Symposium I

Rare Earth Doped Advanced Materials for Photonic Applications

Scope and Focus

The aim of this symposium proposal is to provide to the phosphors and semiconducting communities a unique opportunity to discuss the fundamental topics of common interest that underlie the emission in rare earth (RE) doped materials.

In phosphors, a large amount of work has been carried out and now there are numerous applications, especially in the display and lighting industries. The recent hottest issue is the development of phosphors for white LEDs, in which a new class of host materials including nitrides and oxy-nitrides for RE luminescent centers has been produced in terms of the light absorption in the near-UV to blue spectral region and the spectral control of light emission. The tremendous efforts to improve their performance have accelerated the commercial use of white LEDs in general lighting and backlighting in LCDs. In addition, this concept of wavelength conversion and photon cutting has led to new research avenues and new applications of RE-activated phosphors. One such target is wavelength conversion for Si-based solar cells, in which shorter wavelength components in the sunlight are altered to near IR lights by the phosphor layer to meet the optimum operating condition. Similarly, on the other side of the solar spectrum, RE ions are also explored for upconversion of low-energy photons which are commonly lost in photovoltaic devices. Optimization of the underlying mechanisms has also made basic studies of the structural and electronic properties of the RE ions in these materials critical stimulating both research of the experimental and theoretical aspects.

In semiconductors, important contributions have been made to electroluminescent devices based on Er-doped Si crystals or nanocrystals within amorphous matrix (Si/SiO2, ...). The ambition of many researchers in the photonics area is to realize high efficiency light emission from a Si host, preferably through CMOS compatible processes. Several techniques have been tried in the last 20 years, and doping Si-based materials and light emitting devices with rare earths has emerged as the strongest contender. The remarkable activities of Er-doped fiber amplifiers (EDFA) in the optical network have inspired to develop RE-doped light emitting devices for “silicon photonics”. As processing for nano-devices becomes ever more sophisticated, so too does the development of photonic devices based upon waveguides, resonant cavities and photonic crystals. Considerable progress has been made in understanding luminescence from REs sensitized by nanoclusters in SiO2 and/or Si oxy-nitrides, and under radiative fields controlled by the photonic structures.

In the last few years, there has been considerable research activity in doping wide-bandgap semiconductors such as GaN, SiC, and ZnO, with Er as well as with other rare earth elements such as Pr, Eu, Tb, and Tm in order to obtain efficient visible emission. New opportunities have been opened out by the recent demonstration of the red LED with Eu-doped GaN as well as room-temperature ferromagnetism upon Gd/Eu/Dy doping of GaN.

The goal of this symposium is to highlight the status of light emission at infrared and visible wavelengths from RE-doped phosphors as well as semiconductors. It will address topics
from basic to application driven research. Contributions are solicited on, but not limited to the following topics:

**Topics to be addressed include (but are not limited to) the following**

- **Materials**
  - Bulk, thin film, and nanocrystalline host materials
  - Phosphors,
  - Laser materials
  - Rare earth doping techniques
  - Structural characterization

- **Mechanisms**
  - Characterization
  - Theoretical investigations
  - Coupling
  - Excitation
  - Energy transfer
  - Optical manipulation of spins in DMS
  - Spin polarisation vs light polarisation

- **Devices**
  - Emitters
  - Wave guides
  - Amplifiers
  - Solar cells
  - Novel applications

**List of Invited Speakers**

- **Silicon related photonics**
  - T. Kimura (University of Electro-Communications, Japan)
  - J. H. Shin (KAIST, Korea)

- **GaN & compound semiconductors**
  - A. Koizumi (Osaka University, Japan)
  - K. Dohnalova (University of Amsterdam, the Netherlands)

- **Phosphors**
  - H. Daicho (Koito Manufacturing Co. Japan)
  - M. Mikami (Mitsubishi Chemical, Japan)
  - S. Tanabe (Kyoto University, Japan)

- **Magneto-optics in dilute magnetic semiconductors**
  - V. Kachkanov (Diamond Light Source, UK)
  - T. Kita (Kobe University, Japan)
  - J. Zavada (NSF, USA)

- **Mechanisms**
  - M. Ishii (NIMS, Japan)
• Solar cells
  J. C. Hummelen (Groningen University, the Netherlands)

Symposium Organizers

Lead Organizer (Point of Contact)
Yasufumi Fujiwara:
Division of Materials and Manufacturing Science, Graduate School of Engineering,
Osaka University
2-1 Yamadaoka, Suita, Osaka 565-0871, Japan
Phone: (+81)-6-6879-7498
Fax: (+81)-6-6879-7499
E-mail: fujiwara@mat.eng.osaka-u.ac.jp

Co-Organizers
Kazuhiko Hara:
Electronics Research Institute, Shizuoka University
3-5-1 Johoku, Naka-ku, Hamamatsu 432-8011, Japan
Phone: (+81)-53-478-1362
Fax: (+81)-53-478-1362
E-mail: hara@rie.shizuoka.ac.jp

Hideo Isshiki
Department of Engineering Science, The University of Electro-Communications
Chofugaoka 1-5-1, Chofu-shi, Tokyo 182-8585, Japan
Phone: (+81)-424-43-5152
Fax: (+81)-424-43-5153
E-mail: hisshiki@ee.uec.ac.jp

Tom Gregorkiewicz:
Van der Waals - Zeeman Institute, University of Amsterdam
Science Park 904, NL-1098 XH Amsterdam, the Netherlands
Phone: (+31)-20-525-5643
Fax: (+31)-20-525-5788
E-mail: t.gregorkiewicz@uva.nl

Volkmar Dierolf:
Department of Physics, Lehigh University
16 Memorial Drive East, Bethlehem, PA 18015, USA
Phone: (+1)-610-758-3915
Fax: (+1)-610-758-5730
E-mail: vod2@lehigh.edu
Optional comments

Previous history at MRS and E - MRS meetings is as follows:

MRS Meetings
“Rare Earth Doping of Advanced Materials for Photonic Applications,” Spring 2011.
“Rare Earth Doping of Advanced Materials for Photonic Applications,” Fall 2008.
“Rare Earth Doping for Optoelectronic Applications,” Spring 2005.
“Rare Earth Doping for Semiconductors II,” Spring 1996.
“Rare Earth Doped Semiconductors I,” Spring 1993.

E-MRS Meetings
“Rare earth doped semiconductors & nanostructures for photonics,” Fall 2011.
“Rare earth ion doping for photonics: materials, mechanisms and devices,” Spring 2010.
“Rare earth doped photonic materials,” Spring 2005.
“Rare earth doped materials for photonics,” Spring 2003.
“Rare earth doping for semiconductors III,” Spring 2000.

Each of these meetings had more than 100 participants from around the world and resulted in printed proceedings.

Y. Fujiwara:
Prof. Fujiwara’s area of expertise is in the growth, characterization, and application of rare earth doped semiconductors such as GaAs, GaN and ZnO. He was an organizer of the symposiums on the same topic at the MRS Spring Meeting in 2005 and 2011, the MRS Fall Meeting in 2008, the E-MRS Spring Meeting in 2003 and 2005, and the E-MRS Fall Meeting in 2011.

K. Hara:
Prof. Hara’s area of expertise is in the crystal growth and characterization of rare earth doped GaN-based materials and phosphors.

H. Isshiki:
Prof. Isshiki’s of expertise is in growth and characterization of rare earth complex materials such as silicates and oxides, and their device applications to silicon photonics. He is a vice-chair of the program committee on photonic devices at SSDM 2012.

V. Dierolf:
Prof. Dierolf’s area of expertise is in the site-selective optical spectroscopy and microscopy of rare earth doped insulators and semiconductors. Until Aug. 2009, he was Principal Editor of JMR. He was an organizer of the symposiums on the same topic at the MRS-Spring Meeting in 2011 and the MRS-Fall Meeting in 2008.

T. Gregorkiewicz:
Prof. Gregorkiewicz’s area of expertise is in optical characterization of Er-doped Si nanocrystals embedded in SiO₂ and rare-earth-doped semiconductors. He was an organizer of the