Extended Abstracts of the 2006 International Conference on Solid State Devices and Materials, Yokohama, 2006, pp. 846-847

B-7-5

Photocell system driven by Mechanoluminescence

Nao Terasaki[1], Chao-Nan Xu [1], Yusuke Imai[1] and Hiroshi Yamada[1]

[1] National Institute of Advanced Industrial Science and Technology (AIST)
, On-Site Sensing and Diagnosis Research Laboratory
807-1 Shuku-machi, Tosu, Saga 841-0052, JAPAN
Phone: +81-942-81-4038, Fax : +81-942-81-3690, E-mail: nao-terasaki@aist.go.jp

1. Introduction

The mechanoluminescence (ML) material in the elastic region is a new material, which was developed in our laboratory for the first time, and can give intensive visible light emission during the application of mechanical stress, for example displacement, friction, impact and so on [1-6]. From the previous works, we have obtained the important results listed as below.

1. High stress-photon conversion efficiency has been realized.
2. The intensity of ML is proportional to the energy of stress which is applied to the material.
3. The preparation of ML particles in the nanometer order has been succeeded (Fig. 1).

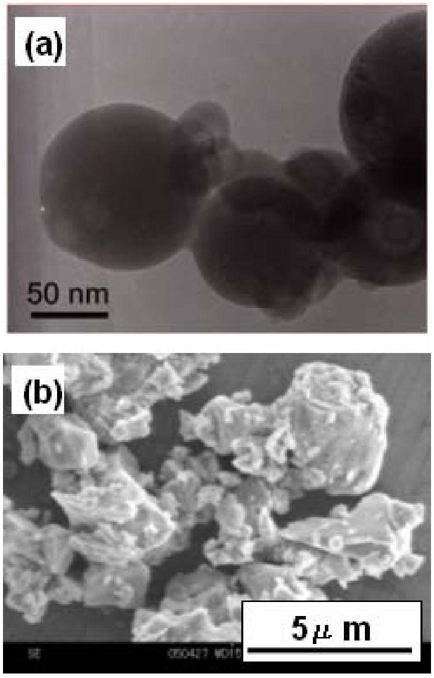

Fig. 1. (a) TEM image of ML nanoparticle, (b) SEM image of traditional ML powder (SAO-E).

By using this material as stress probes, 2 (or may be 3) dimensional stress distributions can be visualized directly and dynamically (Fig. 2). From the viewpoint, the killer application of this material has been, and will be, recognized to monitor the stress distribution of plants and structures from the view point of safety maintenance and reliability improvements.

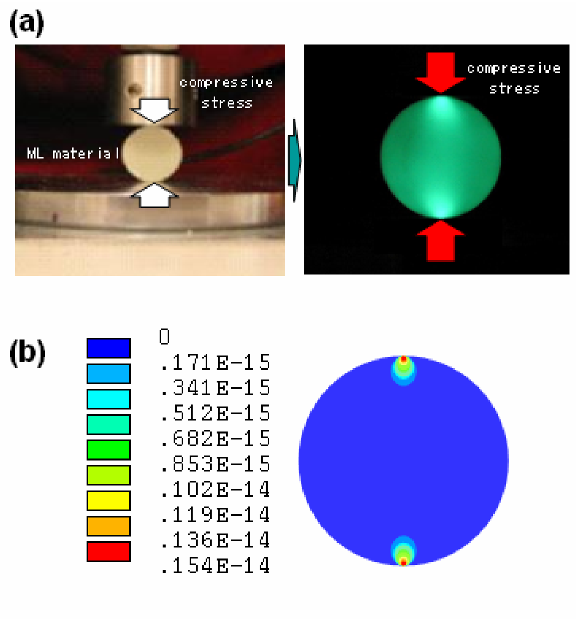

Fig. 2. (a) Picture of ML during the application of compressive stress on cylindrical structure. (b) Simulation of stress distribution upon the intensity distribution corresponds well with the simulation.

Recently, however, with the increase of the ML conversion efficiency, the ML can be observed even under the low applied load power, just like pushing with finger. From these view points, the light source has been certainly in the range as the ability of ML material. In addition, because the ML particle emit light one by one particle itself, in the future, the material can be act as an ubiquitous light source in the micro-nano order.

Here, we report a novel ML driven photocell system consisting of a ML material and a photocell, and the ability of ML material as a light source, which is induced mechanical stress.

2. Experimental

Europium doped strontium aluminate system (denoted as $SrAl_2O_4$:Eu, or SAO-E, shown in Fig. 1b and Fig. 2a [4]) was used as a ML material, because SAO-E was one of the most efficient ML system at this time. On the other hand, an amorphous mono-crystal silicon solar-cell was used as a solar system because of the high photo-electric conversion efficiency. The compressive stress, which induces the green light (510 nm) from SAO-E, was applied by the material testing machines (shown in Fig. 2a), and the current from photocell was observed by the ampere meter (Keithley Instruments Inc.) [7, 8].

3. Results

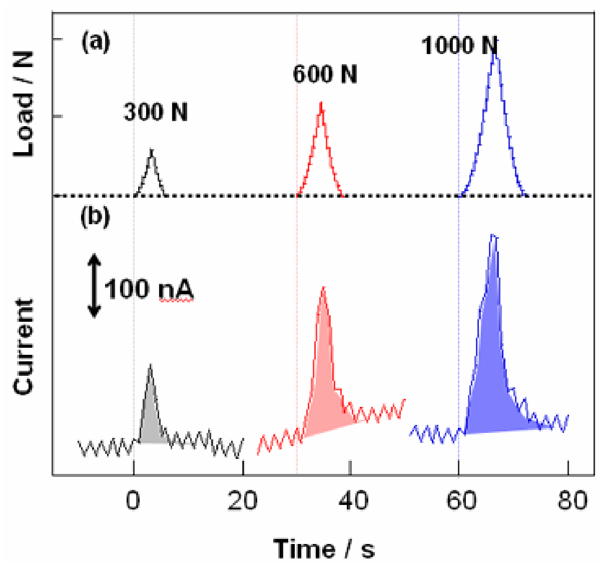

Fig. 3. Correlation of load for the ML material (a) and photocurrent generation (b).

When the load was applied to the ML material (SAO-E), the corresponding photocurrent was observed (Fig. 3). The photocurrent intensity increased with the increase of the load power, exactly the integral of peak area is proportional to the load power. This can be explained with the two proportionally relationships, which are (1) applied load and ML intensity, and (2) irradiated light and photocurrent intensity.

3. Conclusions

We report a novel ML driven photocell system consisting of a ML material and a photocell, and showed that ML material can be act as a light source.

References

[1] C. N. Xu, T. Watanabe, M. Akiyama and X. G. Zheng, Appl. Phys. Lett. **74** (1999) 2414.

[2] C. N. Xu, X. G. Zheng, T. Watanabe, M. Akiyama and I. Usui, Thin Solid Films **352** (1999) 273.

[3] C. N. Xu, T. Watanabe, M. Akiyama and X. G. Zheng, Appl. Phys. Lett. **74** (1999) 1236.

[4] C. N. Xu, X. G. Zheng, M. Akiyama, K. Nonaka and T. Watanabe, Appl. Phys. Lett. **76** (2000) 176.

[5] H. Matsui, C. N. Xu and H. Tateyama, Appl. Phys. Lett. **78** (2001) 1068.

[6] Y. Liu and C. N. Xu, J. Phys. Chem. B **107** (2003) 3991.

[7] N. Terasaki, K. Kakutani, T. Akiyama and S. Yamada, Synth. Met. **139** (2003) 511.

[8] N. Terasaki, K. Otsuka, T. Akiyama and S. Yamada, Jpn. J. Appl. Phys. **43** (2004) 2372.