2012 International Conference on Solid State Devices and Materials
= Short Course (1) =
Solid State Devices and Materials for Sustainable Power Generation

September 24, 2012, Kyoto International Conference Center, Kyoto, Japan

Organizers

Yoshinari Kamakura (Osaka University) and Shigeyasu Uno (Ritsumeikan University)

There are great expectations for the development of the energy harvesting solid-state devices and materials pursuing sustainable power generation. In this short course we will present the lectures from leading experts in the fields of materials, devices, and circuits for realizing highly efficient energy harvesting from various types of renewable energy sources such as solar, vibration, heat, microwave, and biochemical energy. All lectures will be given in English, and will include from the fundamentals to the state-of-the-art, aimed at graduated students and young researchers from both industry and academia.

Speakers

13:00 "Vibration-driven micro energy harvesting"

Prof. Hiroki Kuwano (Tohoku University)

Micro energy harvesting converts energy from the environment in the forms of light, heat, and vibration into electric power. An important issue in advancing wireless sensor network technology is how to supply energy to possibly numerous sensor nodes for which a battery replacement is impractical or impossible. In such a case, three energy resources will play largely complementary roles. The advantage of vibration-driven energy harvesting is that it works when light and heat are absent. The author will introduce and discuss the state of research and development in the field of vibration-driven energy harvesting.

13:45 "Microwave Power Transmission and Energy Harvesting"

Prof. Yasuo Ohno (Tokushima University)

Wireless power transmission is being developed for various purposes with wide signal frequencies of kHz, MHz and GHz. Among those, microwave will be used for wide applications ranging from cosmic scale to mobile phone size with various microwave transmission technologies.

Despite the divergence of the transmission technologies, common technology will be used for DC/RF and RF/DC conversion sections. Due to the high frequency and high power requirements, high electron mobility and high breakdown field strength are the key for the devices. Therefore, GaN based devices, such as AlGaN/GaN HFET for transmitter and GaN SBD for rectifier, will be suitable for these applications. With the high RF/DC conversion efficiency, they will be used for even energy harvesting, which is the conversion of ambient microwave energy into the power for small devices in wireless networks.

In this short course, the basic ideas for the wireless power transmission will be presented, and then, the circuits and devices for DC/RF and RF/DC conversion will be explained.

14:30 "Ultra-low Power and High-Performance Analog Circuit Design Techniques for Energy-Harvesting Systems"

Prof. Tetsuya Hirose (Kobe University)

Energy harvesting systems have attracted much attention for realizing green electronics applications. There are several studies to harness the power from the ambient by using light, vibration energy, thermal energy, and so on. However, because the harvested power from these energy sources is small in the range of several tens of microwatts or less, ultra-low power circuit design techniques are strongly required. In this presentation, preliminaries for energy harvesting from the ambient energy, including state-of-the-art reports, will be discussed. And ultra-low power and high performance analog circuit design techniques for energy harvesting will also be presented.

Break (20min.)

15:35 "Quantum dot solar cells ~Trends and challenges in high-efficiency photovoltaics~"

Prof. Yoshitaka Okada (The University of Tokyo)

Advanced concepts using quantum dots (QDs) for increasing the conversion efficiency of solar cells exceeding the Shockley-Queisser limit are under intense research in recent years. In the short-course, quantum dot-based concepts such as intermediate-band (IB), multi-exciton generation (MEG) and hot carriers will be reviewed. The materials issues, fabrication methods, and recent experimental challenges to demonstrate these types of solar cells will also be covered.

In an QD-IB solar cell, for example, a QD superlattice is inserted in the active region of a pin junction. The presence of IB leads to generation of a net electron-hole pair when 2 sub-bandgap photons are absorbed, *i.e.* one photon pumps an electron from the valence band (VB) to IB, while a second photon pumps an electron from the IB to conduction band (CB). These electron-hole pairs add to those produced by the band-to-band transitions with photons above the bandgap energy that excite the electrons directly from VB to CB.

16:20 "Thick film thermoelectric material and its deposition technology"

Dr. So Baba (National Institute of Advanced Industrial Science and Technology)

Around 34% of the total energy consumed from primary energy such as fossil fuels is effectively used while the remaining 66% is released to the natural environment as waste heat energy. In particular, the waste heat below 150ºC is responsible for around 50% of total waste heat. Thermoelectric generators are devices which are the direct energy conversion from heat into electricity and have attracted much attention as a renewable energy solution. Low-temperature waste heat is difficult to utilize because it is localized and diluted. Thus large-area thick-film thermoelectric module is a particularly attractive to gather and harvest the heat sources. While thermoelectric research has focused on the synthesis of novel and efficient bulk materials, film manufacture has received less attention. We have recently been investigating thermoelectric films formed by aerosol deposition (AD). AD is based on shock compaction of particles in starting powders at room temperature. In the AD, the compaction enables deposition of high-density films that are less than 1 μm thick to several hundreds of micrometers thick on various substrates such as glass, metal, ceramic, and plastic. In this presentation, the necessity of thick film thermoelectric materials and the AD technique for its application will be reviewed.

17:05 "Biofuel cell"

Dr. Hideki Sakai (Sony Corporation)

Biofuel cells can generate electricity under mild conditions through the oxidation of renewable energy source such as sugars or organic acids, coupled with the reduction of O_2, by using enzymes or microorganisms as catalysts. Biofuel cells are expected to be a next-generation energy devices with more eco-friendly system and higher energy density, compared to the present devices. In this short course, the background, the research trend, and the future technology will be shown.