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“Nitride Semiconductor Solar Cells: A Path to Higher Performance Photovoltaic Energy Sources for Terrestrial and Space Applications”

ABSTRACT
Photovoltaic technology holds great promise as a sustainable, environmentally friendly energy source for the 21st century. While photovoltaic devices (solar cells) currently provide a miniscule percentage of the world’s energy needs, it is a surprisingly large and rapidly growing industry. The global market has been growing at over 30% annually since the late 1990’s, and now generates over $4.5 billion U.S. in annual revenue. This rapid growth is expected to continue into the foreseeable future driven by worldwide interest in developing clean, renewable energy sources. Multi-junction III-V semiconductor devices have already demonstrated one-sun efficiencies over 30%; however, they are expensive because different semiconductor materials must be grown on single-crystal GaAs or Ge substrates while maintaining good lattice matching to assure long minority carrier lifetimes. An alternative methodology involves semiconductors such as CdTe and CuInGaSe₂ which exhibit strong optical absorption and acceptable electronic properties even when deposited as polycrystalline films on large-area, low-cost (glass or metal) substrates. Such thin-film solar cells have a favorable cost structure; however, after more than twenty years of research activity, the power conversion efficiencies of high-volume production devices remain well below 20%. Third generation solar cell R&D aims to combine both high power conversion efficiency and low-cost manufacturing in the same photovoltaic technology. Nitride semiconductor alloys show promise as the material of choice for 3rd generation solar cells. Single-crystal quaternary alloys such as BGaInN or BGaNAs with lattice matching to GaN could prove to be a good choice for terrestrial applications at very high solar concentration and space-based power generation for missions operating closer to the sun. Amorphous ternary alloys such as GaInN or GaNAs could lead to high-efficiency, multi-junction solar cells with low manufacturing costs. The feasibility of these new solar cell technologies will be argued on the basis of known materials parameters, proof-of-concept devices reported in the literature, and ongoing and future work at Virginia Tech.

BIOSKETCH
Louis J. Guido was a Member of Technical Staff at AT&T Bell Laboratories from 1982 until 1984 during which time he earned his M.S. degree in Electrical Engineering from the University of Illinois. He returned to the U of I in 1985 to conduct independent research and received his Ph.D. degree during the spring of 1989. Later that year, Dr. Guido joined Yale University as an Assistant Professor in the Department of Electrical Engineering. In 1992, he was one of 15 engineers nationwide to be awarded a five-year NSF Presidential Faculty Fellowship. In 1993, Dr. Guido was promoted to Associate Professor at Yale U and awarded the John J. Lee Endowed Chair in Electrical Engineering. He was elected a Senior Member of the IEEE in 1996. Dr. Guido joined Virginia Tech in 1999 as an Associate Professor with a joint appointment in the Departments of Electrical and Computer Engineering and Materials Science and Engineering. He was named a VT College of Engineering Faculty Fellow in 2004. Dr. Guido was an IEEE Electron Devices Society Distinguished Lecturer from 2000 to 2004. His research interests include the physics of photonic devices operating at short (UV) and long (FIR) wavelengths; the physics of high-power, high-frequency electronic devices; and the synthesis and characterization of compound semiconductor alloys and quantum structures. Dr. Guido's overall work on III-V semiconductor thin-film synthesis and device physics has contributed to 50 journal articles, which have been cited more than 1,100 times to date according to the ISI Web of Science; 50 conference papers; and 30 invited seminars at leading national and international research universities and industrial laboratories.