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The field of 3-D printing and its industrial namesake, 3-D manufacturing or additive manufacturing (AM), have been growing technologies with significant worldwide commercial backing. The promise is the development of a manufacturing approach that will revolutionize the way objects and complex systems can be fabricated and or assembled. It is a step toward the "digitization of matter" and the layer-by-layer building approach which together open the design space where material type and phase can be varied as needed, where small (nano/microscale) devices can be selectively inserted as necessary, and where complex shapes, replete with integrated sensors, can be realized. The latter goal would be the most soaring of visions where a 3-D manufactured product would not only have the necessary complex shape but also include properties for "sensing" the local environment, harvesting energy, and communicating its state.

We are far from realizing this soaring vision, but recent strides in fields such as materials development and controlled process tooling brings hope that 3-D manufacturing could impact the world much like the industrial and electronics revolutions. Only recently, the technology was considered at an embryonic stage with utility in fabricating prototypes on demand. However, just in the past few years, there are reports that 3-D manufactured production parts have been inserted into cars, planes, ships, and spacecraft. We can presume that the initial infusions of this new technology are likely to be in noncritical systems, but it is just a matter of time before 3-D printing technology makes major inroads into all aspects of the manufacturing domain.

Standing in the way are issues of reliability and reproducibility that must be addressed and solved. The editors of this special section feel that these barriers can only be overcome by the development of metrology tools that can characterize the process *in situ*, starting from the source material to the fabrication of the object. Optical engineering can play a vital role in this regard, because it can enable diagnostics and characterization that by its very nature is nondestructive and can be integrated *in situ*. Moreover, because the leading 3-D manufacturing tools employ a laser for particle fusion/sintering, optical engineering technology can also advance 3-D tool manufacturing through development of better laser beam shaping and beam control technologies.

It is not just serendipity that the editors chose to have a special section on AM in this otherwise optical journal. The intent is to place before the readers examples of processes and approaches currently in use within the AM community with the hope that the imagination of the optical engineering community might be sparked on better means to diagnose and characterize. For example, sensors are useful for measuring the local build temperature, surface roughness, and/or grain size of the fabricated object, as are techniques for precisely measuring the placement of a micro/nanoscale object. Sensors could also be used to measure the properties of the precursor matter, powder size and local density, polymer viscosity, and quantify whether the "waste material" within a build can be reused in a follow-on build. In addition to sensors, technologies are needed that can shape a high-power laser beam for specific applications (e.g., Bessel beam, donut shape), and investigations are needed to determine whether an optical vortex beam can help a specific build process or whether optical near-field technologies can push the build resolution down even further.

This special section contains 14 papers that highlight techniques and material processing approaches that are currently relevant to additive manufacturing in metal, polymer, and glass materials. It also includes *in situ* technologies that could help diagnose and/or characterize the build process by way of laser material interaction and optical coherence tomography. It presents examples on the use of optical lithography and projection methods, along with a patterning technique that uses laser-induced shock waves. There are also contributions that address the need to understand the photosensitivity of the material (in this case, resin) and the need to characterize/control the microstructure and its properties of the part built (in this case, metal alloy). Contributions are also included that address the effect of heat treatment on the microstructure and the use of vacuum UV as a means for post-build processing. Finally, this special section also includes the characterization of devices fabricated by 3-D printing and relevant to *Optical Engineering* readers: an attempt to miniaturize a confocal imager and a laser microscanner. In closing, the editors entertain the wish that these papers will help to cross-fertilize ideas and concepts and thereby enable 3-D printing technology to fulfill its promises.

Henry Helvajian is a senior scientist at The Aerospace Corporation. His investigations on miniaturizing satellites led to the development of the world's first <1 kg mass picosatellite. Other research includes laser fabrication of glass/ceramic MEMS, manufacturing methodology for mass-producing nanosatellites, enhancing molecular mobility by surface acoustic waves, altering speed of sound by lasers, and process control for additive manufacturing. He has edited four books on microengineering space systems and authored over 100 articles in multiple disciplines. He currently holds 20 patents and is a fellow of the SPIE.

Bo Gu is the founder and president of Bos Photonics and three start-up companies developing next-generation photonics technologies. He codeveloped the first 10 KW laser-based powder feed additive manufacturing system and 31 commercial products of lasers and laser systems for industrial markets. He has 57 issued patents and 60 pending patent applications and more than 100 publications with 13 plenary and 54 invited papers. He has coedited 7 books on laser applications. He is a fellow of both SPIE and OSA.