Evaluation Technologies – Opening Up Paths to Differentiation with Original Inventions

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Evaluation and Analysis Technologies Demonstrate the Nitto Denko Group's True Capabilities as a Technology-Driven Company

Specially featuring evaluation and analysis technologies, this issue of the Nitto Denko Technical Report presents an excellent opportunity for the Nitto Denko Group – a self-professed technology-driven company – to advertise its technological strengths to the outside world (the users), albeit with some constraints, as many of the Group's technologies, especially those relating to production processes, are confidential in nature.

The true picture of a "technology-driven company" is that of an enterprise spending huge amounts of money on analyzing what unwanted specks and dusts are made of and where they come from, with the size of such specks and dusts shrinking every year to boot.

A warrior battling nano-scale pests may come in a strange shape, but is actually a highly expensive device embodying cutting-edge scientific technologies. What is needed is not just analysis of the composition and structure of these particles but also the ability to describe and analyze what is going on in the physical and chemical phenomena they involve in words that everyone can understand (units and chemical element symbols), with the power to express a vivid image of the mechanism. Earlier, it was enough to let the figures themselves do the talking (quantitative analysis) or to represent them as graphs, but nowadays there is a relentless desire for ever higher performance requiring illustrations and graphic images, in three-dimensional rather than two-dimensional representation. We have come so far these days as to have views from different angles based on video imagery.

Despite Ever Newer Equipment, Creativity of the Researcher Remains Indispensable

Not only are we surprised by all this development happening within a roughly 3,000-year-long human history, but considering the vast progress made in the last ten years and the speed of the progress forthcoming, we also belatedly stand in awe the power of the troublesome DNA which makes mankind so eager to gain knowledge.

For a business enterprise, investment in analytical equipment means comparative superiority in analysis and evaluation capabilities, and ultimately emerging victorious in the field of manufacturing. Such investment does not necessarily guarantee success in manufacturing, but without it, the road to success would be blocked for sure. How massive investment in state-of-the-art analytical equipment is can be appreciated by looking at the share it occupies in the research and development budget of the Nitto Denko Group. Investment in analytical equipment accounts for 60% of the facilities investment of the Corporate Technology Division. It is a particularly burdensome expenditure item, as equipment needs to be updated regularly to avoid quick obsolescence.

While analytical equipment is growing more costly, its functions are also growing more sophisticated and,

in analytical operations as elsewhere, more intelligent. Given the trend toward 'black box' systems, it has become easy to obtain results without understanding the principles and the rules of measurement. If this trend continues, there is a danger that human beings (researchers) will cease to think. However much technology evolves and high-performance analytical devices become available, we must not forget to give due consideration to the basic concept of measurement and measurement methods.

The basic parts of analytical equipment are standardized worldwide, the manufacturer's technological capability can be depended on for hardware, and data can be obtained by understanding the operating manual. However, there are also elements of possible differentiation in certain aspects of how the devices are used where devising original techniques is to our advantage. I hope that some of that originality has been outlined in this report.

Through what kind of process measurement yardsticks evolved and what it means to measure things are illustrated in the example of a tale from ancient China.

Creativity in Measurement Told in an Old Chinese Tale

There is a story I heard when I was a child and still remember today.

Once upon a time in China, when the people saw an elephant for the first time, they were amazed by its size and all wanted to know how much it weighed. But nobody could think of a way of finding out its weight. People were wondering how, when a child spoke up and said 'Let me weigh it'. The grown-ups laughed and said 'How's a little fellow like you going to do it? Are you going to make a weighing-scale the size of a temple belfry?' But the child answered 'I don't need anything special. Just a boat big enough for the elephant to fit in and a lot of stones small enough for a grown-up to hold in their hands.'

Now that I've told you this much I am sure you can guess the rest of the story. The boy had the elephant loaded onto the boat and marked the level it sank to under the animal's weight. Then he took the elephant out and had the boat loaded with stones until it sank to the same level. Afterwards the stones were weighed one by one on a weighing scale and the weights added together to work out the weight of the elephant. I always take the liberty of imagining a little canal, with stone walls along the embankment and some little boats easily available, perhaps somewhere in Suzhou, but in any case this story represents precisely the fundamental concept of measurement.

The tale illustrates the destiny that is embedded in the human DNA that makes us want to know the essence of things. It also teaches us that in order to do so, we have to be a little inventive.

Incidentally, it was in China that fixed units of measurement were first laid down. The first Qin emperor, who ruled China from 238 BC to 210 BC, introduced the concept of standardization into politics and laid the foundation for China to thereafter continue to exist as a unified nation. He introduced new rules under which the country was divided into administrative units, appointed the governors himself, and abolished hereditary rule. He established the units of measurement and also contributed to the standardization of currency. By fixing the length of the axleshaft of carts, he standardized the width of roads, and went so far as to standardize the width of canals. Despite the comings and goings of rulers and governments thereafter, this concept has been passed down and is still with us today.

Nowadays, physical units are defined in different terms. For instance, one meter is the distance that light travels in a vacuum in 1/299,792,458 of a second and one second is the time equal to 9,192,631,770 times the period of radiation corresponding to a transition between two hyperfine levels of a cesium-133 atom in its ground state.

New Evaluation and Analysis Technologies Targeted by Nitto Denko Group

We are now driven by the DNA which makes us want to know and see what is going on in the nano world and our desire has escalated to the point where we want to see it as a three-dimensional image. In 2005, this became possible when a three-dimensional electron microscope technology was successfully developed under the guidance of Associate Professor Hiroshi Jinnai of Kyoto Institute of Technology.

Three-dimensional images can be viewed from a range of different angles. Within the Nitto Denko Group is a company called Nitto Analytical Techno-Center Co., Ltd., which is in charge of developing three-dimensional imaging technology and specializes in analysis and evaluation. I would like to take a look at the kind of concepts under which this company is evolving new analytical technologies, referring here to a schema that takes us from the present to the near future (**Figs. 1** and **2**).

We have drawn an outline consisting of a technology roadmap and a corresponding equipment technology table, specialized in the areas where the Nitto Denko Group envisages needs. Our competency is in creating added value by endowing polymeric materials with advanced functions through polymer processing. In so doing, it is important to reinforce the material design technology by systematically building up technologies for evaluating the mechanism that delivers the high function.

The Nitto Denko Group's needs in terms of evaluation technology in the first generation related to attempts to create high function by controlling polymer structures, and were realized by raising our cross-linking, branching and dispersion technologies to a higher level of sophistication. The next generation relates to attempts to achieve high function by controlling the distribution of polymer domains, and here the keywords are orientation, crystallinity, sea-island structure, and phase change.

Another area competence relates to surface science and requires analysis of surfaces, interfaces, and thin films. Beyond that comes the age of applied nanotechnology, when hypermixed and hybrid technologies will be put into practice and membranes are likely to move into the realm of nano- rather than micron-level thickness control.

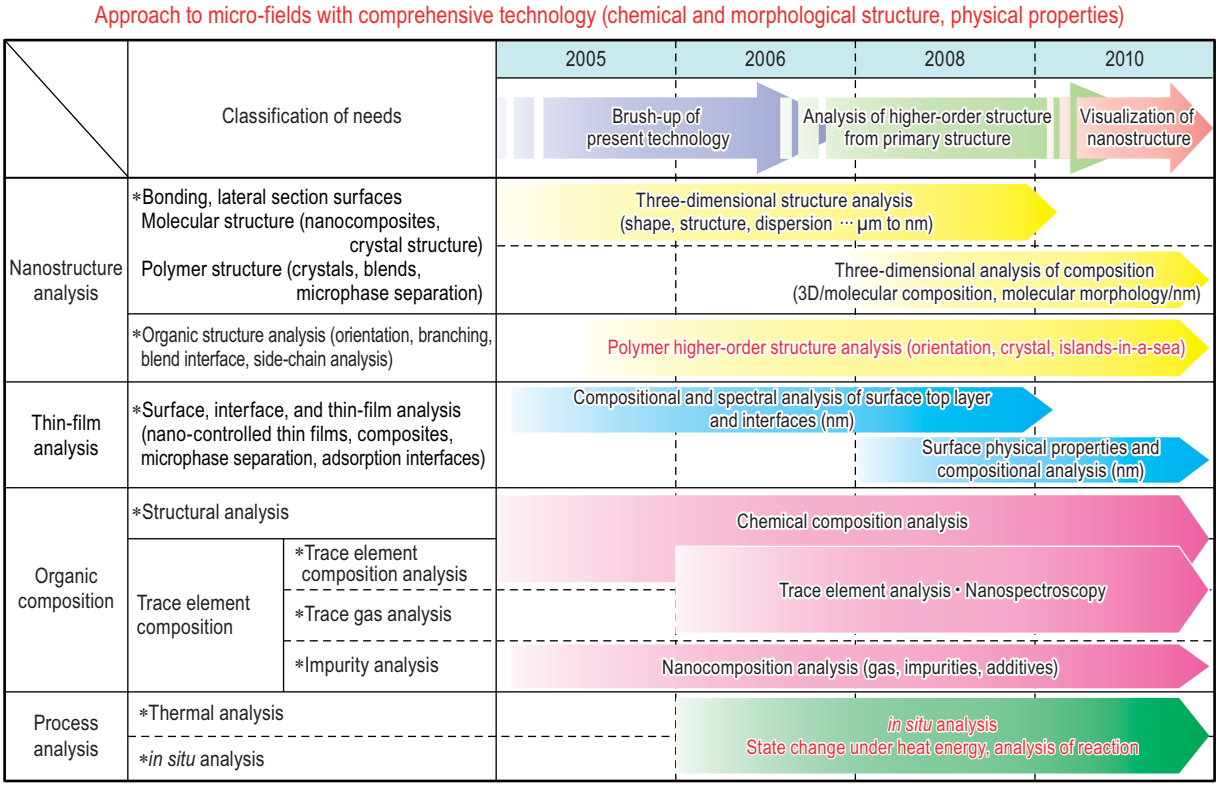

Fig. 1 Technology roadmap (outline)

A summary of equipment technologies is given in Fig. 2. The items shown in red on yellow arrows are those which have been introduced in the last three years, while blue arrows denote those that are targeted for future introduction. This plan connects broadly with our '*mieru-ka*', or 'visibility-enabling' ('diagnosis-enabling') orientation and is known at Nitto Analytical Techno-Center as '*Mieru-ka* Technology'.

These technologies fall broadly into two categories: 'investigating the changes which occur when energy is imparted (temporal resolution)' and 'accurately identifying the microstructure (improvement of spatial resolution) to create a three-dimensional image allowing an accurate identification of structure'. The development of *in situ* analysis also awaits in the future, which means capturing in time changes actually occurring on site. In technology terms, this means an improvement of temporal resolution, and, although the ability to evaluate structure in microseconds is a future development, it is in our sights. Technologies to capture (chemical and morphological) structure in three dimensions microscopically and represent it macroscopically also improve spatial resolution. The roadmap clarifies, in easily understandable terms, the targets to be pursued systematically based on the technological nature of the Nitto Denko Group as a functional materials manufacturer. In that sense, the Nitto Denko Group's strategic thinking regarding evaluation technologies should be apparent, but content at this level is something that is being explored by any company that considers itself a cutting-edge enterprise.

It is no exaggeration to say that we are living in an age in which one new evaluation technology completed means one new product created.

To see the Nitto Denko Group become second to none in evaluation technology in the field of polymer materials is the proud ambition of all those who have contributed to this special report.

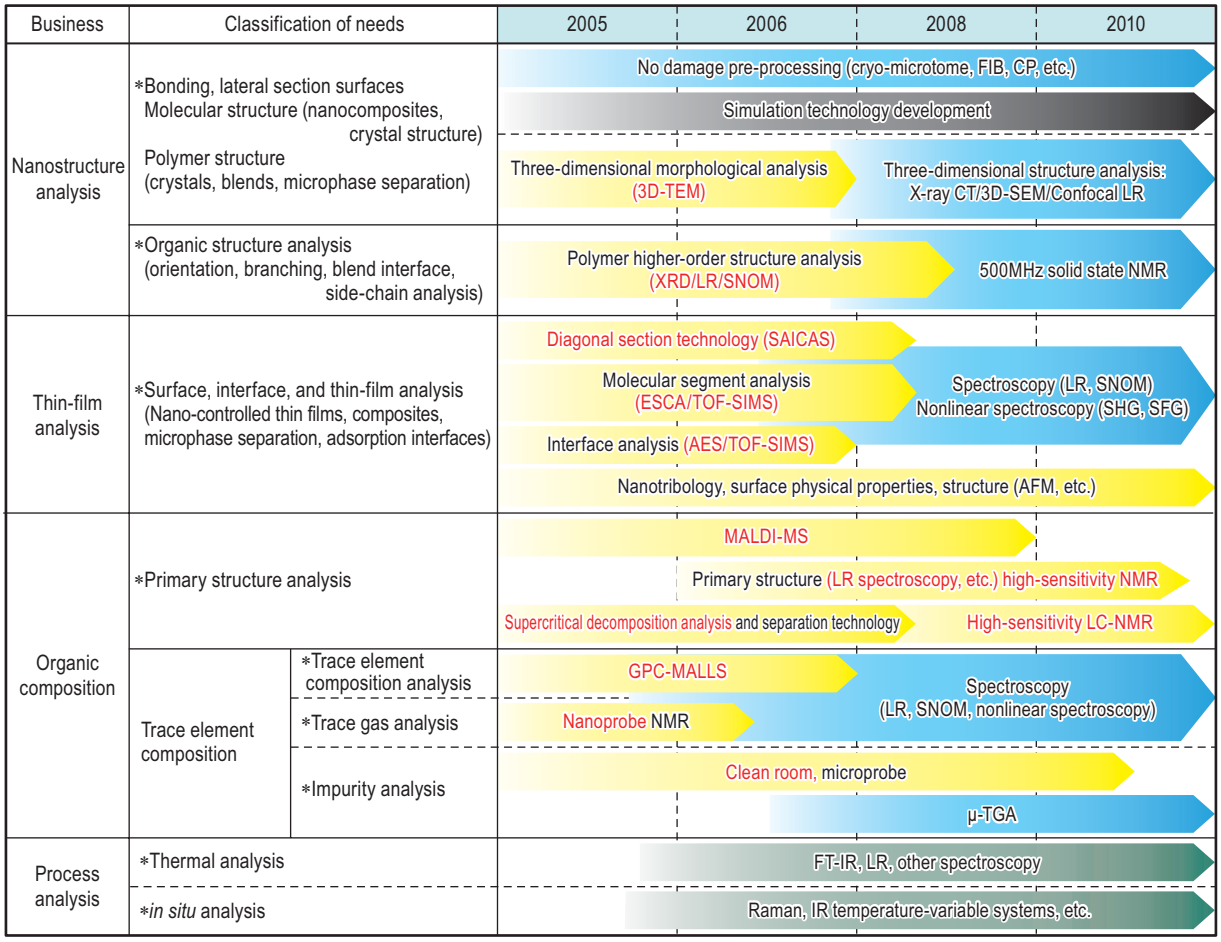

Fig. 2 Technology roadmap (equipment version)