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Characterization of Amorphous Silica Coatings for Gravitational Wave Detectors: A Multitechnique Spectroscopic Approach

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Amorphous silica coatings play a crucial role as mirror components in gravitational wave detectors, such as those used in the Virgo experiment at the European Observatory in Cascina (PI, Italy). Exceptionally high sensitivity is required for the detection of gravitational waves and thermal noise from mirror coatings is one of the main limiting factors in the spectral region where the detector is most sensitive [1]. The main challenge is to identify new materials and define the deposition and post-deposition procedures that ensure thermal noise reduction. In this context, silica is one of the most advantageous materials, and a thorough characterization of its properties would be highly advantageous. Possible tools to obtain structural information and detect the presence of impurities on thin films are specular reflection (SR) and attenuated total reflection (ATR) IR spectroscopic techniques [2]. In our work, these two approaches are employed to analyse amorphous silica coatings produced by ion-beam spattering on a silicon and SiO2 substrates, and treated after deposition at different annealing temperatures, from 500℃ to 1000℃. We highlight how such techniques can be applied to the structural analysis of thin films of nanometric thickness. In particular, we demonstrate how spectroscopic techniques are powerful tools to detect impurities and inhomogeneities. In addition, they provide estimates of effects induced by annealing on the complex refractive index and the effective thickness of the film. To this end, the results of IR measurements are discussed and compared to those obtained by Brillouin scattering, Scanning Electron Microscopy and Spectroscopic Ellipsometry. A multitechnique approach allowed us to provide a comprehensive overview of the properties of silica coatings, highlighting new points for discussion.

References

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