Design and Simulation of a Compact Terahertz Cavity for Reflection Geometry TDS

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Introduction: Optical cavities play a major role in any spectroscopic setup. THz being invisible to normal human eye, designing a proper cavity for TDS setup becomes essential. Unlike the standard TDS setups for transmission geometry, the setups for reflection geometry is tricky in terms of alignment. Also the Gaussian beam shape plays critical role in the setup design.

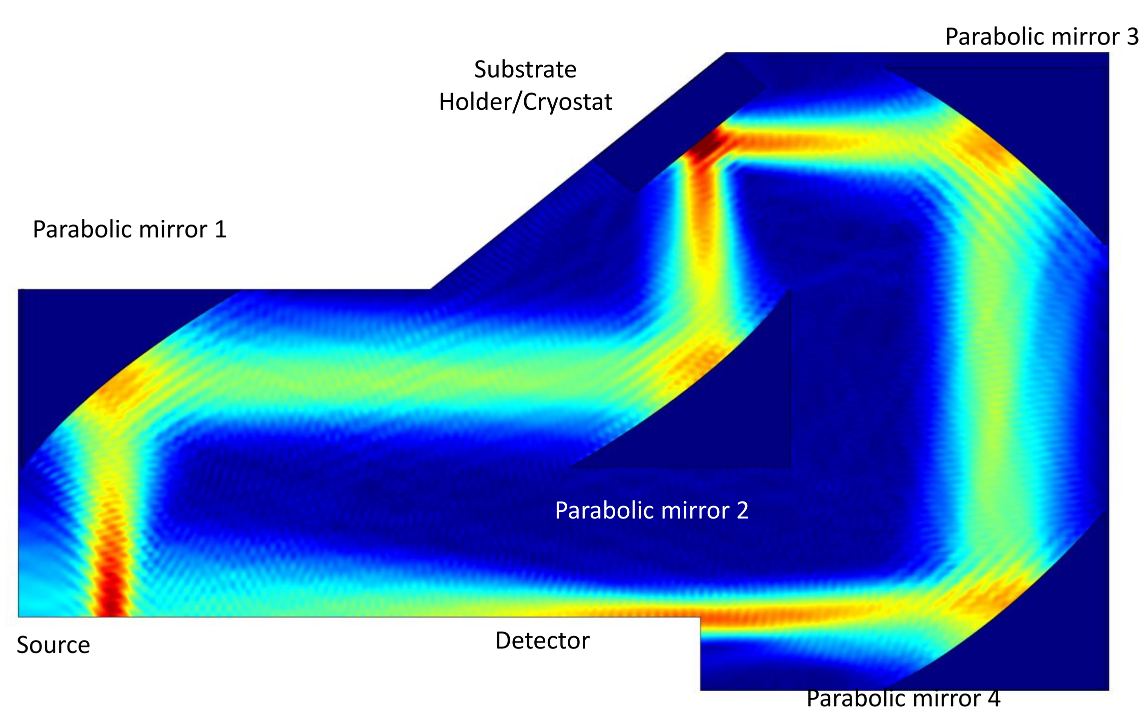

Figure 1. Four mirror cavity for reflection THz TDS

We have designed and simulated a four mirror cavity with a Gaussian beam emerging from a point source. We tried to optimize the total set up size considering all the element dimensions in its true sizes.

Computational Methods: We have simulated the 2D set up RF module using frequency domain study.

A horizontally polarized Gaussian beam in THz regime is launched in the vertical direction as a point source through input port.

$$E_x = e^{-\frac{N(x-X_i)^2}{w_0^2}} \cos k_0 y$$

where, E_x is the electric field along horizontal axis, N=4log2, $k_0 = {}^{2\pi}/_{\lambda_0}$, X_i is the position of the source and w_0 is the beam waist.

The parabolic mirrors with exact coordinates are exported from Matlab. The reflectors are set a Perfect Electric Conductor BC others excluding the input and output ports are assigned as scattering BC.

Results: The present cavity design is extremely compact in size with dimensions of ~(3f+mirror)×(f+mirror). Where 'f' is the effective focal length of an off-axis parabolic mirror. The design also provides liberty to place cryostat for low temperature measurements.

The simulation also helps to figure out beam propagation in each polarization.

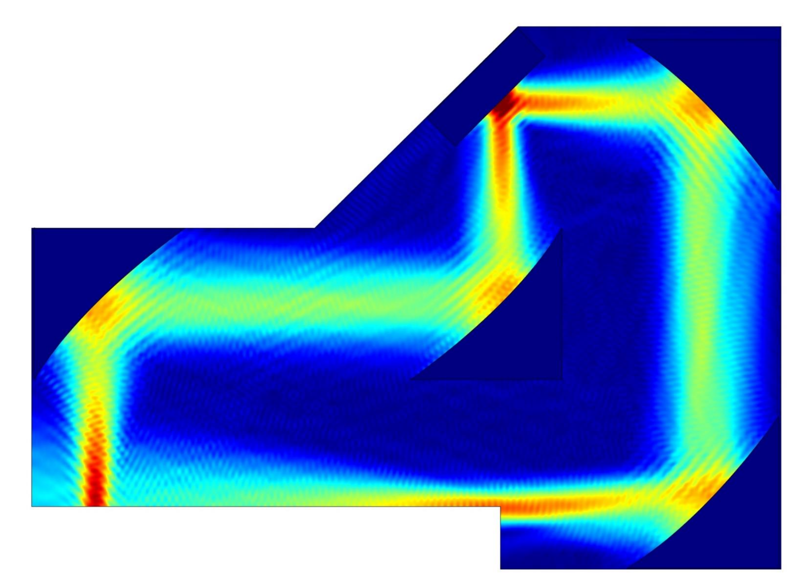

Figure 2. Normal component of Electric field in the cavity

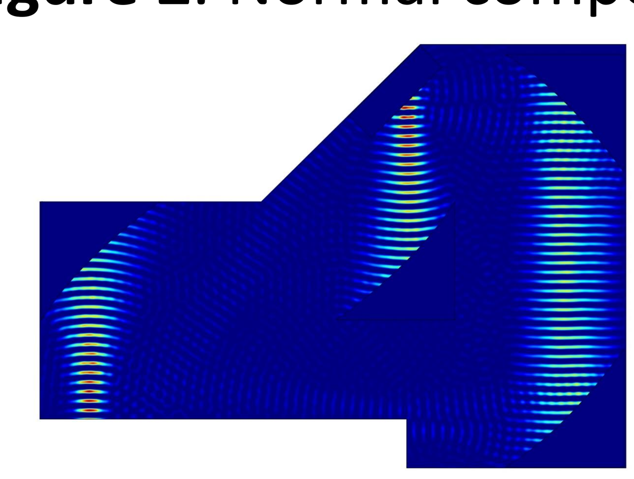

Figure 3. Ex at 0.3THz

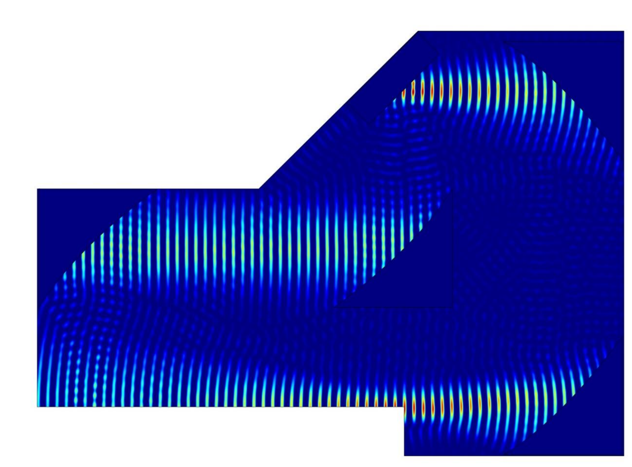

Figure 4. Ey at 0.3THz

Conclusions: With this simulations we are able to design a perfect set up for reflection geometry THz TDS prior to installation. The alignment will be much easier if one has knowledge about how the beam is going to propagate as THz is invisible to human eye. The frequency limitation for dispersion can be derived from the simulation.

References:

1. A. Pashkin et.al. , Phase-sensitive time-domain terahertz reflection spectroscopy, Review of Scientific Instruments, Volume 74 NO.11, 4711-4717 (2003)
2. N. Hiromoto et.al. ,Precise and Convenient Reflection THz-Time Domain Spectroscopy with a Movable Transparent Sample Holder, Infrared, Millimeter, and Terahertz Waves (IRMMW-THz), (2013)
3. D. Hashimshony et.al. ,Characterization of the electrical properties and thickness of thin epitaxial semiconductor layers by THz reflection spectroscopy, Journal of Applied Physics, VOLUME 90, NUMBER 11, 5778-5781, (2001)