Mid-Infrared Cavity Ring-Down Spectroscopy

CPS
CENTRUM VOOR PLASMAFYSICA EN STRALINGSTECHNOLOGIE

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Aim of the project:

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

*International Space Station

Cavity Ring-Down theory:

- A certain number of photons is trapped in an optical cavity and radiation begins to leak out of it
- Record the exponential decrease of radiation
- For a given wavelength λ, the decrease (ring-down) time τ depends on the gas absorption coefficient α and the cavity properties (mirror reflectivity R, cavity length L, broadband scatter processes)

$$\tau = \frac{L}{c} \times \frac{1}{(1-R)+\alpha L}$$

R = 0.997 ; d = 1 m → $\tau_0 \approx$ 1 ms
$\Delta\tau_{min}$ < 1 ns → $\alpha < 10^{-6}$

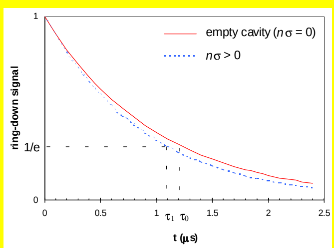
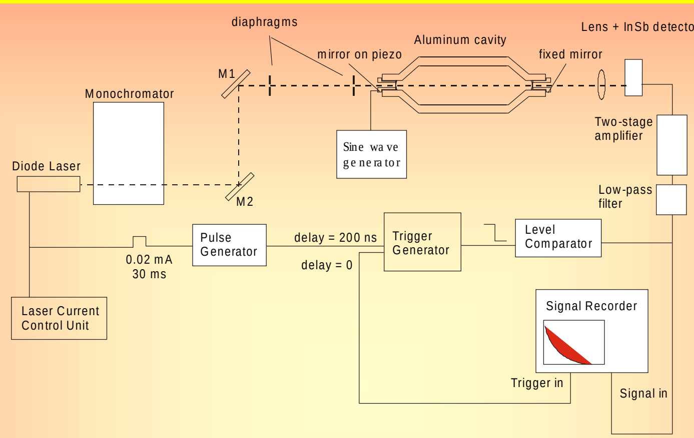


Fig.1 :Theoretical ring-down signal

Set-up:

- Helium cooled infrared laser diode (wide tuning range, narrow line width)
- Plano-concave ZnSe cavity mirrors (R>97 %, radius of curvature 1 m)
- LN_2 cooled InSb photodiode detector

CRDS and infrared detection principle:



First results :

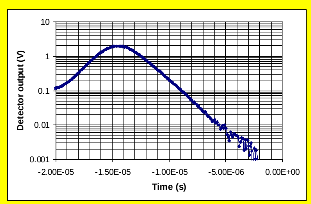


Fig.2 : Ring-down with a CO laser at 5.518 µm
τ = 1.54 µs

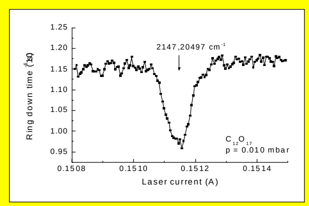


Fig.3 : Spectroscopic ring-down measurements of CO

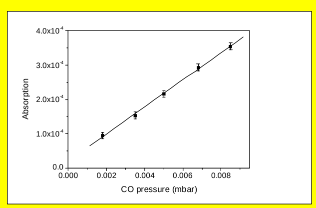


Fig.4 : Absorption as a function of CO pressure

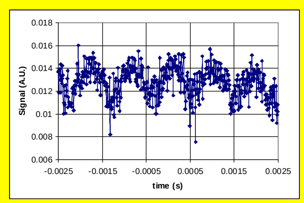


Fig.5 : Laser diode beam through the cavity

Current fields of investigation:

- Diode laser characteristics (beam size, active region geometry, spectral line width…)
  - Approximate vertical dimension 0.5-0.7 µm
  - Junction width of about 1.2-2 µm
  - Cavity length of about 250 µm

⇒ total laser diode diffraction angle is ≈ 112 degrees

△ ***Troubles with laser beam size (∅ = 35 mm) ; might be related to KrS_5 window used…***

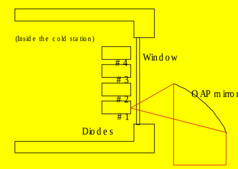


Fig.6 : Diode and OAP set-up

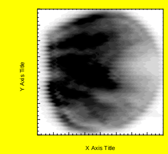


Fig.7 : Size of the laser beam at the OAP output

- Geometric evolution of the laser active region as a function of temperature
  - Output diffraction angle varies with temperature
  - Compromise between working temperature and diffraction angle to be found

△ ***To be investigated***

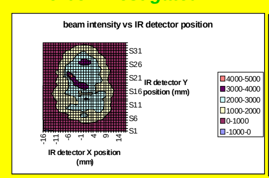


Fig.8 : 2D Beam profile at 58 K

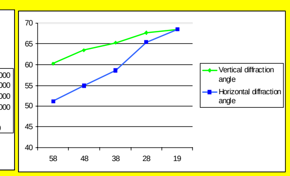


Fig.9 : Diffraction angle evolution towards temperature

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