Electro-Optics & Physics Joint Seminar
Friday, October 25, 2013
3:00 pm CPC 568

Advancing silicon photonics: Approaches to producing infrared active materials and devices on Si

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Abstract

Silicon is the basis for a multi-billion dollar industry, but its optical properties have limited its use in optoelectronics. Its high band gap prohibits optical absorption in much of the infrared, and the indirect nature of the band structure prevents it from being used as a source for optical emission. Infrared optoelectronic devices realized directly on Si could be used for photovoltaics, infrared detection and imaging, optical interconnects, and infrared lasers.

In this talk, I will discuss two different approaches to producing infrared materials and devices compatible with conventional Si processing. First, I will explore the epitaxial growth and properties of Sn-based Group IV alloys on Si substrates using low pressure chemical vapor deposition (LPCVD). Materials with Sn content up to 5% exhibit strong optical absorption and photoconductivity well below the band gap of Si, and they have been used to fabricate prototype detectors with extended wavelength response, as well as infrared LEDs. More recently, the Sn content in these films has been increased to near 10%, and the resulting films have a nearly direct band gap, which could lead to the fabrication of a new laser on Si.

The second approach I will discuss is the modification of the Si band structure through a process known as hyperdoping. Ion implantation of transition metals into Si is performed at very high doses, followed by irradiation by a ns-scale UV laser pulse that melts and resolidifies the implanted crystal. This process yields single crystalline Si with very high amounts (orders of magnitude greater than the solid solubilities) of impurities, which can lead to the formation of an intermediate band in Si. The intermediate band can be used as an intermediate transition between the valence and conduction bands of Si, leading to enhanced absorption and photoconductivity well below the band gap of Si.

Biography

Dr. Jay Mathews is currently an Assistant Professor in the Department of Physics at the University of Dayton. He obtained his BS with double major in Physics and Mathematics from Colorado State University in 2007, and he received his PhD in Physics from Arizona State University in 2011. Following graduation, Dr. Mathews was awarded a fellowship in the National Academy of Sciences Research Associateship Program, where he performed research for the US Army's Benet Laboratories at Watervliet Arsenal in NY until July 2013.

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