U.S. DEPARTMENT OF ENERGY

SBIR/STTR SUCCESS

APPLIED SPECTRA

Every time a solid material, whether originating from research, industry, or nuclear activity needs to be disposed of, it is first chemically analyzed to determine its elemental composition. This is typically done using Inductively Coupled Plasma Mass Spectrometry (ICP-MS), which requires macroscopic samples to be extracted and liquefied by “digestion” in strong and hot acids. This process, which is the standard for industry, research and environmental cleanup efforts produces significant quantities of liquid substances that are themselves hazardous waste. During his career as a scientist at Lawrence Berkeley National Laboratory (LBNL), Dr. Rick Russo laid the foundations and subsequent development of a paradigm change for chemical analysis—a technology that can now be purchased in the form of analytical instruments sold by Applied Spectra.

FACTS

PHASE III SUCCESS
Applied Spectra is growing at a rate of 34% and has sold 300 instruments worldwide.

IMPACT
Based on laser ablation, Applied Spectra analytical instruments allow researchers as well as mainstream manufacturers to map elements and isotopes in any material, cost effectively and without sample preparation.

DOE PROGRAM OFFICES
Energy Efficiency and Renewable Energy (EERE), National Nuclear Security Administration (NNSA), Environmental Management (EM), Biological and Environmental Research (BER), Fossil Energy (FE).

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Applied Spectra's founder Dr. Russo started his career at LBNL in 1982, and since 1989 has been supported by the Basic Energy Science (BES) program of the Department of Energy (DOE) to develop a fundamental scientific understanding of the interaction between a pulsed laser beam and matter, a phenomenon known as Laser Ablation (LA). While working at LBNL, Dr. Russo never imagined that his scientific research could transition outside of the laboratory, much less that he would start and lead a company serving a market of over $6 billion. Unlike today, in the 90's few scientists aspired to become entrepreneurs and entrepreneurship was not incentivized by National Laboratories, requiring founders to either leave their research job or to start their business on their free time and with their own resources. Nonetheless, in 2004, following a successful program with the Army, Dr. Russo fully embraced the prospect of further developing and de-risking his laboratory prototype with the goal of transforming it into a marketable product. This was the birth of Applied Spectra, Inc. and the beginning of a new entrepreneurial career for Dr. Russo and his graduate student, Dr. Jong Yoo.

As part of his research at LBNL, Dr. Russo pioneered the use of LA as a platform enabling spectroscopy by multiple, concurrent analytical methods, yielding qualitative and quantitative chemical analysis of nearly all materials and physical phases, without the need of bulky samples to be digested in acid. Unlike ion-beam-assisted techniques like Secondary-Ion Mass Spectrometry (SIMS), laser ablation-based techniques do not need to be performed in costly vacuum environments, can analyze samples at a distance, and ensure that the sampled species reproduce the exact stoichiometry of the material to be analyzed.

When the short-wavelength, pulsed laser beam is focused on the material to be analyzed, a small volume of the sample is ablated away and converted into a plasma, which is localized in the shape of a plume propagating away from the sample's surface. The plasma plume spectroscopy preserves the stoichiometry of the original material even for complex compounds, which is critical for determining the accurate chemical composition of an unknown material. Once the laser pulse ends, as the electrons and ions forming the plasma return to their ground state, light is emitted in discrete spectral peaks, which can be analyzed to determine the elemental concentration and the isotopic information through the techniques known as Laser-Induced Breakdown Spectroscopy (LIBS) and Laser Ablation Molecular Isotopic Spectrometry (LAMIS), respectively. The plasma plume also contains a flux of fine particulates that can be readily transported to a secondary ICP-MS source (LA-ICP-MS), which provides additional elemental and isotopic information.

The combination of these analytical tools results in a unique technology capable of yielding complete elemental and isotopic chemical analysis, femto-gram mass detection, and sub-micron lateral and depth mapping on any compound. Most notably, the plasma to be analyzed is generated by the laser beam shining at a distance from the specimen, allowing for remote sensing operations. The ability to analyze materials that are up to 1 km away, without the need for sample removal and transport, are of great interest to nuclear detection activities and space exploration efforts—the same technology has been used by the National Aeronautics and Space Administration (NASA) on the Curiosity rover on Mars.

An example of how LA instruments will aid energy technologies is their impact on the production of advanced batteries for electric vehicles and energy storage. Improved performance and reliability of Li ion batteries depend strongly on the ability to monitor changes in the cell chemistry as they happen during cycling, in real time and in 3D. Conventional material characterization techniques have severe limitations due to complexity, long measurement times, high cost, and sample preparation, and have only been available to large laboratories or universities. The lack of adequate metrology tools currently limits the product and manufacturing improvement cycle. LA instruments address this problem by providing cost-effective, rapid 3D mapping of critical elements over large surfaces and in ambient atmosphere. With LA instruments, routine R&D, the ability to screen incoming raw electrode materials for composition QC, and failure analysis can be easily incorporated in the manufacturing process of mainstream battery manufacturers.

Today Applied Spectra has a product line comprising over 9 LA instruments and has sold over 300 instruments worldwide. Applied Spectra's average revenue growth has been 34% between 2016 and 2019, providing a return equal to multiple times the original SBIR investment. Customers include National Laboratories, the International Atomic Energy Agency (IAEA), academic institutions and Fortune 100 and Fortune 500 industries, including major Li-ion battery, electronic, and other industrial material manufacturers in North America, Asia and Europe. Because of their demonstrated cost effectiveness and flexibility, LA instruments are now gaining a significant market share, winning the next wave of customers beyond the early adopters. "There is always a barrier in adopting a new technology" says Dr. Russo, "and industry is particularly reluctant to change analytical instrumentation, sometimes going to great pains to tweak the old system to make it work. However, ultimately a market pull is established as more customers adopt the new technology and recognize its value. This process can take many years—we need only consider how long it took for the PC to replace the typewriter."

LA instruments have penetrated several commercial markets, including oil & gas, mining, energy storage, nuclear non-proliferation and waste, metals and steels, and forensic. But this might be just the beginning for LA instruments as other industries like the food industry might need to implement new ways to measure the substances processed foods are made of.

Applied Spectra fits the model of many so-called deep tech companies. These companies are born from breakthrough research in academia or National Labs and work on technologies that require fundamental science understanding and carry notable engineering challenges. These technologies are transformative because they create new ways to solve some of the world's most important challenges.

Although for deep tech the road to market entry presents many obstacles and is considered too risky by most private investors, Applied Spectra was able to successfully transition from idea to product development and achieve market traction. Thanks to the support of DOE SBIR through 4 Phase II grants, and 2 continuation grants, a paradigm-changing technology is now transforming the way small to large research and manufacturing facilities perform chemical analysis, with great impact on devices and processes that enable energy security and National economic growth.

Written by Claudia Cantoni, Commercialization Program Manager, DOE SBIR/STTR, January 2020.