Laser welding has become a vital industrial tool for important US industries for automotive, electronics, aerospace, and biomedical applications. This is due to the advantages that lasers offer over traditional joining techniques such as increased process throughput, high precision, relatively low energy deposition, and low cost of ownership. As an important tool for manufacturing, The National Institute of Standards and Technology (NIST) has developed an effort to improve the optical metrology resources available for developing both a better basic understanding of the physical processes, as well as to facilitate more precise manufacturing. Our efforts are focused in three areas: high-power laser power metrology, advanced laser weld plume spectroscopy, and dynamic optical coupling efficiency measurements. The first area is based on our extensive background in laser power metrology and a new NIST technology whereby high-power lasers are measured by means of radiation pressure. The technique, where light no longer needs to be absorbed to be measured, means that in principle one can weld while always knowing, to a high degree of accuracy, the absolute power being delivered to the weld piece. Second, we have applied an optical technique known as laser-induced fluorescence (LIF) to monitor dilute alloying elements as they are ejected from a weld pool. We have demonstrated that LIF can enhance the sensitivity of traditional optical emission spectroscopy by a factor of 40,000, as well as temporally resolve the emission of individual elements on a microsecond time-scale. Thirdly, NIST is establishing data to be used as a benchmark for testing laser welding thermal simulations. These experiments use a NIST Standard Reference Material, whose composition and thermal properties are well-known, and determine the dynamic optical coupling efficiencies of a single spot weld under well-known boundary conditions by measuring the light scattered during welding using a calibrated integrating sphere. These parameters can be used as inputs to weld model simulations, which can then be checked against the measured results of our spot welds. In addition to this work, we are involved in process development for laser-driven ultrafast dopant diffusion in Si photovoltaics. In a collaboration with the University of New South Wales, we are investigating a dual high-power laser process by which a deep (~10 µm), low-doped (< 10^{18} cm^{-3}) emitter can be created in seconds as opposed to days with furnace annealing.

Dr. Simonds obtained his Ph.D. in Applied Physics from the Colorado School of Mines in 2012, where he studied defects in nanostructured silicon photovoltaic materials. He then completed a postdoctoral appointment at the University of Utah developing novel laser processes for CdTe. In 2014, Brian joined NIST as a National Research Council postdoctoral fellow to develop spectroscopy tools for measuring alloy element loss during laser welding. Brian spends most of his free time climbing, skiing, and building things, most recently with the Colorado School of Mines Tiny House club.