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High-Quality Coating Materials for future Cryogenic Gravitational-Wave Advanced Detectors

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Interferometric gravitational-wave detectors have opened a new window into the Universe, creating new opportunities in the branch of astrophysics. While current detectors allow for successful detections, there is a need to increase their sensitivity by trying to enlarge their frequency band to observe additional types of gravitational waves sources. Future cryogenic detectors such as the Einstein Telescope aim for this improvement. Improved operating conditions, such as cryogenic temperature, will help reduce the mirror's Brownian thermal noise, one of the limiting noises in the detector. Meanwhile, low temperature applications are driving technological development towards the study of new materials and coating design for the mirrors of these large interferometers.
Material candidates such as amorphous silicon (aSi) and silicon nitrides (SiN) show low thermal noise but their high optical absorption reduces the power in the interferometer and hence the signal-to-noise ratio. In Maastricht University, we are testing a crystalline-silicon top-layer design, based on the industrially established silicon-on-insulator (SOI) technique, which will allow the use of low thermal-noise but highly-absorbing materials such as aSi and SiN. In addition, this new design will potentially reduce the defect density in the upper coating layers, where the high laser power may induce damages, and solve a mismatch in tolerable heat-treatment temperatures of the coating and the mirror substrate.

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