Optimizing a mid-infrared Cavity Ring Down Spectroscopy on a RF Silane plasma

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Aim of the project:

- Study dust formation in Ar-SiH_4 plasmas with CRDS
- Define the collective behaviour of a dust cloud
- Prepare micro-gravity experiments for ISS*

*International Space Station

Cavity figures:

- Effective absorption path length: 350 m
- Cavity beam waist: 1.72 mm
- Spot size on the cavity mirrors: 2.4 mm
- Free Spectral range :150 MHz
- Fundamental mode FWHM: 100 kHz

Set-up:

- Helium cooled infrared laser diode (wide tuning range, narrow line width; 01 mW power)
- Plano-concave ZnSe cavity mirrors (R>99.7 %, radius of curvature 1 m) flushed with AR
- LN_2 cooled InSb photodiode detector (1 mm^2 active area)
- 210 Liter vacuum chamber ($P_{end} \cong 2.74 \times 10^{-6}$ mbar)

Problems encountered with the optics and the laser:

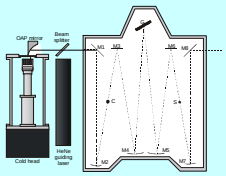
- High diffraction angle at the laser output
- Bad quality of the laser beam at far field
- Monochromator performances
- Low intensity of the beam sent in the cavity

Status of the experiments:

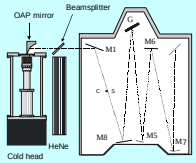
- Plasma chamber ready to operate; Ar and N_2 plasma already ignited.
- Laser beam sent through étalon and CO reference cell. Laser still needs to be aligned with cavity.

Optimizing the optics and the laser beam quality:

STEP 1: the monochromator – increasing the output laser power

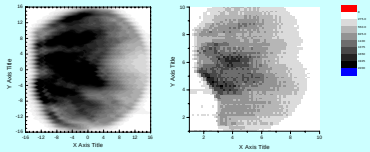


Before

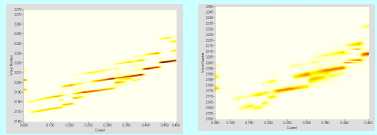


Now

InSb beam profiler



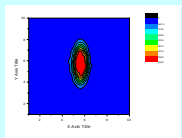
Laser beam profile at the OAP output before and after the monochromator was improved (the X and Y axis unit is mm)



Laser mode charts at 56K before and after the monochromator modifications (the vertical spread of the modes may come from the slit aperture or from the optics of focalization)

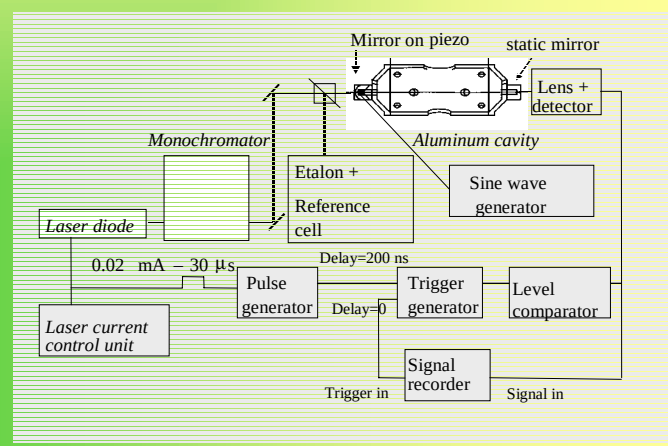
STEP 2: the off axis parabola – higher laser intensity and better shape

Off Axis Parabola

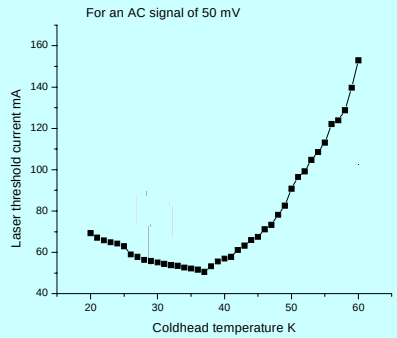


Laser beam focused at 3.30m from OAP (with HeNe beamsplitter, no monochromator) – X and Y axis unit is mm

CRDS and infrared detection principle:



Laser behavior still unexplained:



$$I = I_s(e^{Ve/k\eta T} - 1)$$

Shokley Law

Laser threshold current evolution towards temperature of the diode active region. The current decay at low temperatures does not follow the Shockley law; the dopants might be frozen. No satisfactory explanation has been found yet.