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Ultralow Absorption Conductive Al:ZnO Films for Charge Dissipation in LIGO Vacuum Mirrors

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Accumulated charge on vacuum mirrors can cause degradation of the signal-to-noise ratio in opto-mechanical measurements due to electrostatic coupling of the surface charge to the environment. A conductive film with minimal optical absorption and scattering can dissipate the charge without altering the optical performance of high reflectivity mirrors. We present Aluminum doped ZnO coatings exhibiting < 100 TOhm/sq resistivity while maintaining an optical absorption of 0.1 ppm at 1064 nm. Both Atomic Layer Deposition and Magnetron Sputtering films were used studied. Deposition and post-processing parameters were optimized to achieve the desired specifications. The oxygen vacancies were found to play an important role in both optical absorption and electrical conductivity. Oxygen vacancy density can be controlled during deposition as well as post-deposition annealing in vacuum or oxygen-rich atmospheres. Films exhibiting optical absorption close to the free carrier limit were obtained. On high reflectivity Distributed Bragg Reflectors it was found that for c.a. 10 nm thick films there can be further reduction in the absorption through nulling the electric field at the mirror surface. In such a case, optical absorption reduction of three orders of magnitude can be achieved. Dependence of the mirror reflectivity as well as the reduction in optical absorption of conductive films on film thickness and dielectric parameters are discussed.

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