# Designing of Experimental Setup for Impact Induced Mechanoluminescence Measurements


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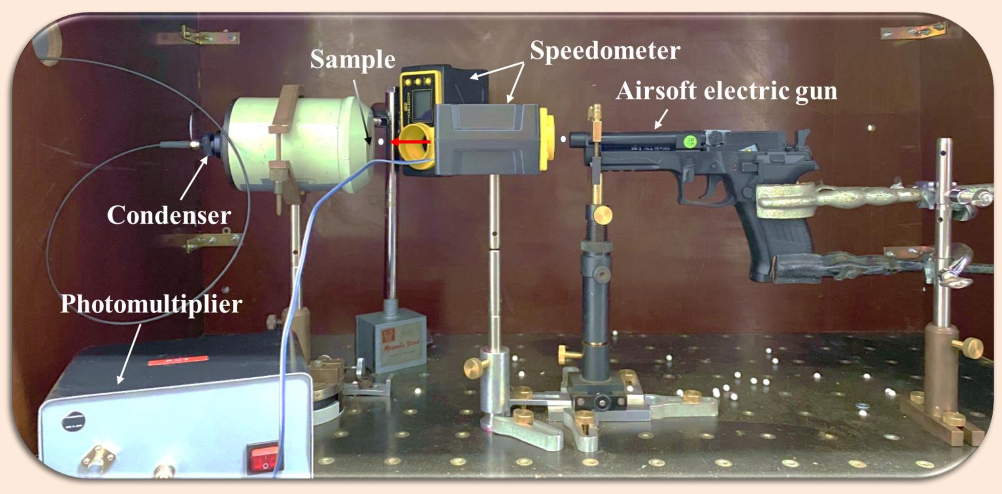
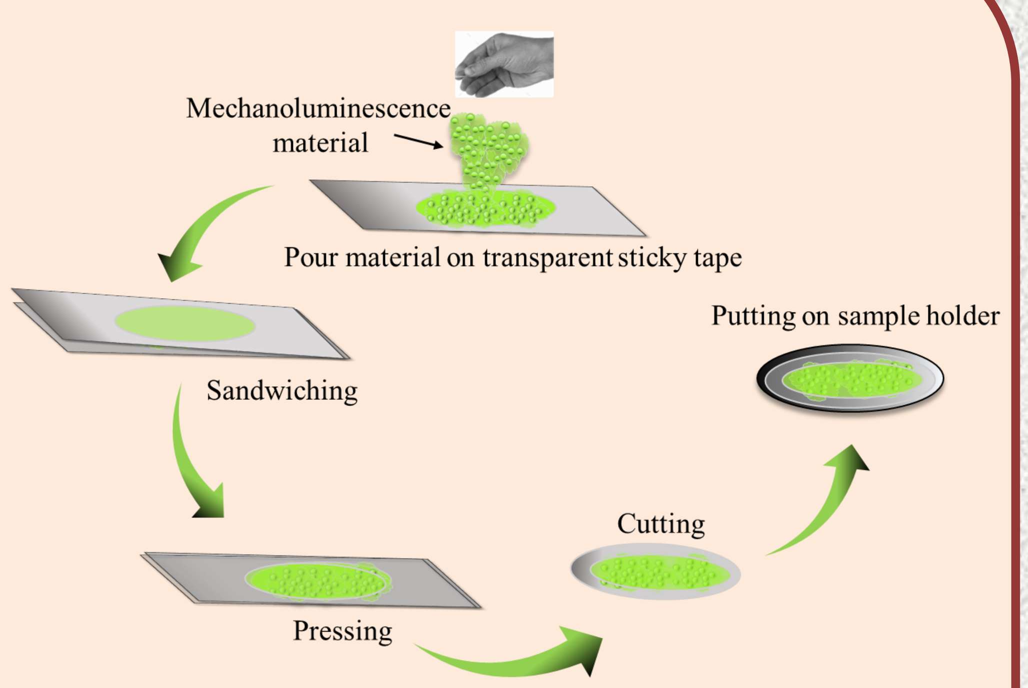
## Motivation and Aim of study

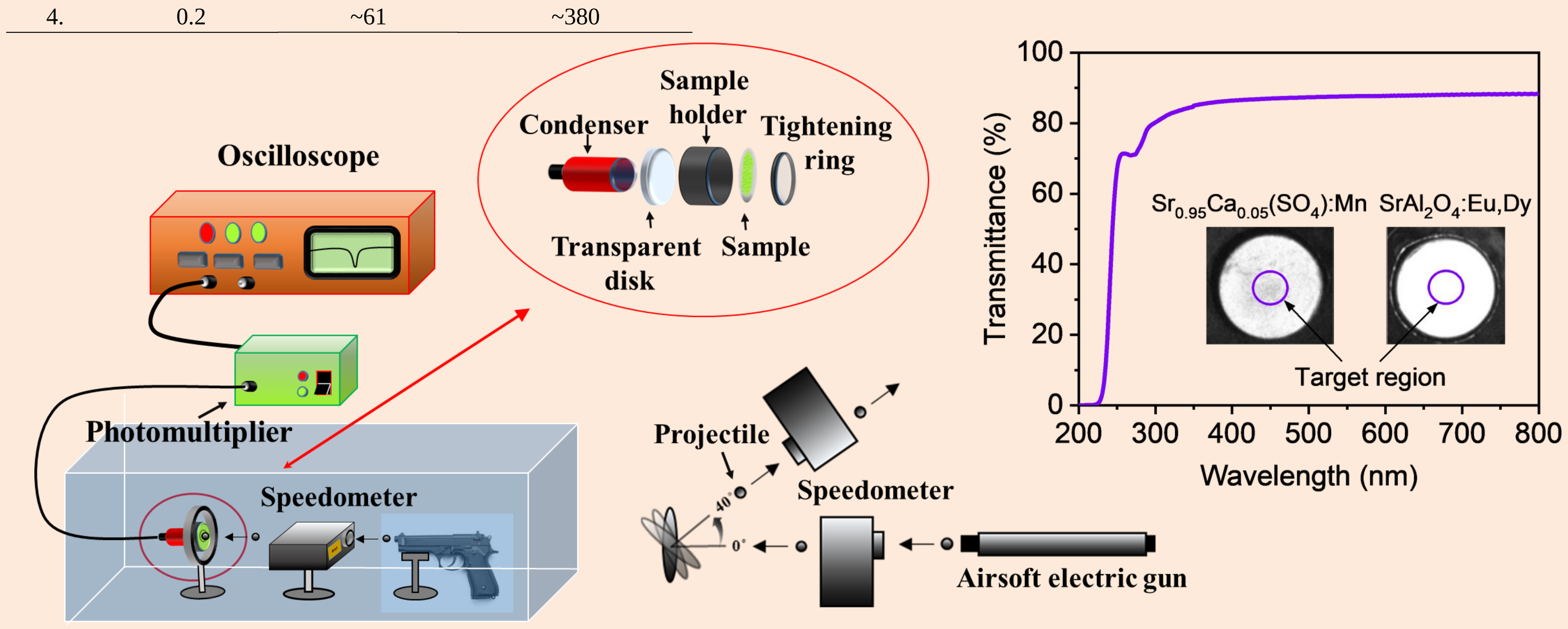
Mechanoluminescence (ML) is a fascinating phenomenon, exhibited by several solid materials in terms of the emission of light upon mechanical stress and physical deformation [1]. Today, the ML have found tremendous applications in robotics, civil engineering, displays and medical science [2]. ML occurs due to the de-trapping of trapped charges, which are found in doped wide band gap semiconductors. In this work, we present a novel designing and performance of a low-cost, simple laboratory set-up to study the mechanical impact induced ML (I-ML) properties of materials, which is different from previously used devices. We conducted comprehensive testing using several commercially available ML materials, such as $SrAl_2O_4$:Eu,Dy, and $Sr_{0.95}Ca_{0.05}(SO_4)$:Mn, to verify the performance of the presented self-designed I-ML.

## Apparatus Description




| S.no | Mass (g) | Speed (m/s) | Kinetic Energy (mJ) |
|---|---|---|---|
| 1. | 0.28 | ~45 | ~280 |
| 2. | 0.25 | ~53 | ~350 |
| 3. | 0.23 | ~55 | ~350 |
| 4. | 0.2 | ~61 | ~380 |

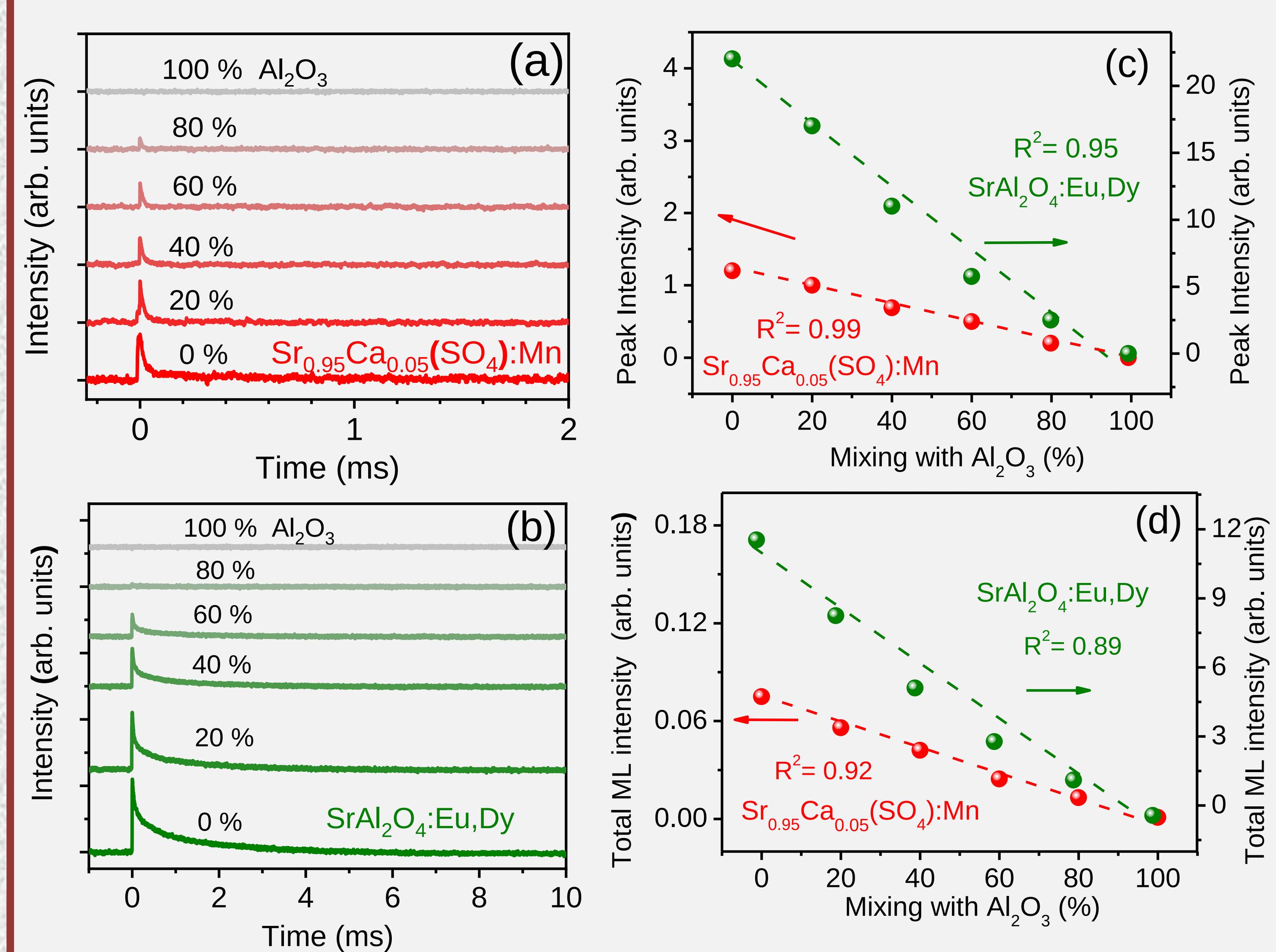



**Side view** **Lateral view**

Deposited Energy, $DE = \frac{1}{2}(mv_i^2 - mv_f^2)$

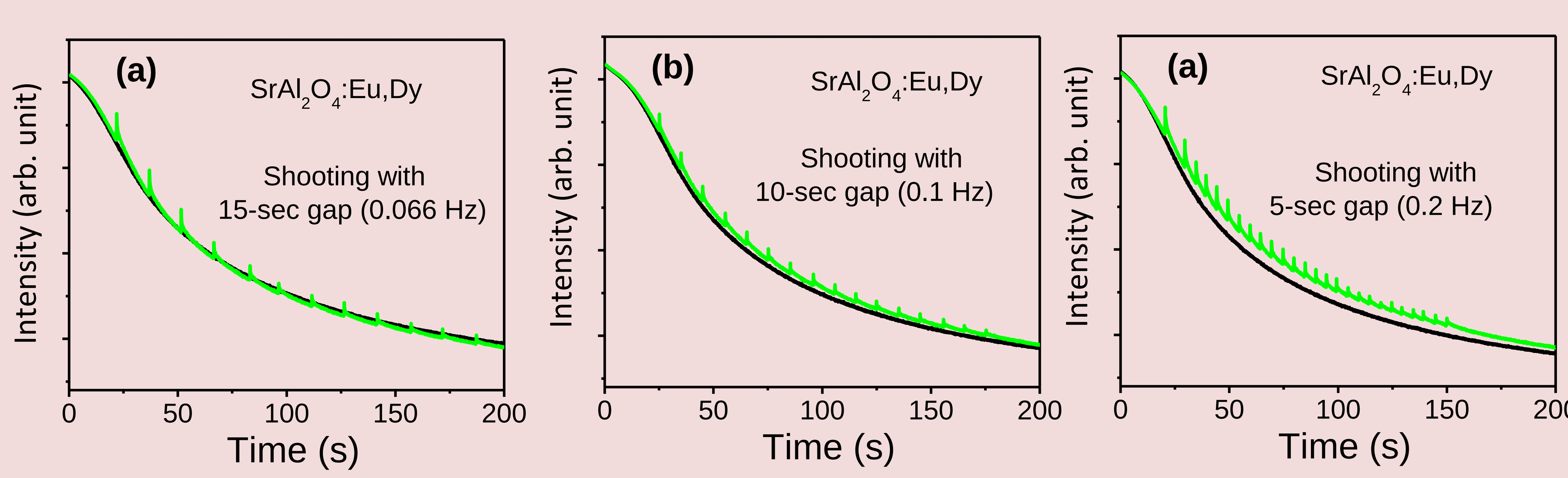
Here, $v_f$ is the velocity of the projectile after striking the target, $v_i$ represents initial velocity before hitting which depends on the type of air gun and the mass of shooting projectile, *m*. We can control initial kinetic energy by changing the masses/speed of the projectile as described in Table.

## I-ML upon non-ML material mixing with ML material



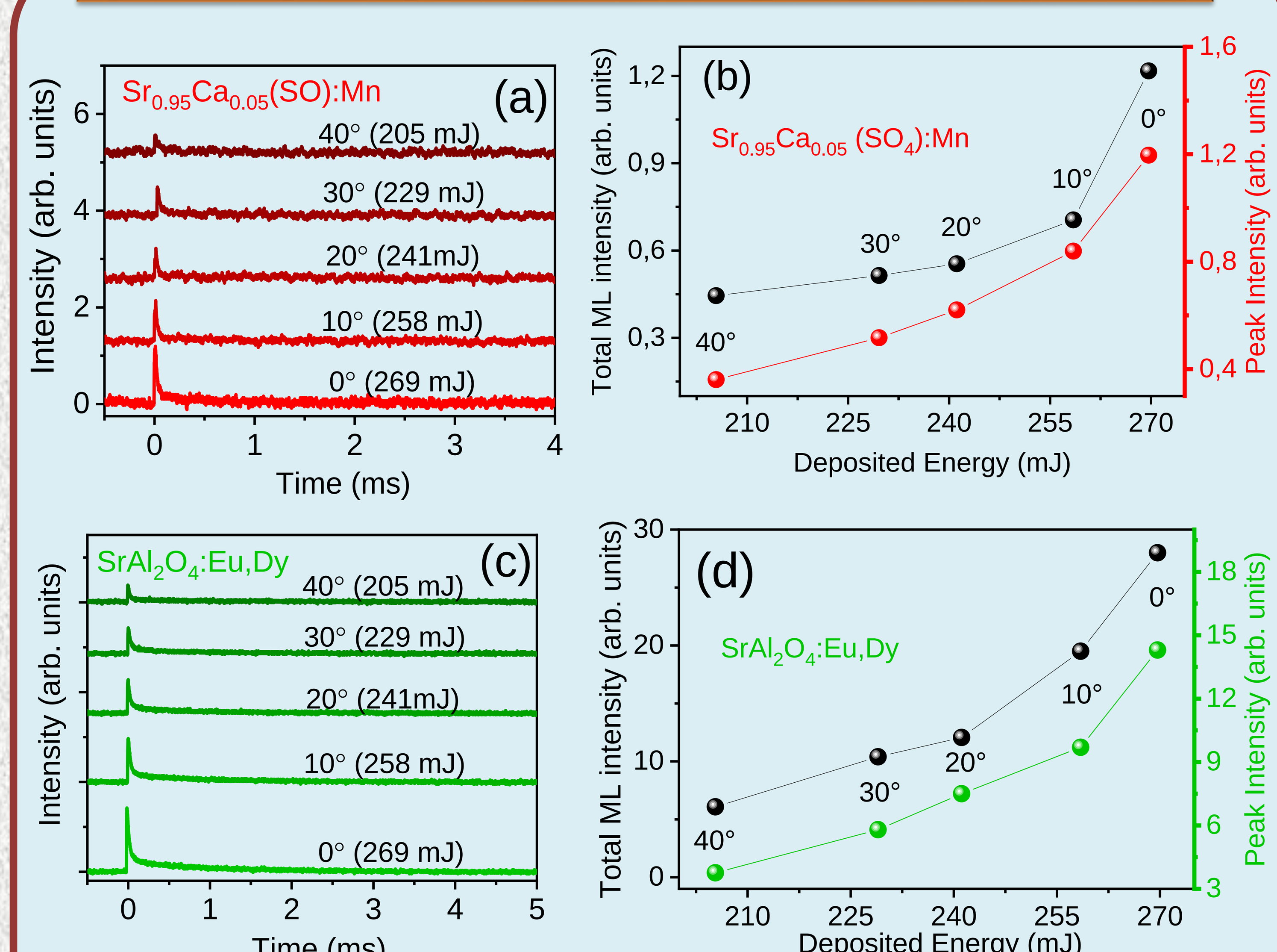

A linear dependence of peak intensity on mixing with $Al_2O_3$ is observed for both examined compounds confirms the accuracy and reliability of the measurement setup for I-ML with excellent sensitivity.

## I-ML's signal for series of shots at several frequencies




These measurements are highly beneficial for investigating the trap states (responsible for persistence + ML) and deep trap states (responsible only for ML) of the testing specimens.

## I-ML's signal by changing incident angle




These results demonstrated the de-trapping of electrons from deep traps might be the main mechanism of ML, depends on deposited energies. i.e, proposed setup is also suitable for the study of energy-dependent I-ML measurements.

## Conclusions

- The self-constructed setup for measuring the I-ML properties is accurately calibrated, and its reliability is also tested by using various ML materials.
- The range of incident kinetic energies can be easily extended, by using another available air-soft gun with different projectile speed or by altering the masses of the fired projectile.
- It would be possible to adapt the setup for the I-ML spectra by replacing the detection part i.e., photomultiplier and digital oscilloscope with a fiber optic spectrometer.
- Such an integrative approach to design a low-cost (~100 €), simple and user-friendly setup helps in exploring the I-ML behavior of ML materials, which is very useful for the advancement of impact detection.

## Acknowledgement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## References


[1] Zhuang, Y. and R.J. Xie, Mechanoluminescence rebrightening the prospects of stress sensing: a review. Advanced Materials, 2021. 33(50): p. 2005925.

[2] Zhang, J.-C., et al., Trap-controlled mechanoluminescent materials. Progress in Materials Science, 2019. 103: p. 678-742.