Precise Detection
for an Uncertain World

Energy Dispersive X-Ray Diffraction (EDXRD)

Sometimes referred to as Coherent X-ray Scattering (CXRS): What it is and How it Works

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Energy Dispersive X-ray Diffraction (EDXRD), sometimes referred to as Coherent X-ray Scattering (CXRS), was first proposed in the 1960's as a simple and high speed way to analyze remotely the crystal structure of material within a vessel. EDXRD uses high powered X-ray beams which gives this technique high penetration power.

In the mid to late 1980's, the method was investigated for possible use as a detection tool for explosives hidden within luggage / packages. The first work took place at Philips Medical Systems in Hamburg, Germany, where a simple, non-tomographic device was built. In 1988, Philips teamed with researchers at Rutgers University to develop the first commercial scale unit, which then became the model for a full tomographic unit. Later Rutgers collaborated with L-3 Communications to develop a similar, non-tomographic diffraction-based system.

In both machines, the XRD method is used as a secondary scanner to investigate suspicious regions that were previously identified by a primary instrument such as a CT scanner. By having the XRD unit look at only a single spot (or at most a few spots), the speed problem of the XRD can be reduced. In return, the XRD unit offers high detection rates with single digit false alarm rates. The research found that when combined, the CT scanner and XRD promise to provide good throughput with good detection capabilities.

All XRD instruments function by matching the diffraction pattern obtained by the instrument against a library of patterns previously obtained. An example is shown in Figure 1.

For comparison, the XRD patterns of C-4 explosive and Sucrose are shown which, even to an untrained eye, are markedly different. Although there may be a few features that are common to both patterns, they are nonetheless very different. In a testing environment, the two diffraction patterns would each be compared against the library and a best match would be found in order to identify an unknown material. Of course, the human eye does this almost instanteously. But a machine-based detection device must rely on mathematical procedures to extract a unique feature set from the pattern and use them to identify the material giving rise to that pattern.

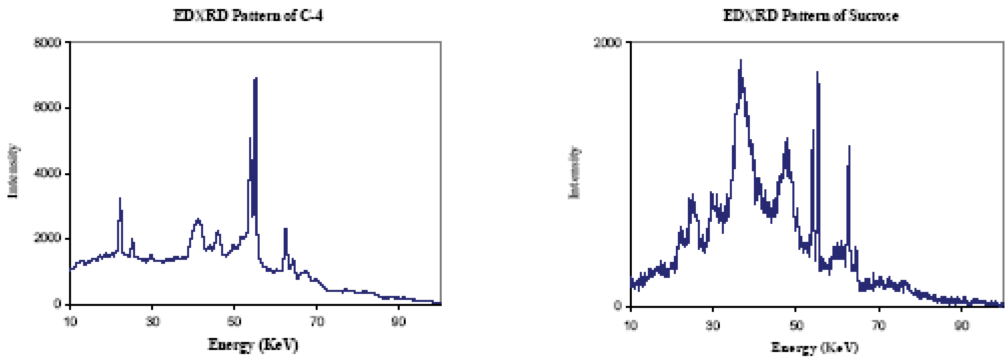

Figure 1 XRD patterns of C-4 explosive (left) and Sucrose (right)

Several methods have been developed to automatically analyze the XRD patterns, but two seem to have become dominant:

- Table lookup - the positions and intensities of the prominent peaks in the pattern are located and then compared to similar data prepared from the reference materials in the library.
- Transform methods - a transform, such as a Fourier, Discrete Cosine, Cepstral, or similar transform is performed on the pattern to extract the key features. These are then analyzed with a neural network to ascertain a match against a library of signatures.

One common component of all analysis methods is that the strongest peaks in the diffraction pattern tend to dominate the process, while the weaker peaks that are easily lost in the background are often ignored. While this approach discards a lot of information contained in the pattern, it does offer several advantages. Specifically, it allows us to ignore the noise and the background, which can easily obscure the weaker peaks. Also, these methods allow us to reduce the effect of absorption, which may cause the low energy end of the diffraction pattern to be preferentially absorbed while the rest of the pattern is less affected. Thus, the methods highlighted above seem to be sufficiently robust to allow us to identify the material with high accuracy.

In general, the XRD methods are highly material specific, since the diffraction patterns of crystalline materials are unique. Thus for explosives, C-4 is different from Semtex, dynamite, TNT, black powder, etc. Equally important is the fact that the patterns of the explosives are very different from the other materials in a suitcase. For example, chocolate, shoe leather, or cotton would never be interpreted as Semtex. This high selectivity of XRD has two important ramifications - high detection rates and low false alarm rates. Under ideal conditions (i.e. - low absorption and high test mass), the detection rate is close to 100% and the false alarm rate is 0.1% or lower.

Xstream Systems Inc. is committed to taking EDXRD to the next level. After 3 years the strong management and technical team has succeeded in its mission and catapulted EDXRD through its evolution. The team conceptualized and architected the world's first countertop EDXRD machine, the XT250 material identification system. This machine made a historically complex technology easy to operate for the average person. The XT250 material identification system was successfully sent out for field trials and is now fully deployed. The first intended use is in the pharmaceutical industry where the XT250 material identification system will detect counterfeit drugs. The system is also expected to ensure quality in the manufacturing processes and provide consumer protection to the end user.

With superior penetrating power, fast results and scalability, EDXRD can verify and detect materials in both small and large packages. Also, due to the vast flexibility of the technology, EDXRD will be well suited for many other market segments and applications such as mining, bulk materials, cosmetics, public safety and much more.

About William E. Mayo

Ph.D., Chairman of the Scientific Advisory Board

Dr. William E. Mayo, Ph.D., co-founder of XStream Systems, Inc., has served as tenured professor in the Ceramics and Materials Science Department at Rutgers University for over twenty five years. Dr. Mayo's research and teaching have focused on materials science technologies based on X-ray technology. Dr. Mayo has authored a number of patents most of which have focused on dispersive X-ray technology. Mr. Mayo is widely known as an expert on X-ray technologies and serves in two editorial positions dealing with archiving x-ray fingerprints for organic and inorganic materials. As a foremost expert in the materials science field, Dr. Mayo has testified as expert witness in many trials.

In addition to his academic work, Dr. Mayo has founded and served in executive positions within several successful X-ray based companies, including BA Associates, H & M Analytical Services, and NanoPac Technologies. Dr. Mayo holds a Bachelor of Science and Masters of Science degree from Carnegie-Mellon and a Ph.D. from Rutgers University. Prior to joining the faculty at Rutgers, Dr. Mayo also served as a Post Doctoral Fellow at Bell Laboratories. Prior to his work in academia, Dr. Mayo worked in the engineering field for industrial corporations such as Harry Diamond Labs, TRW, and Olin.

Rutgers University

Rutgers is one of America's major state universities. Chartered in 1766, it has a unique history as a colonial college, a land-grant institution, and a state university. More information on EDXRD technology, XStream Systems and the XT250 Material Identification System can be found at the Office of Corporate Liaison and Technology Transfer page of Rutgers University at: http://ocltt.rutgers.edu/default.asp?content=startup