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Development of Silicon Nitride by RF Magnetron Sputtering for GW Coatings

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Gravitational wave (GW) interferometers necessitate the use of specialized mirrors designed to minimize mechanical loss and absorption, thereby ensuring the required sensitivity for effective gravitational wave detection.
Currently, a stack of alternating layers of tantalum oxide (Ta_2O_5) combined with titanium oxide (TiO_2) and silicon oxide (SiO_2) is considered the state of the art. Nonetheless, these materials, despite having satisfactory optical absorption, exhibit relatively elevated mechanical losses, thus limiting the interferometer sensitivity. Silicon Nitride (SiN_x) is considered a promising candidate for replacing Ti:Ta_2O_5 in view of its superior mechanical properties. However optical absorption in this material is still too high for GW applications, for reasons that are not well understood yet.
The prevailing method for depositing current-generation gravitational wave coatings is ion beam sputtering (IBS). However, with this technique an optimal control of the film stoichiometry may be difficult.
Since the deposition technique employed significantly influences coating properties, in this study radiofrequency magnetron sputtering is being explored as an alternative approach for depositing silicon nitride, due to its versatility. Initially, the deposition geometry was optimized to achieve film uniformity over a maximal area, considering available deposition system. Subsequently, efforts have been directed towards achieving Si_3N_4 stoichiometry, supposing the condition under which the material exhibits its optimal properties, utilizing Rutherford Back Scattering (RBS) for atomic composition control.
Thereafter, the optical properties of the films have been investigated through ellipsometry and photothermal deflection, also examining the influence of oxygen content in the film and its resultant optical properties.

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