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Continuous visible-light emission at room temperature in Mn-doped Si light-emitting diodes

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Silicon (Si) is an indirect band-gap semiconductor that does not efficiently emit light. Here, by utilizing optical transitions between the *p-d* hybrid orbitals of manganese (Mn) atoms doped in Si, we demonstrate Si-based light-emitting diodes (LEDs) that continuously emit reddish-yellow visible light at room temperature. The Mn *p-d* hybrid states are excited by hot holes that are accelerated in the depletion layers of reverse biased Si p-n junctions. Above a threshold reverse bias voltage of -4 V, our LEDs show strong visible-light emission with two peaks at 1.75 eV and 2.30 eV, corresponding to optical transitions from the t_2^- (spin-down anti-bonding) states to the *e*- (spin-down non-bonding) states, and from the *e*- to the t_2^+ (spin-up anti-bonding) states. We also demonstrate direct amplitude modulation of our LEDs up to 1 Mbps. Our results open a way to utilize the 3*d* orbitals of transition metals in Si-based photonic devices. The present Si-based LEDs can be monolithically integrated into Si electronic devices and circuits, and can be used for visible-light optical data transmissions, an especially promising attribute for chip-to-chip and board-to-board optical interconnections using inexpensive plastic fibers or waveguides.

Biography

Masaaki Tanaka received his PhD degree in Electronic Engineering from the University of Tokyo, in 1989. He is currently a Professor of Electrical and Electronic Engineering at the University of Tokyo. His current research covers various materials and nanostructures, spin-related phenomena, and devices, including magnetic semiconductors, ferromagnet/semiconductor heterostructures and nanostructures, magnetic tunnel junctions, and spin transistors. He has authored and coauthored over 200 scientific publications, and presented over 80 invited talks at international conferences and meetings. He is an executive editor of AIP Advances, and is on the board of directors of the Japan Society of Applied Physics.

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