A Paradigm Shift in X-ray Imaging

X-ray Imaging System Equipped with Direct-conversion FPD (Flat-panel Detector)

Shimadzu has been involved in the development of X-ray imaging systems for over a century.
Last year, it developed the "Direct-conversion FPD (Flat-panel Detector)" and, in so doing, realized a remarkable step forward in the quest for higher resolution and lower radiation dose. (The direct-conversion FPD was developed in collaboration with Sharp Corporation and Shindengen Electric Manufacturing Co., Ltd.)
X-ray imaging systems equipped with direct-conversion FPDs have already been released in the Japanese market and have received much attention from interventional cardiology professionals and other radiological imaging institutes.

Providing Dynamic X-ray Imaging with Quality Equivalent to that of Film

A perennial issue for doctors and technicians involved in medical X-ray imaging has been how to reduce the burden on the patient by improving resolution and reducing radiation dose. Shimadzu has developed a large number of X-ray imaging systems over the past 100 years. With each new system it has created new technology promoting the evolution of diagnostic imaging systems. In recent years, amidst a trend of digitalization, Shimadzu has created highly acclaimed fluoroscopy and cardiac/vascular systems equipped with CCD cameras. In October last year, Shimadzu released an epoch-making new product in its imaging system equipped with a direct-conversion FPD (flat-panel detector). This system offers superior resolution equal to that of film which can be obtained for both still and dynamic images.

Converting X-rays Directly to Electric Signals

The direct-conversion FPD developed by Shimadzu has two noteworthy features. The first is that it is digital, and the second is that the conversion method is direct rather than indirect.
The advantages of being digital include

The "DIGITEX Safire HC" cardiovascular X-ray diagnostic system equipped with direct-conversion FPD is packaged with a ceiling-mounted C-arm. A system with a floor-mounted C-arm, "DIGITEX Safire HF," is also available.

the elimination of the need to develop films, and the ability to allow real-time image observation.

The difference between the indirect-conversion FPD and the direct-conversion FPD is as follows. The role of the FPD in an X-ray imaging system corresponds to the lens and film in a camera. In place of a lens and film, X-rays are received by an array of detector elements and converted to electric signals. Whether this conversion is direct or indirect is what differentiates the two types of detectors.

Indirect-conversion FPDs can be developed by combining pre-existing technologies and several manufacturers have already released systems based on this method. With indirect conversion, the image obtained with the X-rays is first received by fluorescent material; the X-rays are converted into light, which is received by an array of photodiodes where it is further converted to electric signals. In other words, the indirect-conversion method can be thought of as consisting of 4 stages: the X-rays that pass through the patient are received; the X-rays are converted to light; the light is received; and the light is converted to electric signals. As with the photocopying of documents, it is impossible to prevent degradation of the resolution at each stage.

The direct-conversion FPD developed by Shimadzu, however, incorporates an X-ray detecting layer that can handle the X-rays that pass through the patient without prior conversion to light. This allows direct conversion to electric signals and ensures that the drop in resolution is kept to an absolute minimum. This method had for some time been considered an ideal way of improving resolution but was dismissed as posing too many technical problems. Shimadzu, however, recognized that the indirect-conversion method was insufficient for meeting the needs of modern medical facilities and embarked on the development of the direct-conversion FPD. Last year's sales release in Japan represented the fruit of these efforts.

Greatly Improved Visibility

In October last year Shimadzu released the world's first cardiovascular X-ray imaging system[*1] equipped with a direct-conversion FPD, DIGITEX Safire. It has been well received, earning high praise for its clinical performance.

In interventional cardiovascular treatments, angina and myocardial infarction are treated by inserting catheters into narrowed blood vessels and scraping away the plaque inside arterial walls, or by inflating the blood vessels with balloons. This is facilitated by injecting contrast medium into the blood vessels and determining the appropriate direction in which to move the catheter by viewing dynamic X-ray images of the medium. Naturally, in order to ascertain which blood vessels have narrowed or to locate the tip of the catheter, a high resolution is demanded of X-ray imaging systems. This is where the direct-conversion FPD proves its worth. Images obtained by conventional I.I./CCD camera system and direct-conversion FPD are shown below.The high resolution of 150 μm/pixel and the low noise level ensured by the direct-conversion method significantly improve the visibility of fine blood vessels, which are difficult to see with either the indirect-conversion FPD or the conventional I.I.[*2] systems.

"Visibility of stents[*3] and microcatheters

Test image obtained by conventional I.I./CCD camera system

Test image obtained by direct-conversion FPD

Tsunekazu Matsuyama
Director of Shimadzu Corporation
General Manager, Medical Systems Division
Profile

in blood vessels, which were hard to make out with the conventional I.I. system, has greatly improved. It seems that we can anticipate many benefits as a result, such as shorter examination times, reduced radiation dose and lower volumes of contrast medium," says Tsunekazu Matsuyama, General Manager, Medical Systems Division, Shimadzu Corporation.

Creating New Possibilities in Interventional Cardiovascular Therapy

This system offers a wide 9″×9″ field of view without peripheral distortion thanks to the flat-panel design. Even though the I.I. offers a circular field of view with a 9-inch diameter, it is impossible to prevent peripheral distortion (see photographs below). The FPD produces clear, undistorted images over the entire field.

"This means that the catheter operation time can be shortened. This reduces both the burden on the doctor and the invasiveness on the patient," says Matsuyama.

Shimadzu is currently developing a 17″×17″ direct-conversion FPD. When this is completed, it will be able to cover the entire chest region. Its application to general X-ray imaging is keenly anticipated.

Contributing to Society through Healthcare using X-rays

"At present, Japan's medical technology ranks as one of the most advanced in the world and high-level medical treatment is available to everybody. On the other hand, as the population continues to age, healthcare costs continue to increase. In order to reduce these costs and improve the level of patient care, major reforms of the health service are unavoidable."

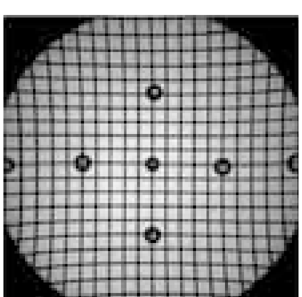
"Here at Shimadzu, in addition to developing cardiovascular X-ray systems, we plan to use the direct-conversion FPD in a variety of X-ray diagnostic systems. If these systems become widely used, the digitalization of images will become possible at medical facilities that still use mainly film. We believe that this will encourage the use of IT in the field of medical imaging and advance teleradiology technology based on digital image communications, thereby reducing differences in medical expertise levels among regions and enabling faster diagnosis and treatment," explains Matsuyama.

Shimadzu's X-ray technology has a history of more than 100 years. Its accumulated knowledge and technological framework as well as consideration of the needs of medical facilities and patients have led to the birth of the direct-conversion FPD.

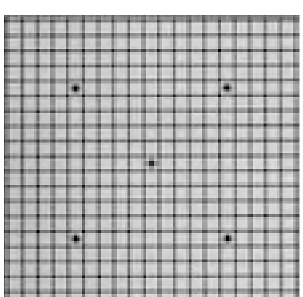
*1 **Cardiovascular X-ray imaging system :**
By injecting a contrast medium into the blood vessels, the blood vessels and blood flow around the heart can be observed in dynamic images. This system is used to check for disorders, such as coronary arterial stenosis, and to perform procedures for expanding narrowed blood vessels.

*2 **I.I. :**
"I.I." stands for "image intensifier" and is the vacuum-tube device traditionally used to produce fluoroscopic images.

*3 **Stent :**
A special wire-mesh tube used to expand a narrowed blood vessel from the inside.



9-inch I.I.

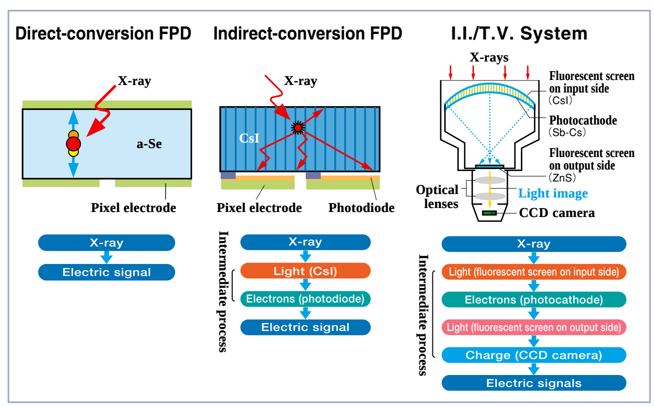


Direct-conversion FPD (Safire)

Mechanism of Direct-conversion FPD

Direct Conversion of X-rays to Electric Signals
Innovative Technology That Minimizes Deterioration in Image Quality

With the conventional I.I., there are several conversion processes between the incidence of X-rays and the creation of electric signals for displaying the image, and it is impossible to prevent loss of information and generation of noise. Even the indirect-conversion FPD offers no major improvements in this respect. The direct-conversion FPD, however, converts X-rays directly to electric signals in the conversion material (amorphous selenium). This optimizes the conversion process and reduces deterioration in image quality to the absolute minimum.



Xray Imaging System Equipped with Direct-conversion FPD Supports the Latest Treatment

Striving for Patient-centered Treatment

Hokuto Cardiovascular Hospital (Sapporo City, Hokkaido Japan), which carries out advanced, specialized treatments for heart disease, currently uses two DIGITEX Safire systems. Dr. Hideki Abe, Chairman of the hospital and head of its cardiology department, abides by a personal philosophy of “patient-centered treatment” and has carried out over 2,000 stent procedures. We asked him about his impressions of the Safire system and his visions for the future of community healthcare.

A Powerful Weapon in the Fight against Heart Disease

We moved to the present site in January this year in order to expand our services by opening a heart-surgery department. At the same time, we purchased and installed Shimadzu’s DIGITEX Safire system, which is equipped with a direct-conversion FPD. Although I had seen the visual clarity with prototypes, I was still very impressed. The image quality was significantly better than that of the I.I. (image intensifier) we had been using and even fine blood vessels could be clearly visualized.

There is no peripheral distortion or blurring and no halation, making it easy to see fine blood vessels. The thing that surprised me most was that the stent could be seen clearly without injecting a contrast medium. The most common treatment in current interventional cardiology is the prevention of restenosis of the blood vessels using stents. Positioning the stent has always been very difficult but since we installed the Safire system, it has become possible to place the stent at the exact position with just one test shot of contrast medium. As a result, both the radiation dose to the patient and the amount of contrast medium injected can be significantly reduced. The amount of contrast medium is typically 20% less than before. We can also anticipate greater success with restenosis prevention.

Because fine details can be seen with the Safire system, some conditions that would usually have necessitated surgical treatment can now be treated with less invasiveness. This means that the burden on patients can be reduced and makes the Safire system a powerful tool for medical practitioners.

A new treatment using a “drug-eluting stent”*1 is due for approval in Japan this autumn. The introduction of this treatment is expected to further reduce the angina recurrence rate and heralds the start of a new era in interventional cardiology. Accurate stent positioning is very important with this treatment. It is very encouraging to know that we will be able to implement this treatment with the help of such clear images.

Dr. Hideki Abe
1980: Graduated from Sapporo Medical University; 2000: Appointed Chairman of Hokuto Cardiovascular Hospital. Certified by the Japanese Society of Internal Medicine; registered as a specialist with the Japanese Circulation Society; panel member at the Japanese Society of Interventional Cardiology and executive officer for the Hokkaido region; director at Japanese Association of Cardiovascular Therapeutics; visiting professor at the affiliated hospital of Fujita Health University’s School of Medicine Hospital; professor emeritus at Dalian Central Hospital in China.

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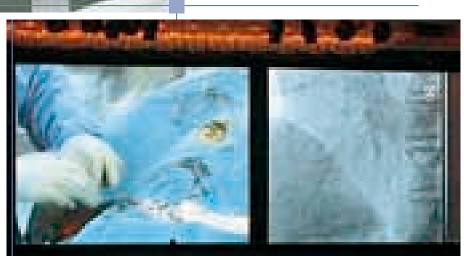

Hokkaido Education Live Demonstration, Jan.2004

High Praise for Shimadzu's Support Framework

In a sense, the catheterization lab is a battlefield. We are fighting disease in order to protect the patient. If our “weapon” is broken, we are no longer able to fight. It is therefore very important for clinicians to know that the equipment is durable and stable. Nevertheless, the possibility of malfunction cannot be completely avoided with any machine. It is important to know what to do when the machine malfunctions and what kind of help is available. In this area, Shimadzu is a company worthy of special mention. Whenever there is a problem, a technician comes straight away and, in cases where lengthy repair work is required, continues working throughout the night so that the equipment is in perfect working order for the next day. I very much appreciate this level of response.

Establishing Regional Coordination

Although Hokkaido is a very large area, the number of doctors and medical facilities here is very limited. With the aim of creating a network of cardiovascular specialists working in the region, for the past 5 years I have been conducting demonstrations dubbed “Hokkaido Education Live”.

At this year’s demonstration, which was held at a hotel in Sapporo City, we connected to my own hospital, Hokuto Cardiovascular Hospital, and a hospital in Muroran (another large city in Hokkaido) via fiber-optic link and showed a PCI procedure*2 to doctors involved in interventional cardiology and heart surgery in Hokkaido. The quality of the images produced by the Safire system raised quite a stir.

In the future, by holding similar demonstrations connecting Sapporo to other major cities in Hokkaido via fiber optics, I hope to foster the creation of a network stretching all over Hokkaido and gradually establish a system for the regional coordination of medical treatment.

*1 **Drug-eluting stent :** *Restenosis may occur in a coronary artery even if a stent is used. As an improvement on the conventional stent, a "drug-eluting stent", namely, a stent that has been coated with a drug that prevents restenosis, is used.*

*2 **PCI (Percutaneous Coronary Intervention) procedure :** *General term that refers to any procedure used to perform coronary revascularization with a catheter by expanding a blood vessel at a point where stenosis has occurred due to ischemic heart disease, such as angina or myocardial infarction.*

Even Smaller, Even Faster An Eye That Watches for Changes in Body Functions

Whole-body PET System

The PET (Positron Emission Tomography) system diagnoses cancer and other diseases by identifying changes in body functions. Shimadzu is currently the only manufacturer of clinical PET systems in Japan. The new PET-Eminence-G system, released in Japan this spring, offers even higher resolution and will create new possibilities in PET examinations.

Eminence-G system

Identifying Disease from Body Functions

The PET (FDG-PET) examination has become the subject of increasing expectations as a means of further investigation when the results of a urine or blood test suggest the possibility of cancer. While MRI and CT scans are used mainly to investigate forms within the body, PET scans are used to observe functional and physiological processes, such as the consumption of glucose.

In examinations for cancer, a radioactive isotope and a constituent similar to glucose are combined to produce a drug called ^{18}F-FDG and this is injected into the patient's body. Taking PET scans once the FDG has flowed all over the body provides images that make it possible to observe the way that, for example, the FDG gathers around malignant tumors. The whole body can be screened in just one examination and so there is little invasiveness on the patient, and even in the early stages of cancer it may be possible to find tumors in places other than those already known.

In the U.S., this treatment has become so widespread that many medical practitioners observe a policy of "PET first" when faced with a suspected tumor. Following the decision to extend public insurance cover to ^{18}F-FDG in April 2002, it is hoped that the treatment will become equally widespread in Japan.

Anticipating an Expanded Range of Application

Shimadzu has been performing R&D in PET technology for over 20 years and is the only manufacturer of clinical PET systems in Japan. Shimadzu possesses a high level of technology in this field, with the capacity to achieve quantitativity and short acquisition times. The new model due for release this spring offers an even higher level of resolution than previous models and, as a whole-body clinical PET system, it currently offers the highest spatial resolution in the world. The potential of this system to discover early-stage cancer that would, until now, have gone undetected is keenly anticipated.

The application of PET is not restricted to examinations for cancer. The same fundamental technique can be used to perform examinations for heart or brain disease by injecting, for example, ^{15}O-water or ^{13}N-ammonia. The whole body can be examined in one screening with minimal burden on the patient. With increased resolution, the capabilities of PET seem set to expand even further.

Shimadzu's new PET system Eminence-G was introduced to the Japanese market this spring at the International Technical Exhibition of Medical Imaging and the Japan Radiology Congress 2004 held in Yokohama.