A Combined Fabry-Perot Interferometer for Moessbauer Radiation And Visible Laser Light

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Introduction

By x-ray interferometry, the lattice constant of silicon can be defined as a length standard in the subnanometer regime, with relative uncertainties typically 10^{-8} [1]. The limiting factor is the variation of the lattice constant due to impurities and the isotopic mixture ratio.
In order to define a better standard on this length scale we aim to use the wavelength of ^{57}Fe Moessbauer radiation $\lambda_M = 0.086$ nm (photon energy $E_M = 14.4125$ keV) and to trace it back to the SI system. The relative spectral width of the Moessbauer radiation and thus the uncertainty in the wavelength is as small as 3×10^{-13}.

Methods and Materials

To achieve this aim, we are going to use a combined scanning Fabry-Perot interferometer (FPI) for both Moessbauer radiation and visible Light [2]. The scheme of the future setup is shown in Fig. 1. The Moessbauer radiation in sufficient quantities can be generated by nuclear forward scattering (NFS) at a third generation synchrotron facility like the **A**dvanced **P**hoton **S**ource [3]. The (1 3 -4 28) Bragg reflection of sapphire crystals at 371.6 K is to be used for the backscattering mirrors which form the Fabry-Perot cavity for the Moessbauer radiation [2,4]. The crystals are also used as the cavity for three optical FPIs. The inner surfaces have partitioned silver coatings which also form three capacitors (Fig. 2). Theese capacitors can be used to monitor angular deviations in the nanoradian region and displacements in the nm scale. By scanning the mirror spacing it is possible to compare the wavelength of an iodine-stabilized laser at 532 nm with that of the Moessbauer radiation. The mechanism for scanning has to provide very linear movement practically without angular deviations ($\lesssim$ 3 nrad). This task is believed to be achievable by the structure shown in Fig. 3. It consists of two flexure hinges that are connected by a cylinder.

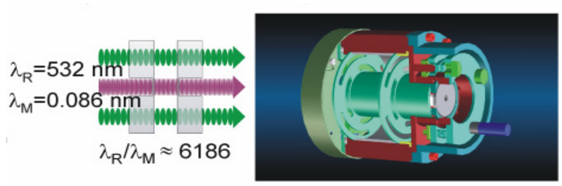

Fig. 1
Left: Schematic sketch of the Fabry-Perot cavity for Moessbauer radiation and visible light. Right: Layout design of the setup.

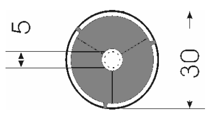

Fig. 2
Layout of mirrors (and electrodes) for the optical cavities (and capacitors) at the inner crystal surfaces.

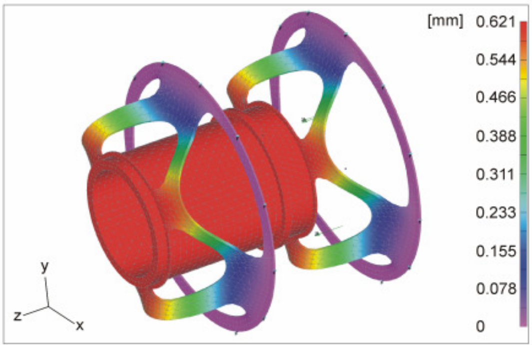

Fig. 3
Finite-element analysis of the linear movement stage (scaled deformation).

The sapphire crystals used for this setup have to be free of dislocations and defects at least in the region of interest. Therefore, crystal selection by x-ray topography techniques is necessary [2].

Results and Discussion

The development of the combined scanning FPI for both Moessbauer radiation and visible Light is in progress. All the preliminary studies show that the concept is feasible.
The technical challenges are: (1) The parallelism of the reflecting crystal lattice planes and the crystal surface is crucial and must not be much larger than an angular second. (2) Milling and polishing of the sapphire crystals induces stress that has to be relieved without damaging the optical grade surfaces. Therefore etching is not a feasible option. (3) At operation a very stable temperature control ($\delta T < 30$ mK) and (4) a very high quality vibration isolation is more than essential.

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