Characterizing Magnetorefractive Glass

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Abstract
Modern optical fibers are used for transmission of data and strain sensing, but a novel application of optical fibers can be utilized to detect magnetic fields. To this end, research is focused on characterizing a novel magnetorefractive glass. Theory and past literature suggests that magnetorefractive glasses exhibit a relationship between the glass’ index of refraction and an applied magnetic field. An ellipsometer is used to characterize this correlation through a reflectivity study. Work has been done to increase resolution in the data, but further refinement is necessary to quantify the magnetorefractive effect in a glass. Once the setup confirms a strong correlation, the next step is the fabrication of a magnetorefractive waveguide.

Objectives
• To create a glass that displays magnetorefractive properties.
• To characterize with maximum precision the magnetorefractive effects on fabricated glass.
• To improve mechanical experimental characterization setup.

Background
Magnetorefractive material’s index of refraction (n) exhibits a dependence on a magnetic field (H).

Magnetoresistance gives rise to this dependence, formally called magnetorefractance.

If such a material can be formed into a glass, then magnetically sensitive optical fibers can be produced.

To date, no glasses have displayed this property.

Lanthanum Strontium Manganite Oxide (LSMO) is magnetorefractive as a crystal film, and literature suggest it is the strongest candidate to be a magnetorefractive glass.

Application

Collision Prevention

Optical sensors can detect the strength of magnetic fields to measure current running to homes.

Power Line Monitoring

Optical Sensors can detect the strength of magnetic fields to aid in collision prevention in low visibility conditions.

Key Concepts

To test for magnetorefractance, two characterizations of index of refraction are needed.

As a laser strikes a surface, the reflected intensity (R) is a function of the index of refraction (n) and the angle the polarized light strikes the surface (θ).

\[ R = \frac{n_2 \cos \theta - n_1 \sqrt{n_2^2 - n_1^2 \sin^2 \theta}}{n_2 \cos \theta + n_1 \sqrt{n_2^2 - n_1^2 \sin^2 \theta}} \]

Reflectivity (R) is precisely measured at various angles of incidence (θ).

Fitting Fresnel’s equation to obtained plot yields index of refraction.

Same test performed with magnetic field may show an index of refraction shift, thus verifying the material is magnetorefractive.

Results

Non magnetorefractive glass has been tested as a benchmark for the system.

As expected, the index of refraction of the plain glass remains constant for varying magnetic fields.

This benchmark shows that the setup is ready to test for magnetorefractive capabilities.

Currently, the fabrication of magnetorefractive glasses is in its preliminary stages.

No characterization studies have been performed on magnetorefractive glasses.

Discussion

• Preliminary data shows a 25% increase in precision as noted by the standard deviations of old and new setups.

• New characterization setup is ready to test fabricated materials for magnetorefractive properties.

Future Work

• A high quality glass needs to be created to yield a stronger magnetorefractive correlation.

• A magnetorefractive planar waveguide needs to be fabricated to model a section of a planar waveguide.

References

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