L.5: Laser energy meter using flexible polymer films

Laser energy meters are essential components of every laser laboratory. The commercially available laser energy meters are usually based on single crystal material and hence are expensive. As a result, if they are replaced with a polymer film, the cost will be considerably reduced due to the ease of production, since neither of the steps such as crystal growth, cutting, polishing, or thinning of material are involved in the fabrication process. The working of these laser energy meters is based on the pyroelectric effect. The pyroelectric properties of materials depend on the crystalline phase and domain distribution in the materials. However, the fabrication of sensing elements using ferroelectric polymer is not easy due to domain distribution in polymer and fabrication of β-phase ferroelectric polymer.

Hence, the problem of fabrication of laser energy meter using polymer film was taken up in RRCAT and laser energy meter based on poly (vinylidene fluoride–trifluoroethylene) P(VDF-TrFE) polymer films has been fabricated successfully. In view of technical limitations, a single model of laser energy meter can't satisfy the requirement of energy measurement of all the types of lasers. Therefore, different manufacturers release diverse models of laser energy meters to meet the energy measurement needs of various lasers. Hence, it has also been planned to make ten such models of energy meters using polymer film sensors to meet energy measurement needs in RRCAT.

To begin with, a laser energy meter has been fabricated using polymer film to measure incident laser pulse energy (Figure L.5.1). The polymer film was manufactured using the casting process and conductive coating was applied on both the bottom and top surface of the film. Metallic holders were designed and developed in-house to withstand its arrangement. The components were assembled in this metallic holder and electrical contacts were established. Testing of this fabricated laser energy meter was carried out using pulsed Nd:YAG laser at 1064 nm wavelength. A damage threshold of ~110 mJ/cm^2 at 10 Hz of repetition rate was achieved for 1064 nm of incident laser beam.

The output of laser energy meter is connected with a computer through electronic circuit. A program using LabVIEW software has been developed to record its output in terms of energy unit (milli-Joule). Thus, display unit shows energy of each pulse and average energy of incident laser pulses as shown in Figure L.5.2. Finally, this recorded output data is calibrated using a commercial laser energy meter. Repeatability of these energy meters were tested by fabricating a few laser energy meters keeping identical parameters during fabrication process. The specifications of fabricated laser energy meter (Model-I) are listed in Table -1.

Table 1: Main features of the laser energy meter.

Sr. No.	Parameter	Value
1.	Wavelength range	400 - 2400 nm
2.	Energy range for (400 - 2400 nm)	1 mJ to 1 J
3.	Active area diameter	40 mm
4.	Max energy density	110 mJ/cm^2 (at 1064 nm, 10 ns)
5.	Maximum pulse repetition rate	20 pulse per second
6.	Calibration wavelength	1064 nm
7.	Energy calibration uncertainty	±2 %
8.	Interface	USB
9.	Display	Tablet/Laptop

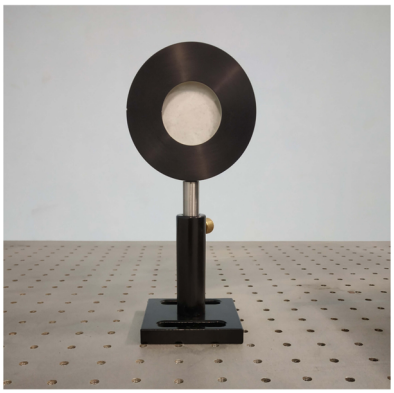

Fig. L.5.1: Laser energy meter fabricated using P(VDF-TrEF) polymer film.

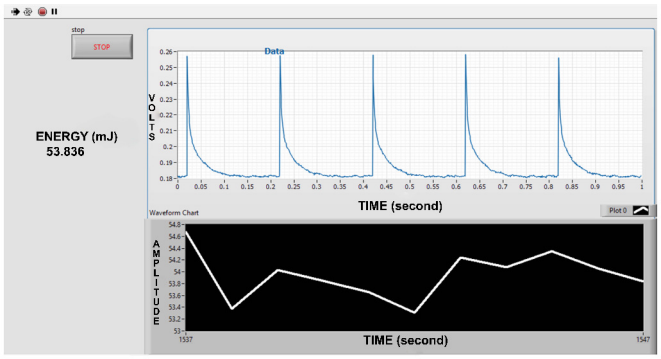

Fig. L.5.2: Developed display compatible with Windows-10, which shows pulse energy as well as average energy with respect to time.

As a future perspective on improving applicability of flexible polymer film-based energy meter for further higher energy measurements, development of laser energy meter (Model-II) is under process.

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