







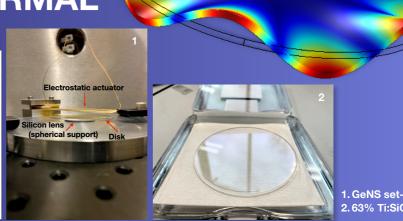
V.Spagnuolo<sup>1,2\*</sup>, G.McGhee<sup>3</sup>, S.Tait<sup>3</sup>, R.Johnston<sup>3</sup>, G.A.landolo<sup>1,2</sup>, P.G.Murray<sup>3</sup>, J.Hough<sup>3</sup>, S.Rowan<sup>3</sup>, F.Schiettekatte<sup>5,</sup> L.Terkowski<sup>4</sup>, J.Steinlechner<sup>1,2</sup>, I.W. Martin<sup>3</sup>.

TiO<sub>2</sub>:SiO<sub>2</sub>: **MIRROR COATINGS FOR IMPROVED ROOM TEMPERATURE THERMAL** 

**NOISE** 

## 1. Introduction

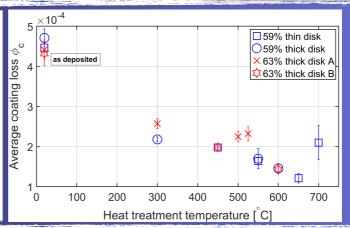
The replacement of high refractive index material in the highly-reflective (HR) mirror coating stacks of gravitational wave detectors to reduce the coating thermal noise is the goal for the next detector upgrade. Beside the Ti-doped Ge investigation[1], titania coatings can be improved by doping them with silica<sup>[2]</sup>, to allow further post-deposition heat treatment with crystallisation and possibly to reduce the loss.



1. GeNS set-up. 2.63% Ti:SiO<sub>2</sub>.

## 2. Mechanical loss

In this work HR coating stacks with SiO<sub>2</sub> & TiO<sub>2</sub>:SiO<sub>2</sub> as low & high refractivity index materials were investigated. A world-leading commercial coating vendor, FiveNine, deposited via IBS two different films on two silica substrates each, 2x 59% (thin, thick disk) and 2x 63% (disk A and B) of TiO2 concentration. Several annealing steps were carried out and mechanical loss was measured with GeNS[3] system at room temperature.

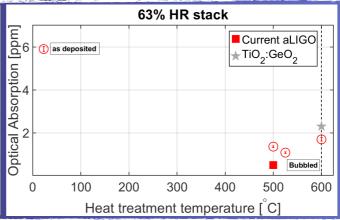


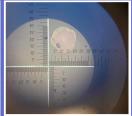
59% HR thin lower level loss @650C  $(1.2 \pm 0.1) \times 10^{-1}$ 

•63%HR lowest loss @600C  $(1.4 \pm 0.1) \times 10^{-4}$ 

## 3. Absorption

The optical absorption of the coatings was measured using photo-thermal-common-path interferometry (PCI). A Pump beam is chopped at known frequency to provide periodic heating of the sample resulting in a formation of a thermal lens. A Probe beam crosses the pump beam at the sample surface resulting in an interference pattern proportional to the absorption of the materials<sup>[4]</sup>. The setup is sensitive to absorptions at levels <1ppm at 1064nm.

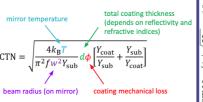




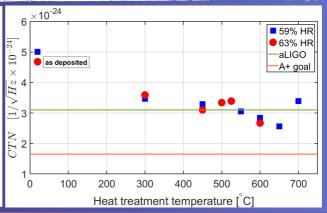
**Bubble formation** could be an effect of both the polishing quality and the presence of residual argon gas.

## 4. Coating Thermal Noise (CTN)

From the formula, there are some possible strategies to reduce the CTN. In particular slightly higher refractive index of



Ti:SiO<sub>2</sub> than Ti:GeO<sub>2</sub> suggested it could be quite competitive in CTN.



\*59%HR @700C partially crystallised gets worse in CTN. Good performance of 63% @450C which matches aLIGO[5] curve @600C but here we get concentration don't goal[1]. Further investigation will follow, mainly on the absorption side, we get results 50%lower than Ti:GeO<sub>2</sub>.