A air-bearing based, random orbital drive system for a longitudinally pumped solid state dye laser

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Abstract

We present our results of an investigation of organic dye doped plastics as a lasing medium. The host materials we have examined are poly(methyl methacrylate) [acrylic], epoxy, polyester and polyurethane. Various solvents have been used to improve dye dispersion within the material. We produce plastic doped disks which are contained in a Littman configuration cavity. Longitudinal pumping with a frequency doubled pulsed Nd:YAG laser is used. To improve the lifetime of the doped disks we have incorporated the disk into an air-bearing assembly. By introducing translational motion with a solenoid, the disk undergoes random orbital motion with respect to the pump laser beam. Lifetime of the disk, lasing quality parameters (bandwidth, tunability, power) are examined.

Motivation

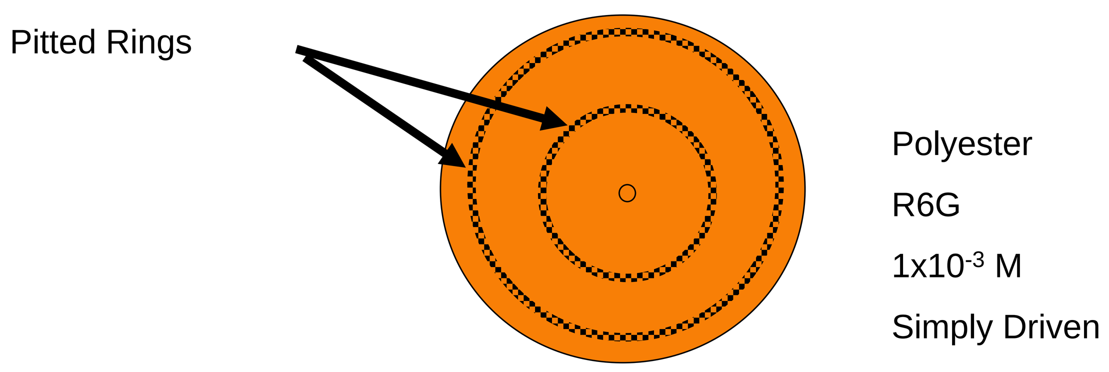
- Reduce hassles of a liquid dye laser, i.e. hazardous liquids
- More compact
- Easily changeable medium

Difficulties

• Upon designing and building a longitudinally pumped solid state dye laser, extreme fatigue of disk medium occurred.

• In order to reduce fatigue and maximize lifetime of the medium, there was a need to minimize the amount of exposure time to pump laser beam.

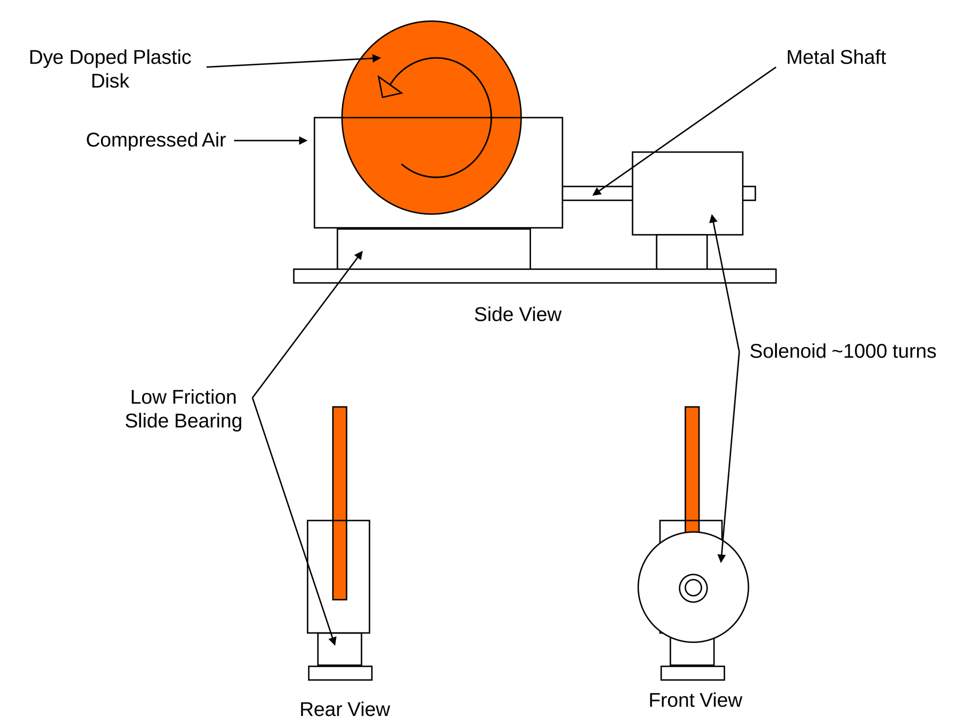
- Problems with thermal damage of disks
  - Solution: Mechanically rotate the disk



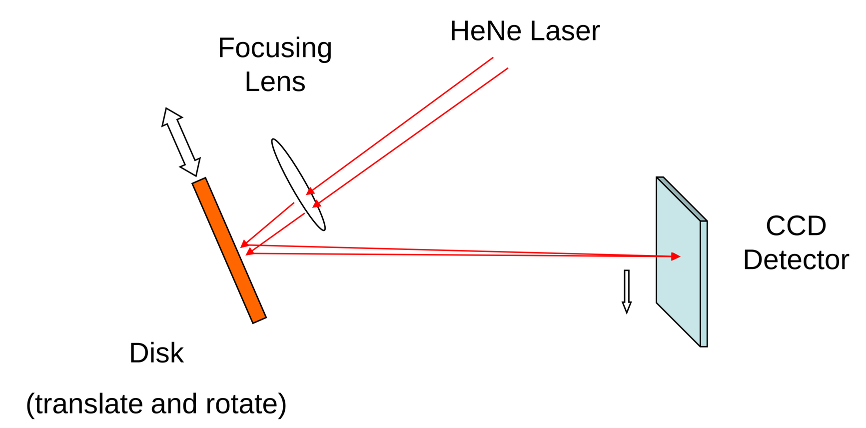
Air Bearing, Random Orbital Drive System

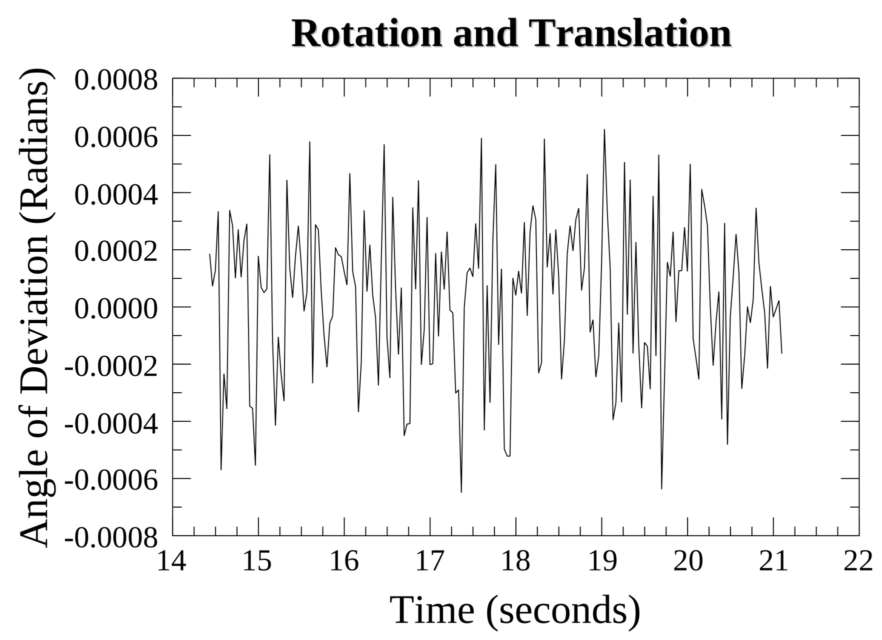
- Linear Motion
  - Translates disk to prohibit unequal exposure to the pump laser at a particular radius
- Orbital
  - Float the disk
  - By introducing turbulence in the air flow on one side of the disk, we can rotate the disk
- Stability

Simplified Schematic of Random Orbital Mechanism



Optical vibration analysis



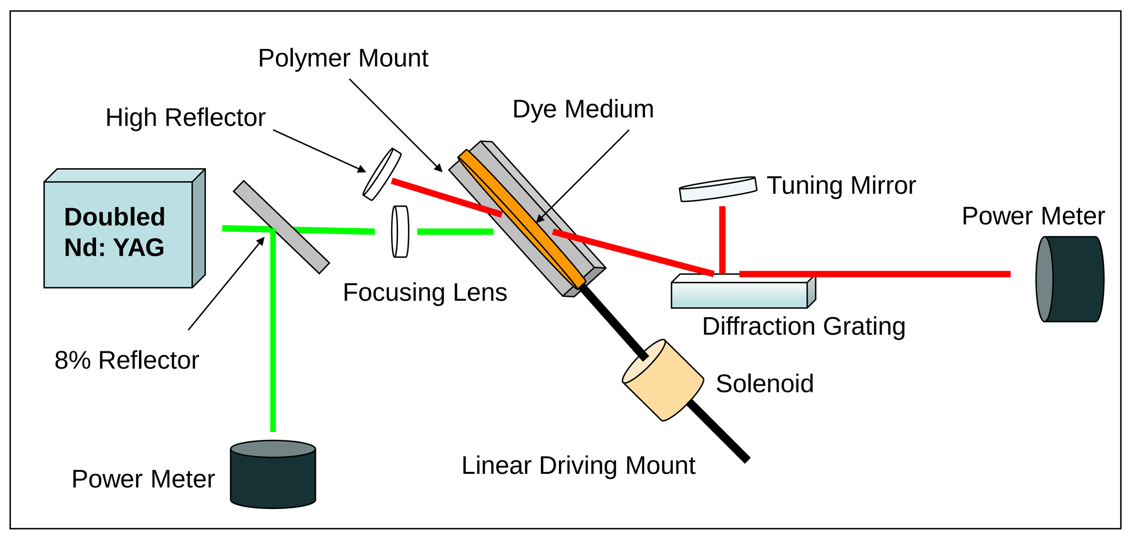


Vibration Measurements

Translation effects	~1x10-4 radians
Rotation effects	~5x10-5 radians
Combined (rotation and translation) effects	~3x10-4 radians

~7.5 micrometers of disk movement fro the disk edge (with combined effects)

Test Configuration

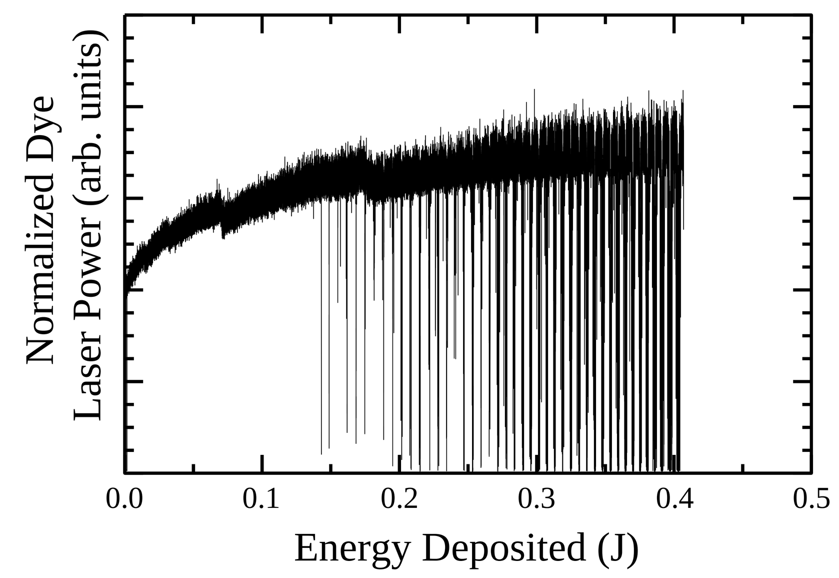


Dye Concentration Issues

- Problems with dye concentrations
  - Too low concentration does not allow lasing
  - Too high a concentration causes the absorption depth to be too small enhancing the thermal damage.
- Solution: Find the lowest concentration that still lases.

Preliminary Results

	Polyester	Polyurethane	PMMA
Power	Osc: 1mW Conc: $1x10^{-3}$M	Osc: .9mW Conc: $8x10^{-4}$M	Osc: .9mW Conc: $1x10^{-4}$M
Tuning Range	573-605 nm	548-600 nm	579-587 nm
Durability	>38,000 pulses	>36,000 pulses	>50,000 pulses
Threshold	15.8 mJ/cm^2	12.5 mJ/cm^2	15.8 mJ/cm^2



Conclusions

- Lifetime of disk is not dye degradation but optical damage of the medium.
- Relative dye laser output actually was increasing with increased total energy deposited.
- Still have stability issues.
- Changing dye disks is trivial.

Further Investigations

- Different host mediums
  - Polyurethane (difficult to polish)
  - PMMA (difficult to make)
  - Hybrid sol-gel plastic host
- Correct stability issues
- Lower energy density in the dye laser medium – closer to threshold – and use an amplifier.