Weighing photons

Background

The range of high power (10 W – 100 kW) laser applications as laser welding, cutting, marking, 3D printing etc. are increasing and accurate measurement of laser power is important for product quality, operational repeatability, and process validation. Accurate real-time measurement of high-power lasers, however, is difficult. Typical thermal power meters must absorb all the laser power in order to measure it. This constrains power meters to be large, slow and exclusive (that is, the laser cannot be used for its intended purpose during the measurement). A way to work around these limitations are to measure high power radiation by measuring the radiation pressure of the beam from a high reflectance mirror. [1,2]

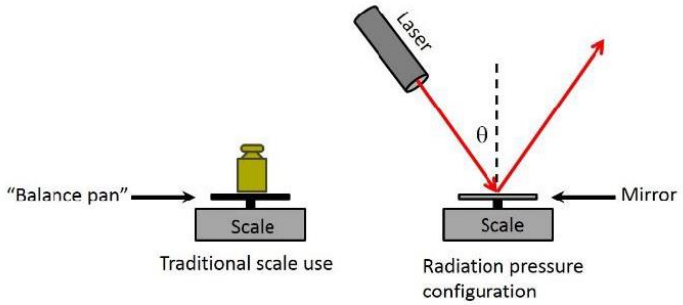

Figure 1. Schematic working principle of a scale configured to be used to measure radiation pressure. Illustration taken from [1].

Task

Review various principles used to measure optical power by exploiting radiation pressure and the required dynamic range for such measurements. Evaluate the possibilities and needed requirements to use microelectromechanical systems (MEMS) as a weighing sensor for photon pressure applications. Design of a MEMS based system, evaluation of sensitivity enhancing techniques and absolute calibration of the system [3] are natural follow up elements for evaluating the system.

Additional information

The task is suitable for a clever and dedicated single student or as shared amongst two students.

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References

[1] Williams P. et. al.: "Measuring laser power as a force: A new paradigm to accurately monitor optical power during laser-based machining operations", SPIE Photonics West, 9741-19, (2016)
[2] Agatsuma K., et. al.: "Precise measurement of laser power using an optomechanical system", Optics Express, Vol. 22, No.2, 27. January 2014.
[3] Stock M.: "Watt balance experiments for the determination of the Planck constant and the redefinition of the kilogram", Metrologia, Vol. 50 (2013), R1-R16.