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Active Electro-Optical Sensing: Phenomenology, Technology, and Applications

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Active electro-optical (EO) sensing, whether known by lidar, ladar, or laser radar, is becoming much more significant as a sensing modality for scientific, military, and commercial applications. New commercial applications abound. A major economic driver in the relatively near future will probably be driverless cars; this will be a huge market, and affordable active EO sensing is critical to its development. Because of the economic scale of this application, it will likely drive the development of low-cost short-range 3D active imaging. Microsoft Kinect, a lidar using structured light, is another large-volume device in the market. Of course people are familiar with police lidar to catch speeders. Moving up the scale we can see a large developing market in 3D imaging active EO sensors for both commercial and military applications. Many cities are being 3D mapped, with applications to flood control and other civic planning activities. We have even seen 3D lidar mapping used for archeology. At a closer range, 3D printing will increase the need for 3D imaging to develop the template for some 3D printed objects. Environmental applications of active EO sensing are expanding as well. You can map wind velocity, or detect chemicals like methane or other objectionable chemicals. NASA has landed an active EO sensor on Mars that zaps a rock with a short pulse laser and then measures the spectrum of the gaseous cloud generated to type the materials a rock is made from. It is likely that in the future active EO sensing will revolutionize detection and extraction of fossil fuels. At the higher end, active EO sensing is ideal for identifying objects at long range.

This special section of *Optical Engineering* comprises 23 papers spanning several areas of active EO sensing phenomenology, technology, and applications. The paper by Molebny et al. provides a synoptic view of the international development of laser radar from a historic perspective, from pre-laser days to some of today's most exciting developments, and serves as a backdrop for the special section.

Many of the papers in this collection deal with active EO imaging, but from a variety of perspectives, from "seeing around corners" in the paper by Laurenzis et al., to the utility of one-dimensional imaging in the paper by Steinvall et al., and active underwater imaging in the paper by Imaki et al. Several papers deal with nonimaging applications of active EO sensing, including laser vibrometry in the paper by Lutzmann et al., and several papers on various forms of atmospheric sensing such as the aerosol lidar sensor network described in the paper by Shimizu et al. Other papers in the special section present advances in active EO components and systems and address important phenomenology aspects including propagation, scattering, and the potential utility of quantum effects.

Active EO sensing is becoming more and more prevalent. Its rich phenomenology can provide an abundance of information, and components are becoming cheaper and more reliable and more capable. This is a rapidly developing field with a very bright future. We hope that this special section will provide the community with an overview of recent progress in the field and spur further development and applications of its rich sensing modalities.

Paul F. McManamon is a president of Exciting Technology and Technical Director LOCI, University of Dayton. He has chaired laser radar study for the National Academy of Sciences and cochaired "Optics and Photonics, Essential Technologies for Our Nation." He is a fellow of SPIE, IEEE, OSA, AFRL, DEPs, MSS, and AIAA. He was the president of SPIE in 2006. Until May 2008, he was a chief scientist, AFRL sensors directorate, and responsible for AFRL sensing technologies, recognition, CM, and warfare technologies. He received the Meritorious Presidential Rank Award in 2006.

Walter F. Buell is principal director of the Electronics and Photonics Laboratory at The Aerospace Corporation, where his research interests include atomic clocks and laser remote sensing. He received his PhD in physics from The University of Texas at Austin. He was visiting researcher at the Max Planck Institute for Quantum Optics and performed postdoctoral research in laser cooling at SUNY Stony Brook. He was vice chair of the laser radar study for the National Academy of Sciences and serves on the APS Industrial Physics Advisory Board. He is a member of APS, SPIE, IEEE, and a Fellow of OSA.

Gary Kamerman: biography is not available.

Ove Steinvall received his MS degree from Uppsala in 1969 and his PhD from Chalmers Institute of Technology in 1974. He has been employed by the National Defense Research Establishment (FOI) since 1969. He is a research director in laser systems. He is an associate professor at Chalmers Institute of Technology. His activities involve laser CM, laser radars, and free-space laser communications. He has 110 papers and 300 reports. He is a fellow of SPIE, senior member of OSA, Swedish Optical Society, and the Royal Academic of Military Sciences. He received three national and NATO awards. He is a chair of numerous laser conferences.

Kazuhiro Asai received the Dr. of Engineering from Tohoku University in 1978. He worked at the Radio Research Laboratory, then joined Tohoku Institute of Technology as a professor in 1989. He is now professor emeritus. His major studies are lasers and laser radar (lidar). He served as a local committee chair at the 17th International Laser Radar Conference (ILRC, 1994), a symposium chair at SPIE Asia Pacific Remote Sensing (APRS 2000), and a conference chair at the 13th Coherent Laser Radar Conference (CLRC, 2005). He is now involved two lidar programs in JAXA: Multi-footprint Observation Lidar and Imager (MOLI) onboard ISS-JEM, and the SafeAvio program for detection of clear air turbulence with airborne CDL.