



Phase-Controlled Magnetic Mirror for Wavefront Correction

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Typically, light interacts with matter via the electric field and interaction with weakly bound electrons. In a magnetic mirror, a patterned nanowire is fabricated over a metallic layer with a dielectric layer in between. Oscillation of the electrons in the nanowires in response to the magnetic field of incident photons causes a re-emission of photons and operation as a “magnetic mirror.” By controlling the index of refraction in the dielectric layer using a local applied voltage, the phase of the emitted radiation can be controlled. This allows electrical modification of the reflected wavefront, resulting in a deformable mirror that can be used for wavefront control.

Certain applications require wavefront quality in the few-nanometer regime, which is a major challenge for optical fabrication and alignment of

mirrors or lenses. The use of a deformable magnetic mirror allows for a device with no moving parts that can modify the phase of incident light over many spatial scales, potentially with higher resolution than current approaches. Current deformable mirrors modify the incident wavefront by using nano-actuation of a substrate to physically bend the mirror to a desired shape.

The purpose of the innovation is to modify the incident wavefront for the purpose of correction of fabrication and alignment-induced wavefront errors at the system level. The advanced degree of precision required for some applications such as gravity wave detection (LISA — Laser Interferometer Space Antenna) or planet finding (FKSI — Fourier-Kelvin Stellar Interferometer) requires wavefront control at the limits of the current state of the art.

All the steps required to fabricate a magnetic mirror have been demonstrated. The modification is to apply a bias voltage to the dielectric layer so as to change the index of refraction and modify the phase of the reflected radiation. Light is reflected off the device and collected by a phase-sensing interferometer. The interferometer determines the initial wavefront of the device and fore optics. A wavefront correction is calculated, and voltage profile for each nanowire strip is determined. The voltage is applied, modifying the local index of refraction of the dielectric under the nanowire strip. This modifies the phase of the reflected light to allow wavefront correction.

This work was done by John Hagopian and Edward Wollack of Goddard Space Flight Center. Further information is contained in a TSP (see page 1). GSC-16008-1

Frame-Transfer Gating Raman Spectroscopy for Time-Resolved Multiscalar Combustion Diagnostics

This invention could potentially benefit the development of advanced combustion systems such as gas turbine engines and internal combustion engines.

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Accurate experimental measurement of spatially and temporally resolved variations in chemical composition (species concentrations) and temperature in turbulent flames is vital for characterizing the complex phenomena occurring in most practical combustion systems. These diagnostic measurements are called multiscalar because they are capable of acquiring multiple scalar quantities simultaneously. Multiscalar diagnostics also play a critical role in the area of computational code validation. In order to improve the design of combustion devices, computational codes for modeling turbulent combustion are often used to speed up and optimize the development process. The experimental validation of these codes is a critical step in accepting their predictions for engine performance in

the absence of cost-prohibitive testing.

One of the most critical aspects of setting up a time-resolved stimulated Raman scattering (SRS) diagnostic system is the temporal optical gating scheme. A short optical gate is necessary in order for weak SRS signals to be detected with a good signal-to-noise ratio (SNR) in the presence of strong background optical emissions. This time-synchronized optical gating is a classical problem even to other spectroscopic techniques such as laser-induced fluorescence (LIF) or laser-induced breakdown spectroscopy (LIBS). Traditionally, experimenters have had basically two options for gating: (1) an electronic means of gating using an image intensifier before the charge-coupled-device (CCD), or (2) a mechanical optical shutter (a rotary chopper/mechanical shutter combination).

A new diagnostic technology has been developed at the NASA Glenn Research Center that utilizes a frame-transfer CCD sensor, in conjunction with a pulsed laser and multiplex optical fiber collection, to realize time-resolved Raman spectroscopy of turbulent flames that is free from optical background noise (interference). The technology permits not only shorter temporal optical gating (down to $<1 \mu\text{s}$, in principle), but also higher optical throughput, thus resulting in a substantial increase in measurement SNR.

The new technology is an experimental method (or scheme) for isolating true Raman spectral signals from flames using a single CCD detector. It does not use an image intensifier or a mechanical shutter. Individual electrical or optical devices employed in this method are not