

Sound-to-light conversion in mechanoluminescent materials

Marcin Runowski^{1,#}, Kevin Soler-Carracedo¹, Przemysław Woźny¹, Fang Zhao¹,
Jan Moszczyński¹, Adrian Drozdowski¹, Tomasz Grzyb¹, Teng Zheng², Dengfeng Peng³,
Justyna Barzowska⁴, Sebastian Mahlik⁴

¹Adam Mickiewicz University, Wydział Chemii, Uniwersytetu Poznańskiego 8, 61-614, Poznań, Poland

²Hangzhou City University, School of Information and Electrical Engineering, Hangzhou 310015, China

³Key Laboratory of Optoelectronic Devices, College of Physics and Optoelectronic Engineering,
Shenzhen University, Shenzhen 518060, China

⁴University of Gdansk, Faculty of Mathematics, Physics and Informatics, Gdansk 80-308, Poland

Mechanoluminescent materials enable non-invasive optical sensing and deep-tissue bioimaging by converting mechanical inputs into self-powered, remotely activated optical signals. Ultrasound-induced ML significantly enhances these capabilities, as focused acoustic waves can trigger light emission through intact tissues with minimal thermal or mechanical damage. This remote excitation is particularly valuable for dynamic sensing and for operation in regions inaccessible to direct mechanical manipulation. Moreover, sono-optogenetics leverages ultrasound-activated ML emitters to stimulate neural tissues without the need for implanted optical fibers, offering a highly promising, minimally invasive neuromodulation strategy. Collectively, these advances position mechanoluminescent systems as attractive platforms for future biomedical diagnostics, imaging, sensing and therapeutic interfaces.

Here we show the use of different mechanoluminescent materials based on ZnS, CaZnOS, SrAl₂O₄, AlN and Al₂O₃, activated with lanthanides (Nd³⁺, Er³⁺, Eu²⁺) and d-block metal ions (Mn²⁺, Cr³⁺), for optical sensing and (bio)imaging. Importantly, the mechanoluminescence effects are generated with ultrasounds, allowing acoustic waves visualization and continuous light generation, due to the sound-to-light conversion phenomenon, accompanied with sound-to-heat conversion. We show the effects of materials excitation with both continuous and pulse acoustic waves, and their implication in temperature sensing and sono-optogenetics. The effects of materials excitation with different stimuli, i.e. light and mechanical waves, are also discussed and compared.[1-3]

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[1] M. Runowski, J. Moszczyński, P. Woźny, K. Soler-Carracedo, J. Barzowska, S. Mahlik, D. Peng, T. Zheng, *Advanced Materials*, 37 (2025) e10117.

[2] A. Drozdowski, K. Soler-Carracedo, J. Barzowska, S. Mahlik, T. Grzyb, M. Runowski, *Small*, 22 (2026) e12389.

[3] T. Zheng, P. Woźny, K. Soler-Carracedo, D. Han, J. Wang, L. Peng, W. Li, D. Peng, H. Wu, J. Moszczyński, S. Mahlik, M. Runowski, *Advanced Materials*, 38 (2026), e11943.

corresponding author: runowski@amu.edu.pl