a gas-particle mixture flowing through a capillary into a vacuum. The profile and density of the microparticle beam as well as velocity of microparticles is measured by a diagnostic system based on He-Ne laser with splitted light beams. The target thickness (7,0 10^{14} atoms/cm^2) has been determined by weighting procedure. The scheme of other target design are presented.

1. INTRODUCTION

The development of accelerating storage rings with internal targets offers a number of experimental benefits. Among the main advantages are increasing of variety of interacting pairs, high efficiency of a beam utilization, fine energy resolution, lowest detection thresholds for heavy charged products of nuclear reactions. To realize these benefits one obviously should use the regime of the superthin internal target [1-9]. The allowable range of thickness of internal targets depends on some conditions, but it is roughly between 10^{14}-10^{16} atoms/cm^2[3]. This thickness is some orders of magnitude lower than commonly used in one-pas experiments. This constraint rules out self supporting foil targets. Gas targets in the desired thickness range are easily realized [6], but this is not the fact for solid state materials. Several approaches are known for inhomogeneous targets in form of fibers, pellets and microparticle dust [10]. The present paper is concerned with the construction and operation of two types of superthin micropowder spray targets designed as internal targets for the electron storage ring of the Novosibirsk Institute for Nuclear Physics.

2. EXPERIMENTAL SET-UP

2.1. Spray micropowder internal target (SMIT)

The schematic view of the first target-design (SMIT) is shown in Fig.1. The micropowder in amounts of 5-7 grams is loaded into a generator-mixer "G" via the hole "H" while the carrier-gas is supplied via the needle-valve "V". The sound generator "D" is used to excite the 20-200 Hz vibrations of the electromagnet connected with the bottom of a mixer cavity. The resonance frequency depends on the amount of a micropowder and should be tuned during the experiment. The flow of carrier-gas involves microparticles by a dragging force into movement along the flowing direction, while the Bernoulle force concentrates them close to the capillary "K" axis. Inside the long (~ 500 mm) and narrow (diameterr 0.2-0.4mm) stainless capillary the micron - size (0.2 - 2.0 μm) microparticles attain velocities up to 300 m/s.

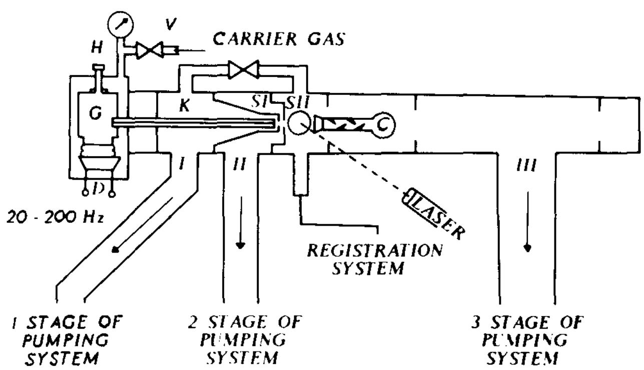

Fig. 1. The schematic view of the first target design (SMIT).

At the exit of the capillary the gas diffuses, but particles, due to their inertia continue to move and arrive to the intersection region with the circulated electron beam. The dust beam is then collected in a catcher "C".

To provide a high vacuum requirement inside the storage ring and to have appropriate acceleration of microparticles which depends on the pressure difference between mixer and vacuum chambers we have used the differential pumping system consisted of three stages with two skimmers "S1","S2" (diameter 2 mm and 4mm respectively). The 1,2,3 stage was pumped up to 10^{-1} Torr, 10^{-3} Torr and 10^{-6} Torr respectively. The pressure inside the generator-mixer cavity - 200 - 400 Torr.

To control density and velocity distributions as well as a profile of the microparticle beam we utilized a laser diagnostic system similar to one described in detail elsewhere [10]. The Mie scattering of laser photons has been focused onto a photomultiplier mounted in horizontal plane at 0^0 to the laser and microparticles beam axez. We used He-Ne laser at a 2 mW power. This technique allows to count microparticles crossing the laser beam as well as to measure the microparticle beam profile by scanning procedure. For homogeneous microparticles it was possible to measure the velocity distribution as well. For that purpose the time-of-flight technique was employed to measure time difference between the microparticle crossings of two narrow laser beams. In practice the He-Ne laser beam was splitted into two parallel beams 4 mm apart and 150 μm wide. The measurements have shown that commercially available micropowder is rather inhomogeneous and we have used so-called gravitational filter to separate microparticles of different size [3]. We have also investigated the monitoring system based on discharge pulses occurred at the catcher region when the microparticle beam interacted with a lexan foil. We have checked the target operation for C,Ni,W,Mo,Ti elements. The target thickness has been measured by means of weighting. The measured target thickness (W, diameter of microparticles 1-2 μm, N_2 carrier - gas) for the microparticle beam diameter 4 mm was estimated as 7.0 10^{14} atoms/cm^2.

2.2. Electrodynamic micropowder target (EMT)

Recently we have tested another method of introducing microparticles into circulating electron beam. It is so-called Electrodynamic Micropowder Target (EMT). A schematic diagram of a target is shown in Fig.2. The principle of operation is similar to the described elsewhere [8] and based on a contact-charging of dust particles in electric field on metal surfaces of preparing (1) and injecting (2) chambers.

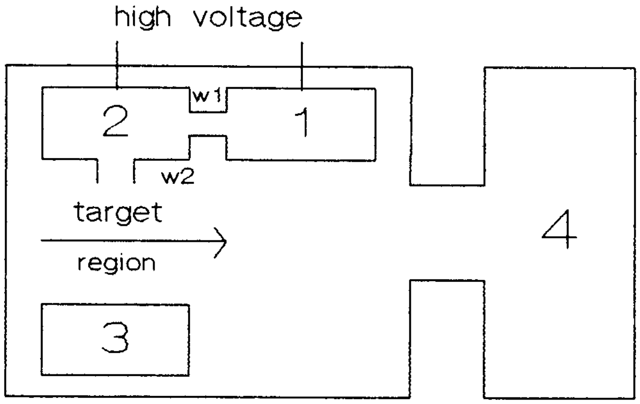

Fig. 2. The schematic diagram of a target (EMT).

The chamber (1) is connected with chamber (2) by window (W1). The density of dust cloud in injection chamber is regulated by variable window (W1) dimension. Moving microparticles are extracted from injection chamber through the hole (W2) (diameter 4 mm) in a lower electrode to the target region. After crossing target region microparticles are collected in the catcher (3). The electric field applied between electrodes chamber (1),(2) ranged 10^5-10^6 V/m. In that case target thickness was in the range of 10^{16} atoms/cm^2. The pumping system provides vacuum up to 10^{-7} Torr (4). The laser diagnostic system described above has been used for the microparticle beam monitoring.

3. EXPERIMENTAL RESULTS

The first construction of the micropowder spray target described above has been installed in the straight section of the electron storage ring at Novosibirsk [3]. The Ni-micropowder particles with a diameter close to several micrometers were brought into reaction area, by CO_2-carrier gas. The short (50 mm) glass capillary with an exit diameter of 100 micrometers linked the mixer-cavity-gravitational filter region with a vacuum chamber of the storage ring via two-stage differential pumping system. The two criopanels effectively pumped the CO_2-carrier-gas so that at ~ 5 l*Torr/s gas flow the contribution of carbon and oxygen nuclei into measured spectra was not detectable (less 2%). The Ni-micropowder beam density measured by weighting procedure as well as calculated from electron elastic scattering data was in the range of 10^{15}atoms/cm^2. The example of electron spectrum obtained at electron energy 122 MeV by means of the magnetic spectrometer at $\theta=56^0$ is shown in Fig.3.

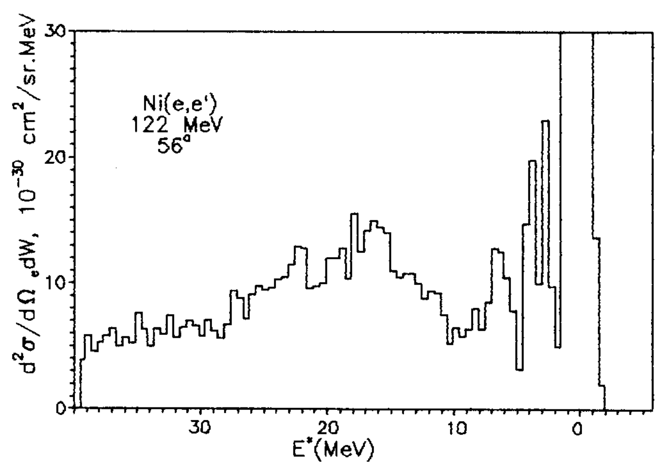

Fig. 3. The electron spectrum obtained at electron energu 122 MeV.

Besides the sharp discrete peaks corresponding to the ground state and low-lying levels of Ni the broad structure at excitation energy ~15 MeV as well as at ~ 35 MeV were clearly seen and identified as contribution from 1^-, 2^+ and presumably from 2^- giant resonances of ^{58}Ni.

The more sophisticated installation (SMIT) has been constructed for the new electron storage ring NEP-220 in Novosibirsk. The parameters of the

NEP-220 beam make limits for target thickness 10^{14} – 10^{17} atoms/cm^2 for different elements (luminosity 10^{31} – 10^{34} cm^{-2}s^{-1}), respectively.

It is worthwile to point out that a micropowder of other elements such as B, Al, Co, Cu, Re and combinations: Ti, Si, B carbides; Al, Ti, Si nitrides; Al, Zr, Y, Hf oxides; Zr, Ti, Al borides were produced for operation with internal target.

REFFERENCES

1) S.T.Belyaev, G.I.Budker, S.G.Popov. Proceed. III Intern. Conf. High Energy Physics and Nuclear Structure, (New York, 1969, Plenum Press, 1970) p.606.
2) S.G.Popov, Proceed. Workshop on the use of electron rings for nuclear physics, (Lund, Oct.5-7, 1982) v.2, p.150.
3) B.B. Wojtsekhowski,et al., Proceed. 35-th Workshop on Nuclear Spectroscopy and Structure of Atomic Nuclei (in Russian), (Leningrad, Nauka, 1985) p.367.
4) H.O.Meyer, CEBAF Workshop, Newport News, U.S.A., 1985.
5) Workshop on Internal Targets for COSY, KFA, (Julich, 1987) Jul-Spez - 409.
6) C.Ekstrom. CERN Accelerator School, Third Advanced Accelerator Physics Cours, (Uppsala, Sweden, 1989).
7) Topical Conference on Electronuclear Physics with Internal Targets SLAC, (Stanford, California, 1989).
8) T.Tanabe, I.Sugai, M.Yasue. Nucl. Instr. and Meth. A265, (1987) 439.
9) A.Berdoz et al., Nucl. Instr. and Meth. B40/41, (1989) 455.
10) H.O. Meyer et al., Nucl. Instr. and Meth. 295, (1990) 53.
11) B.B. Wojtsekhowski et al., Sov. J. Nucl. Phys.(in Russian), 52, (1988) 907.
12) G.I. Budker, A.P. Onuchin et al. Sov. J Nucl. Phys.(in Russian), 6 (1967), 775.
13) N.S. Korobeinikov, L.M. Kurdadze et al., ibid, p.84.