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Ultra-thin Nanolayers Coatings for gravitational wave detector

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To improve the sensitivity of laser interferometric gravitational wave detectors, the reduction of noise sources is of great importance. A primary noise source, which is dominant in the 20-300 Hz band, is thermal noise from the coatings deposited on the terminal masses. Currently, these coatings consist of alternating layers of low- and high- index materials, SiO2 and TiO2-doped Ta2O5 respectively, in the amorphous phase. These materials are not suitable for the coatings of cryogenic 3rd-generation gravitational wave interferometric detectors because they suffer from large mechanical losses at cryogenic temperatures. In this work, a new strategy to replace TiO2-doped Ta2O5, with nanostratified structures composed of alternating layers of SiO2 and TiO2, was proposed. As it has been modeled that this nanostructure has excellent properties in terms of mechanical losses at cryogenic temperatures and withstands high annealing temperatures without crystallizing. The SiO2/TiO2 prototype was deposited by plasma- assisted electron beam deposition. The composite consists of 38 TiO2 layers, each with a nominal thickness of 2.0 nm, and 38 SiO2 layers, each with a nominal thickness of 1.3 nm, for a total of 76 nanolayers and a total thickness of 125.4 nm. Structural, morphological, and optical properties of the as-deposited and annealed 76-nanolayer sample were explored by using Atomic Force Microscopy, X-Ray Reflectivity, Raman Spectroscopy and Spectroscopic Ellipsometry. In addition, a section analysis of the sample was performed by means of Scanning Transmission Electron Microscopy. By performing morphological analysis, a high uniformity of coverage and remarkable surface flatness was demonstrated. It was remarkable demonstrated that the amorphous phase is preserved upon annealing. Loss angle measurements are in progress at room temperature and the first results are very interesting.

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