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Use of X-ray absorption spectroscopy in the search for the best LIGO mirror coatings[1]

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The Laser Interferometer Gravitational-wave Observatory (LIGO) seeks to improve its sensitivity for gravity-wave detection by a factor of ten during its next phase of operation, Advanced LIGO. In order to achieve this goal it is necessary to design and fabricate test mass mirrors that help minimize the noise in the interferometers and in doing so maximize gravity-wave detection capability. In this talk we will present recent results from our program of X-ray absorption spectroscopy measurements to obtain detailed chemical composition and structure of titania (TiO_2)-doped tantala (Ta_2O_5) multilayers fabricated via ion beam sputtering on SiO_2 substrates. Our investigations focus on how the microscopic features of the coatings influence their macroscopic mechanical loss properties. Our goal is to obtain correlations between chemical impurities and/or dopants and the optical absorption and mechanical loss characteristics of these multilayer coatings. To examine our samples we use synchrotron-based X-ray absorption Spectroscopy (XAS) techniques including Extended X-ray Absorption Fine Structure (EXAFS), X-ray Absorption Near Edge Structure (XANES) and X-ray Fluorescence (XRF). We present chemical and structural data obtained at the titanium K-edge and tantalum L_{III}-edge as well as relative elemental distribution information (Ti/Ta, Fe/Ta, and Cr/Ta) obtained via XRF. Following a brief description of the LIGO experiment, our program of research in optical materials for use in advanced versions of the interferometer will be described.

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