Contribution ID: **148** Type: **Poster**

Optimized design for on chip Fabry-Pérot resonators

Thursday, 25 July 2019 18:45 (15 minutes)

On-chip spectrometers, such as DESHIMA and SuperSpec, require transmission lines with $Q_i > 10^4$ to achieve sufficient system efficiency. Transmission lines with lower Q_i would introduce too much losses in the line from antenna to filter and in the filters themselves. Data regarding the losses of transmission lines at THz frequencies and sub-K temperatures is severely lacking. An on-chip Fabry-Pérot resonator can be used to measure the internal losses, Q_i, of a transmission line with high sensitivity at high frequencies. To create the in-line Fabry-Pérot resonator, a transmission line of certain length is coupled to an THz source via a twin-slot lens antenna on one side and to an Al-NbTiN hybrid MKID on the other side.

We show the detailed design of the Fabry-Pérot resonator to measure the losses of a dielectric in the order of $10^3 < Q_i < 10^5$. There are several experimental challenges for measuring Q_i. The first challenge is the limited frequency resolution of the source, due to which resolving high Q can become impossible. Secondly we experimentally found that there is stray light coupled to the detector which causes a spurious response with a level of $-30dB$ with respect to the peak transmission of the Fabry-Pérot resonator. Taking these experimental challenges into account we design an on-chip Fabry-Pérot resonator for measurements of high Q_i dielectrics. In this design we optimize the length, the mode number and the couplers of the resonator. Furthermore we use multiple resonators on a single chip, each coupled to a separate antenna and detector, with different Q_c values. This design method is applicable for different dielectric materials and different transmission line configurations. Using this method we designed and fabricated a chip with which we measured a $Q_i \approx 10^4$ @ 350 GHz for a PECVD deposited a-Si dielectric.

Less than 5 years of experience since completion of Ph.D

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Session Classification: Poster session

Track Classification: Low Temperature Detector fabrication techniques and materials