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Hot hollow cathode discharge as a tool for high-rate plasma deposition of oxide thin films

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In this work we present a plasma deposition technique that allows fast reactive deposition of various oxide layers with extremely high deposition rate. The new approach combines reactive sputtering by DC hollow cathode discharge with thermal evaporation from the hot surface of the hollow cathode. As an example of successful fast deposition, thin and thick layers of titanium dioxide (TiO_2) or cobalt oxide (Co_3O_4) were prepared using this technique. The uncooled titanium (or cobalt) nozzle served as a hot hollow cathode and simultaneously as an inert gas (Ar) inlet. The reactive gas (O_2) was introduced into the vacuum chamber through a separate inlet, which effectively prevents oxidation of the cathode material. During deposition, the temperature of the hollow cathode reached up to 1600 °C, depending on the discharge parameters. This made it possible to combine the ion sputtering of hot hollow cathode with its thermal surface evaporation, which significantly increased the deposition rate. The instantaneous value of deposition rate was measured by quartz crystal microbalance (QCM) technique. For titanium dioxide, the highest achieved deposition rate was 567 nm/min (34 µm/h), which (with respect to the geometry of this process) corresponds to the total volume of deposited TiO_2 material 1.2 mm^3/min per 1 kW of absorbed power. Despite extremely high thermal flux to the substrate, TiO_2 films were successfully deposited even on thermally-sensitive PET foil. However, the layers prepared by a single nozzle are considerably inhomogeneous. For the deposition of homogeneous films, a several plasma jets arranged side by side has to be used. In such configuration, we have prepared transparent TiO_2 layers with a high refractive index on micro-structured polymer substrates.

Keywords
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