Energy-efficient Visible Light Communication

What is the problem?

The white light-emitting diode (LED) stands at the threshold of a new era of energy-efficient lighting bringing revolutionary advances in the use of light for illumination and a host of other applications, including sensing, navigation, and communications. With the increasing global demand for “anywhere, anytime” connectivity to mobile devices, there is a growing need to develop wireless access technologies that are broadband, interference-resistant, reliable, and cost-effective. The proposed research is a major step towards the vision of ubiquitous wireless connectivity and the development of “green”, environmentally-friendly wireless networks using white LEDs. Our research addresses the need to develop low-power, integrated hardware components for “smart lighting systems” combining illumination control and high-speed wireless access in a single platform.

Why is it an important problem?

Optical signal processing hardware that takes advantage of state-of-the-art silicon integrated circuit technology is key to realizing energy-efficient “smart lighting systems”. To extend the bandwidth capabilities of current RF wireless systems will require complex, power-hungry signal processing hardware. Solid-state lighting systems provide a means for pervasive communication that is cost-effective and multifunctional with energy management and illumination control. Furthermore, “smart lighting systems” will address a number of needs for miniaturized, energy-constrained sensor network nodes requiring sensor signal processing, communication, memory, and energy management in system-on-chip platforms.

How are we addressing the Problem?

We are developing integrated circuits and systems combining photonic devices and analog/mixed-mode circuit architectures in a single system-in-package solution. We are designing optical driver circuits enabling color quality control and feedback control for temperature compensation and LED stability. The optical characteristics of silicon in the visible range are ideal for monolithic receivers combining photodetectors and signal processing, and energy management circuitry on a single die. We are also investigating the feasibility of optical wavelength division multiplexing (WDM) and multi-level signaling to increase aggregate data capacity.

Project related picture:

(Image courtesy of Boston University)

What are the expected results and impact?

Energy-efficient solid-state lamps open new possibilities for architectural lighting systems, consisting of networked solid-state lamps with multi-variable distributed control, adaptive features to alter color quality temperature, and high-speed data transmission. One of the key merits of optical wireless systems, which operate at baseband, is the relatively low transceiver complexity and low energy-per-bit required for data transmission compared to RF systems. Furthermore, transceiver integration using well-developed silicon processing paradigms, which are inherently low-power, show promise in providing combined illumination/communication networks with “net-zero” energy increase using LEDs. Such systems provide an opportunistic medium for:

1. **Light Therapy**: There are quantifiable correlations between lighting and specific health disorders. Color-tuning can be applied for circadian rhythm adjustment and other therapeutic features.
2. **Communications**: High-definition video streaming in homes, airplanes, airports, and hospital/medical care centers where RF is prohibited or RF bandwidth is limited.
3. **Industrial Automation/Control**: Sensor networks to ensure vibration, pressure, temperature, flow, and level measurements in industrial areas that are uneconomical to wire.
4. **Smart Grid**: Intelligent, indoor wireless systems to control utility loads and home appliances to save energy and increase grid reliability.

Who is sponsoring this project?

National Science Foundation – Engineering Research Center on Smart Lighting
http://smartlighting.rpi.edu/

How can we find more Information on this Project?

www.ece.tufts.edu/~vjoyner