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Non-Invasive Image-Based Mid-IR Laser Molecular Recognition Products

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Co-Founder

Sensitive, highly specific and fast molecular recognition in standoff mode is highly desired in diverse application sectors including the security and medical industries. Infrasign offers mid-IR Laser image-based non-invasive molecular recognition products at different standoff distances.

Interview conducted by: Lynn Fosse, Senior Editor, CEOCFO Magazine

CEOCFO: ***Dr. Mukherjee, what is the concept for InfraSign?***
Dr. Mukherjee: At InfraSign, we develop sensors mainly based on the middle infrared (Mid-IR) range of wavelengths. They are typically three microns to twelve microns long wavelengths. These sensors are needed all over the map, in diverse industry sectors, from petroleum to defense to healthcare, medical diagnosis and drug discovery. Primarily, we chose sensors based on middle infrared, because by and large all molecules have strongest vibration absorption bands in this range. Therefore, as a consequence of strong absorption of the fundamental vibration of these molecules, we are able to quantify the molecules that we are looking for with very high sensitivity. That is a big change from what exists today, particularly from Raman spectroscopy and near infrared spectroscopy. Both of them are used qualitatively in material analysis across different industries. Due to the recent availability of cascade lasers (compact semiconductor Mid IR lasers), highly sensitive long wave IR cameras that work at room temperature and fast Hyperspectral image processing we offer a powerful alternative to both of these technologies where they have failed in quantification of trace molecules at video graphic speeds.

CEOCFO: ***For those of us who may not be very technical, why do we want to quantify molecules? What is the end result of what you are able to do?***
Dr. Mukherjee: That is a good point. Let me give you an example. Suppose you would like to do pathology on tissue and you would like to know if part of that tissue has become mildly malignant, which is the onset of cancer. If you qualitatively map the malignant region, you have no idea of at what stage the cancer is. However, if you have a quantitative map you will know the exact stage of the cancer, if it is early stage or at a later stage. Another example is in Quality Control/Quality Analysis in Pharmaceutical manufacturing and catching counterfeit drugs that are being imported in large quantities. In-line real time quantitative full batch (not sampled) imaging of API (Active Pharmaceutical Ingredient) in Pharma manufacturing not only satisfies FDA's mandate on PAT (Process Analytical Technology) but will save billions of dollars for Pharma companies besides assuring high quality healthcare products for our citizens. This facility is not available today and our products provide this valuable unmet need. We would like to propose to DHS that it should be mandatory for all imported drugs to go through full batch quantitative characterization before being released into our country. We feel this may be a potential channel for future terrorism that has not been recognized by DHS. We would rather be proactive now than reactive after a potentially disastrous terrorist incident through lethal chemicals embedded in imported drugs.

The other well known example in defense and security would be in standoff detection of explosive traces for TSA. Our products can be deployed as shoe scanners at airport security lanes so opening shoes and delays can be avoided. Since our imaging products scan for HAZMATs on the surface only, they can accompany X-Ray tunnels for baggage screening and millimeter wave full body scanners adding one more level of security by looking for any HAZMAT trace on surfaces of baggages and clothing. Similarly, other applications, for examples in petroleum leaks, there is a flashpoint called a low explosive limit of petroleum gas leaks in pipelines and if the leak is above this limit there is a fair chance of explosions. Therefore, quantification of that leak is vitally important for security in Petrochemical industries.

CEOCFO: ***Would you please explain the science behind what you have developed? Has it been tried before? Have you figured out something that others have not?***
Dr. Mukherjee: The image sensors that we have developed fall under two categories, passive and active. In passive sensors you do not need a light source. By light source I mean a laser source or an LED that emits in the middle infrared.

That is because vibrational absorption of molecules is strongest in the middle infrared. Let us take an example of an active source at these wavelengths. Nowadays, we can buy lasers in the middle infrared laser range called cascade lasers (quantum and interband). These look similar to the common diode lasers. These lasers have only has been around commercially in the last ten years. Nowadays these tiny lasers can produce plenty of power which is needed to flood a scene 100s of meters away and then use a long wavelength IR camera to detect the reflection from the scene and then do spectrum analysis to find out the target material. In an imaging device, it will display the target concentration in a false color map. For example, suppose there are some trace elements of TNT, which is an explosive, on the door handle of a car. You take our hand held instrument to detect the TNT trace just like a spectroscopic video camera. Instead of visible light illumination, you are illuminating with one or more of these very advanced lasers that image the scene at the wavelength at which the TNT absorbs. Therefore, if you flood it with that light, there will be dark patches which will show up. That is because those regions of TNT residue will absorb more of this light that is tuned to its absorption than surrounding areas with no residue.

Similarly in medical applications, a laser can be tuned to a sharp absorption of a cancer signature region in the Mid-IR spectrum of a tissue in which we would like to detect cancer at a very early stage. Over the last 20 years significant research has been done towards FTIR (Fourier Transform Infrared) characterization of cancerous tissues. FTIR microscopy is far less sensitive and far more time consuming than our method. However, we use the large amount of research data available in the literature on the FTIR study of tissues for cancer characterization. The FTIR studies points us at the Mid-IR spectroscopic regions symptomatic of cancer. Like in FTIR, the reason for using our laser based imaging technology is that we do not need any staining of tissues that is presently used by pathologists. The tissue does not need to be stained with a fluorescent molecule or some antibodies for color contrast imaging. This staining method being used today in hospitals and clinics is a fifty year old technology. We are trying to bring new generation of quantitative diagnostic equipment that break the present barrier of lack of quantization and slow speeds of detection in Raman, NIR and FTIR methods and take pathology to the next level. After initial proof-of-principle demonstration in dry biopsy tissues, we plan to use fiber optic probe for in-vivo quantitative imaging at the site of the live tumor, determine the level of malignancy and at the flip of a switch carry out laser surgery at-the-diagnosed spot. This future product of ours will perform both the important jobs of cancer diagnosis and surgery at the same time with significant impact in saving lives, time and money. This will allow biopsy-less diagnosis at the live tumor as well as microns-sharp precision laser surgery removing only the malignant part of the tissue and no more as errors in manual surgery particularly in Brain cancer can be devastating and stressful for brain surgeons.

We are the first to propose this new concept of Mid-IR diagnosis/surgery product. We are the leaders in this industry breaking new grounds in quantitative cancer diagnosis and surgery at-the-diagnosed spot. Our use of cost effective single wavelength lasers, long wavelength IR cameras and IP protected optoelectronic packaging allows these new age products that is set to revolutionize cancer diagnosis as well as surgery at-the-diagnosed spot.

“InfraSign’s hand held cascade-laser imaging platform product is the market leader in multi-sectoral applications for trace material mapping in video mode.”- Dr. Anadi Mukherjee

CEOCFO: ***Are your products in use today? Where are you in the process of getting known in the appropriate circle?***

Dr. Mukherjee: Yes. We have sold our first product SPoT to Block Engineering last year that is capable of imaging 4 explosive traces and one binder over large areas using a multiplexed set of three Quantum Cascade Lasers. We have been around for over four years now. I came out of a quantum cascade laser company in Santa Monica called Pranalytica. Starting from August 2009, we have been successful in building a platform product that could easily be adapted to medical, security &defense applications. This platform product is designed in such a way that by the simple change of one or more modular lasers we can custom configure the product to suit different sector applications. In medical application we have published our first paper in the Journal of Biomedical Optics last year that shows that we could do quantitative imaging of proteins in blood serum with record high sensitivity and specificity. Stains from Lemon tea, sugar solution, serum, water stains all look the same. You would not know any difference. Therefore, this paper proves the concept and the power of this technology that can be harnessed to quantitatively image biomolecules selectively. For example, what we have shown in the paper is that this is a very highly sensitive and highly selective imaging process looking for proteins in a stain. Similarly, we could, use another laser with other components remaining same for detecting a particular cancer; let us say brain cancer. That laser will be at another different wavelength than what is used for detecting serum.

For the security and defense application, all we need to do is change the laser module appropriate to a particular target trace determination, e.g. HAZMATs, fuel gas leaks, solid and liquid contaminants etc. All other hardware components remain the same. Slightly modified application specific software needs to be loaded.

We have presented at CLEO 2013 Technology Transfer and SPoT has been selected as a finalist for the SPIE Prism Award in Photonics West 2014.We will be presenting our hand-held platform product at PITTCON this month in Barnett Technical Services booth.

CEOCFO: ***You have published the paper; you have had some interest, but how do you break through? There is so much information and so many ideas. What is the plan?***
Dr. Mukherjee: That is a good point! In the last two weeks, we have been approached by a major leader in Petroleum Industry saying, "We are very intrigued about your technology."Although there are major companies around the world who are trying to address their problem, petroleum leaks, they are not happy with the capability of the products presently available. Therefore, they want to evaluate our products, what the specifications are and if that meets their requirements. We are having ongoing discussion with this major Petroleum company to see how many of our products (passive and active) will suit their needs. Right now that is one of the major requests we have had. The other one we got in the last ten days is from the Ministry of Defense at the UK. Just like the US Navy, they want a portable image based, real time imaging of explosive traces or HAZMATs.

In 2009I was faced with the situation of how to develop this company. This is a classic startup company in the worst of economic times. What do we do as funding situation had come to a grinding halt? Do we go to the government for funding, for SBIR grants? Do we run for VC funds or do we just develop the technology hoping to get funded one day? I figured out that each of these three routes is a full time consuming job. We were literally left to choose one of these three choices. My belief is that you can only do one of these three very well. I have seen companies who are experts in only one of them. Although some companies have become successful businesses after being supported by Government grants like SBIRs, I feel that is a long route to success, often connections with Government officials play a large role in the selection process. On the other hand, I have seen VC funded companies' suffering from problems of mismanagement, lack of insight or patience from VCs and/or founders. Therefore, at that point I said, "I am not going to hunt for funds, I am just going to develop technology and see if we get funded or not." That is where we are right now. Now we have plenty of customers who are very excited about our products, but we do not have the money to manufacture and test them. I think this is a good problem to have. In hindsight, I think I have made the right choice.

CEOCFO: ***Will someone like a major Petroleum company work with you on co-developing or would they really want you to go it alone?***
Dr. Mukherjee: At this initial stage of discussions, they said, "Although we do not fund development of products, we will, however, refer you to some VCs who are associated with us." We are in the process of exploring that opportunity.

CEOCFO: ***It sounds like a product with many uses. Everyone should want one at some point!***
Dr. Mukherjee: We are a company with proven expertise on designing, manufacturing and testing cost effective, portable spectroscopic video cameras for material identification in trace quantities. The trace material may be organics, inorganics, HAZMATs, biomolecular markers as all these molecules have strong absorption in the Mid-IR where we take images, analyze them in real-time and display target material as color maps just like you are looking for target substances through a video camera.

CEOCFO: ***Why should people pay attention to InfraSign today?***
Dr. Mukherjee: We have already built and sold a platform imaging product that has multibillion dollar applications as we are getting requests for our product from leading players in the different industry sectors. I would say that we should be funded right now, today, so that we can manufacture these products, test them and deliver them to our customers.

BIO: Anadi Mukherjee has over 30 years of R&D experience and leadership in laser-matter interaction. In large University labs and companies he has initiated, developed and led over $ 20 M grants from DOD.As a co- founder of Infrasign he is developing new Molecular and Biomolecular Recognition technologies for unmet need applications in Pharmaceutical, Biomedical, Chemical and Security industries. He completed his PhD in Physics from Center for Applied Quantum Electronics, University of North Texas. As a Research Assistant Professor at the Center for High Technology materials & EECE Departments at University of New Mexico he initiated new R&D projects in different areas of optoelectronics including Mu-Lasers, polymeric waveguides and devices, quantum well surface emitting lasers, laser patterning of thin films particularly controlling oxygenation. Recently as a Senior Scientist at Pranalytica Inc., he developed single-mode tunable external cavity quantum cascade lasers and multiplexed them for multigas detection with high sensitivity and selectivity. Just before leaving Pranalytica to open Infrasign he led a DARPA funded team and demonstrated a new technique for efficient standoff detection of explosives in battlefield environments. He has published over 40 papers in peer reviewed journals.

InfraSign

Revealing the invisible for a safer world

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