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Plasma Sputtering Robotic Device for *In-Situ* Thick Coatings of Long, Small Diameter Vacuum Tubes[1]

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A novel robotic plasma magnetron mole with a 50 cm long cathode was designed fabricated & operated. Reason for this endeavor is to alleviate the problems of unacceptable ohmic heating of stainless steel vacuum tubes and of electron clouds, due to high secondary electron yield (SEY), in the BNL Relativistic Heavy Ion Collider (RHIC). The magnetron mole was successfully operated to copper coat an assembly containing a full-size, stainless steel, cold bore, RHIC magnet tubing connected to two types of RHIC bellows, to which two additional pipes made of RHIC tubing were connected. To increase cathode lifetime, movable magnet package was developed, and thickest possible cathode was made, with a rather challenging target to substrate (de facto anode) distance of less than 1.5 cm. Achieving reliable steady state magnetron discharges at such a short cathode to anode gap was rather challenging, when compared to commercial coating equipment, where the target to substrate distance is 10's cm; 6.3 cm is the lowest experimental target to substrate distance found in the literature. Additionally, the magnetron developed during this project provides unique omni-directional uniform coating. The magnetron is mounted on a carriage with spring loaded wheels that successfully crossed bellows and adjusted for variations in vacuum tube diameter, while keeping the magnetron centered. Electrical power and cooling water were fed through a cable bundle. The umbilical cabling system is driven by a motorized spool. Excellent coating adhesion was achieved. Measurements indicated that well-scrubbed copper coating reduced SEY to 1, i.e., the problem of electron clouds can be eliminated. Room temperature RF resistivity measurement indicated that 10 μm Cu coated stainless steel RHIC tube has conductivity close to that of pure copper tubing. Excellent coating adhesion was achieved. Device detail and experimental results will be presented.

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