Investigation of crystalline AlGaAs mirror coatings at room temperature

Chun Yu Ma[1], Jialiang Yu[1], Thomas Legero[1], Sofia Herbers[1], Daniele Nicolodi[1], Mona Kempkes[1], Fritz Riehle[1], Dhruv Kedar[2], John M Robinson[2], Jun Ye[2] and Uwe Sterr[1]

[1]Physikalisch-Technische Bundesanstalt (PTB), Bundesallee 100, Braunschweig, Germany
[2] JILA, National Institute of Standards and Technology and University of Colorado, Boulder, CO, USA

Email: chun.ma@ptb.de

Brownian thermal noise of highly reflective dielectric coatings limits the fundamental frequency stability of ultra-stable lasers based on Fabry-Perot optical resonators. Crystalline AlGaAs mirror coatings with low mechanical losses are promising candidates to reduce this limit. However, our optical silicon resonators operating at cryogenic temperatures based on crystalline mirror coatings showed unexpected photo induced birefringence, as well as novel noise contributions that are higher than the low thermal noise level of these coatings at 1.5 µm[1,2,3].

To gain more insight into these effects, we investigate the coatings performance at room temperature with a 48 cm long ULE cavity. We will present our frequency measurements of two individual lasers locked to the fast/ slow polarization eigenmodes (HG_{00}) of this cavity. Upon a step change in intracavity power, the observed frequency change from the different eigenmodes is asymmetric (see figure 1). The asymmetricity can be explained by the sum of the thermal response of the cavity which is proportional to the change of the power, and the anticorrelated contribution that is polarization dependent as well as non-linear to optical power. Therefore, power-induced frequency instability of the laser locked on the fast axis could be minimized by adjusting the intracavity power such that the photo-induced birefringence and the thermal response cancel each other out. We also investigate the photo-induced coating birefringence at different photon energies by illuminating light from the rear side of the mirrors. Our findings help to understand the physical mechanism of the novel photo induced effects and noises found in the coatings.

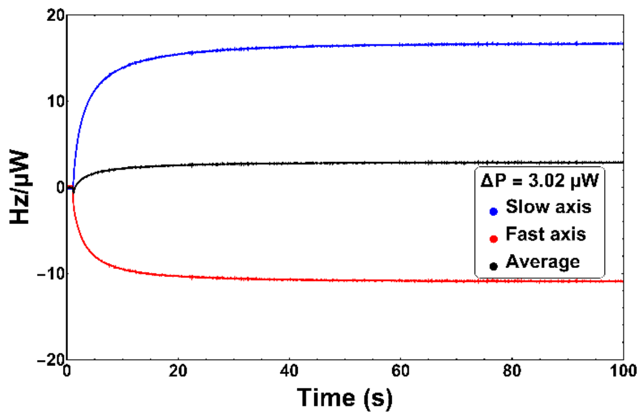

Figure 1. Frequency change of two individual lasers locked to the slow (blue) and fast (red) axes of adjacent HG_{00} modes of the ULE cavity normalized by the optical power step size. The black curve indicates their average which contains the polarization independent frequency change.

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