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Approaches to the new field of multi-piezo: Ceramics, films and composites

Piezoluminescence, which is also called elasticoluminescence, is a form of mechanoluminescence (ML) during the elastic deformation, which has attracted considerable attention because it can be repeatedly used for mechano-optical conversion. Elastic ML offers the advantages of wireless detection and nondestructive analysis, making it a promising candidate for various applications, such as stress sensing and damage diagnosis, and in particular for immediate *in situ* dynamic visualization of stress distribution in industrial plants, buildings, and living organisms. In piezoelectric materials, mechanical stimuli generate electricity, a phenomenon that is widely utilized in industry and daily life. Recently, we have found the first well-known piezo multifunctional material that exhibits both piezoelectricity and efficient elastic ML. By precisely tuning the Li/Nb ratio in nonstoichiometric $LiNbO_3:Pr^{3+}$, a material that exhibits an unusually high piezoluminescence intensity, which far exceeds that of any well-known piezoelectric material, is produced. $LiNbO_3:Pr^{3+}$ shows excellent strain sensitivity at the lowest strain level, with no threshold for stress sensing. These multipiezo properties are useful for nano-micro sensing, damage diagnosis, electro-mechano-optical energy conversion, and multifunctional control in optoelectronics.

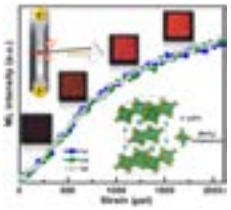

Figure 1: ML response of LiNbO3:Pr.

Recent Publications

1. J Li et al. (2018) Tailoring bandgap and trap distribution via Si or Ge substitution for Sn to improve mechanoluminescence in $Sr_3Sn_2O_7:Sm^{3+}$ layered perovskite oxide. Act. Mater. 145:462-469.
2. D Tu et al. (2017) $LiNbO_3:Pr^{3+}$: a multi-piezo material with simultaneous piezoelectricity and sensitive piezoluminescence. Adv. Mater. 29(22):1-4.
3. A Yoshida et al. (2017) Mechanoluminescent testing as an efficient inspection technique for the management of infrastructures. J. Disas. Res. 12(3):506-514.
4. Y Fujio et al. (2016) Sheet sensor using $SrAl_2O_4$:Eu mechanoluminescent material for visualizing inner crack of high-pressure hydrogen vessel. Int. J. Hydrogen Energy. 41(2):1333-1340.

Biography

Chao Nan Xu is the Principle Research Manager at National Institute of Advanced Science and Technology (AIST), Founder and Chair of Mechanoluminescence Technology Consortium, Fellow of the Ceramic Society of Japan. She has been concurrently serving as Full Professor of New Material Lab at Kyushu University since 2005. She discovered the intensive new type of elasticoluminescence, and established the hybrid concept of inorganic/organic composite coating (skins) and the principle for quantitative analysis of stress/strain and faults. She also made discovery of grain size effect for gas sensitivity. She pioneered the new repeatable mechanoluminescent materials and their novel applications particularly in lighting, health care, and stress/strain visualization.

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