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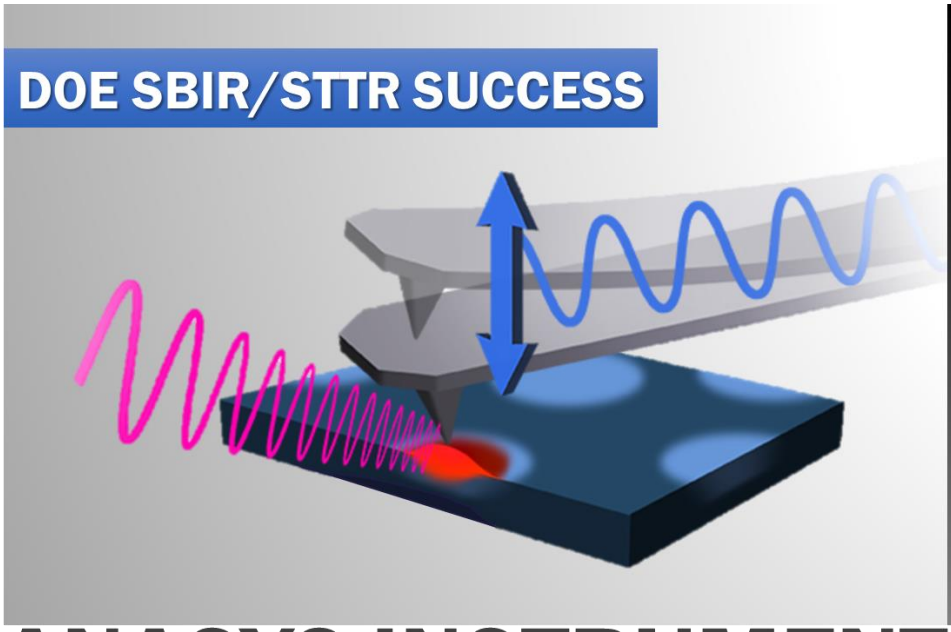

Microscopic mechanism enabling nanoscale FTIR spectroscopy. Local thermal expansion occurs when the IR radiation matches the material absorption bands, exciting the cantilever response.

ANASYS INSTRUMENTS

When it comes to sample characterization and analysis, the dream of any materials scientist is an instrument that given an "as grown" material of undefined composition would easily produce a map of its chemistry and other electronic properties along with its topography with *nanoscale spatial resolution* and without the need of sample preparation steps or costly high-vacuum environments. Developing such an instrument was the vision behind the genesis and subsequent success of Anasys Instruments. Now, with its recent acquisition by Bruker, Anasys nanoIR technology is posed to dramatically impact materials research worldwide.

FACTS

PHASE III SUCCESS
After five Phase II DOE SBIR awards between 2010 and 2017, Anasys was successfully acquired by Bruker in 2018.

IMPACT
Anasys has pioneered the field of nanoprobe-based infrared measurements and developed the first instrument capable of providing chemistry and IR spectroscopy mapping with spatial resolution of 10 nm in a tapping AFM.

DOE PROGRAM/OFFICE
Basic Energy Sciences (BES)/Office of Science.

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Anasys was founded in 2005 by CEO Roshan Shetty and VP Kevin Kjoller with the idea of fundamentally modernizing the field of nanoscale chemical imaging of materials. Anasys founders had a strong background in both technical and business aspects of Atomic Force Microscopy (AFM), having worked in this field for many years. Based on their prior experiences, they endeavored to bring together two different materials characterization techniques, Scanning Probe Microscopy (SPM) and Infrared (IR) spectroscopy, which greatly complemented each other, in a single, unique instrument. Before Anasys, these techniques were specialized methods adopted by different scientific communities with no overlap.

IR spectroscopy, mostly adopted by Industry and Chemical Sciences, probes the vibrational energy levels of materials and provides direct chemical composition with no prior information about the composition of a sample. A shortcoming of IR spectroscopy originates from the physics of diffraction for the long wavelength IR radiation, which intrinsically limits the spatial resolution of this technique to nearly 10 microns, an unacceptably large length scale in the field of nanotechnology. SPM, a Materials Science technique developed in the 80's, works by scanning an atomically sharp tip over a sample's surface, yielding nanoscale-resolution images of the sample's topography along with other information on mechanical, electrical and thermal properties depending on the nature of the tip and its interaction with the sample.

Before Anasys, there were a number of techniques developed to allow chemical composition measurements using an SPM, but due to technical limitations and challenges with the ease of obtaining results, these techniques were not broadly adopted. In fact, chemical nanoscale mapping by SPM had been considered the Holy Grail of this technique for decades.

Combining IR Spectroscopy with AFM, allows scientists to overcome the IR diffraction limit on the basis of a simple principle. When a molecular bond in the analyzed material absorbs the IR radiation, the molecule heats up and consequently expands, pushing the AFM tip. Although all the molecules excited by the IR beam expand, only the ones probed by the atomic tip provide a response, making the technique extremely localized. By exploiting this phenomenon, originally discovered by Prof. Alexandre Dazzi at the University of Paris, and by fully developing the technology involved, Anasys was ultimately able to achieve a breakthrough 1000× higher spatial resolution for IR chemical imaging.

Anasys' latest "nanoIR" instruments can map chemistry and other material properties with a spatial resolution of 10 nanometers on both organic and inorganic materials. Such an impressive result was not easily obtained but required intensive multi-disciplinary R&D with significant advances in multiple disciplines like IR lasers, optics, AFM probes, mechanics, and electronics. For example, Prof Dazzi's early developments were obtained with a free-electron laser, which cannot be adopted for a broad market. Anasys needed to develop a tunable, high-repetition rate, broad-range, sufficiently powerful and cost-effective IR source to be coupled to the AFM. This was realized around 2013 with the second generation Anasys nanoIR instrument, when the field of Quantum Cascade Lasers (QCLs) had sufficiently progressed. Another issue Anasys had to solve was moving away from the complex sample preparation required by the first generation nanoIR instrument. Initially, to avoid interaction with the AFM tip, the IR beam was delivered to the back of the sample, which consequently, needed to be thin and IR transparent. The second generation nanoIR solved this problem by minimizing the response of the AFM tip to the IR beam and moving to a reflection geometry in which the surface of the sample was now probed. The newly developed nanoIR technology impacted two different industries: 1) the AFM industry (around $250

Million/year), which had been chemically blind until then, and 2) IR spectroscopy (around $1 Billion/year), which suffered from low spatial resolution.

Contrary to the expectations of Anasys founders, the early adopters of nanoIR were IR users or industry people with nanoscale chemistry problems, not the AFM community. “The addition of an IR laser to the scanning probe equipment considerably increased the cost of the new apparatus. In addition, nanoscale chemistry using IR spectroscopy was still too new for the AFM community to fully appreciate the price-value proposition,” commented Mr. Kjoller. It was only in 2013, after several technical advances brought significant improvements in sensitivity and spatial resolution that the original vision of SPM plus nanoscale spectroscopy mapping was realized and with it came customer acceptance, allowing sales to take off.

The SBIR support was critical for Anasys to take the market learnings from nanoIR1 and incorporate them into nanoIR2, finally achieving the high resolution and overall cost-performance ratio needed to reach a broad market. Anasys had some sale revenues from earlier products but profits were not nearly enough to fund the needed R&D. “Without the SBIR, Anasys would have not had the resources to aim at these type of scientific instrumentation breakthroughs for which adoption takes time. Private investors are not interested in markets that take so long for adoption,” explained Mr. Shetty. “In addition to the time needed for product development,” added Mr. Kjoller, “companies need to take into account the time needed for product acceptance.” In the case of Anasys, reaching acceptance involved educating the customers, which in turn meant ongoing interaction between Anasys’ technical staff and the research and industry communities. Anasys’ commercialization strategy focused on quick iteration on their product through customer feedback. “We worked very closely with the customers listening to what they liked and disliked about the instrument and were fast to incorporate the needed changes. We also invested heavily in recruiting application scientists who could understand customers’ needs and readily communicate with scientist and technical personnel, encouraging customers to be early adopters.”

This business strategy was ultimately successful in validating a large potential market, which made it possible for Bruker, a large manufacturer of scientific instruments for materials research and applied analysis, to decide to acquire Anasys and enter the nanoscale IR market in a major way. By the time Bruker acquired Anasys in 2018, the company had grown to 35 people and boasted year-on-year increasing sales around the world. Bruker brought to the table increased R&D funding, a much larger worldwide sales channel, and an assurance of company stability and top support and service for its products.

Bruker’s Nano Surfaces division is the market leader in Atomic Force Microscopy with products such as Dimension Icon and MultiMode, recognized as providing the most advanced nanoscale material property mapping capabilities. Now, with the acquisition of Anasys Instruments, Bruker is also the number one leader in nanoscale IR spectroscopy, with great potential for high growth in all market segments.

Written By Claudia Cantoni, Commercialization Program Manager, DOE SBIR/STTR, February 2018.