An Investigation into Improving Intellectual Property Creation and Commercialization for AIST Nanotechnology Initiatives

Authors: Edward W. Scheckler, PhD; Todd Tilma, PhD; Thomas Giuffre
Monolith Corporation, Azabudai 3-3-9-702, Minato-ku, Tokyo 106-0041

Date: Friday, December 21, 2007

Supported By: The National Institute of Advanced Industrial Science and Technology
Technical Information Section

Executive Summary

Nanotechnology is an important enabler for advanced industrial processes, influencing everything from manufacturing to medicine, and is thus central to 21st century economic growth and development. In the early 1990s, Japan enjoyed a significant head start in nanotechnology research and commercialization; however, Japan is no longer a global leader in nanotechnology and also risks losing ground to other nations in Asia. The National Institute of Advanced Industrial Science and Technology (AIST) can play an important role in improving Japan's position at the forefront of nanotechnology research and development, but only if it addresses several fundamental problems that have inhibited success to date.

This report first reviews the seriousness of the problem. Several examples present the degree to which Japan has fallen behind the US and Europe. Furthermore, Japan is also likely to fall behind China and India in multiple metrics if current trends continue. We attempt to show that the mindset that has worked for many years must be changed: The US can still be the inspiration but the motivation must be the rise of China and India.

This report presents a number of potential solutions to reverse the trend of Japan's declining nanotechnology leadership. Fundamentally, the research culture within AIST must be aligned to its mandate as an Independent Administrative Agency (IAA) tasked with delivering economic and social value. AIST must establish a robust culture of innovation, risk-taking and entrepreneurship among researchers. Additionally, the term "nanotechnology" must be correctly understood. Nanotechnology is a set of enabling technologies, with application to a variety of disciplines, and should not be thought of as an end in and of itself. Furthermore, a sound framework for managing the issues of Environmental Health and Safety (EHS) is required. Finally, a successful marketing, PR and communication program is critical to sustaining a leadership position.

The main section of the report concludes with ideas for improving communication through better use of available Internet and web technologies and design concepts as well as specific actions that can be taken in the short, middle and long-term to achieve the goal of enabling AIST to more effectively and efficiently benefit from its current leadership position as the vanguard of research for industrial benefit.

I. Introduction & Project Background

As the US State Department noted recently [NNI 2005], governments around the world spend about USD 4 Billion a year on nanotechnology related research and development (R&D). In total, global spending on nanotechnology R&D continues to increase, and reached nearly USD 12 Billion in 2006. [RNCOS 2006] Currently, the US, Japan, South Korea, and Germany dominate this R&D landscape, however Taiwan and China are quickly becoming key players.

The authors have previously investigated nanotechnology technology transfer processes at AIST and published findings in mid-2007. [Scheckler 2007] The report included several observations based on reviews of published materials and interviews with AIST staff. Among the observations were a number of issues that can be summarized as follows:

1) AIST has many domestic patents, but low license revenue, and a low number of international patents, relative to the annual investment in R&D.
2) AIST patent management (AIST internal patent office) is separate from license marketing (by the Technology Licensing Organization: AIST Innovations), which is not industry best practice, neither in Japan nor in other major countries.
3) AIST does not appear to have a strong culture of new business creation among staff, nor do the support structures for new businesses appear to be effective, for example introduction to sources of venture capital.
4) AIST is not the center of an ecosystem for innovative new technology able to drive social value. It is difficult for external parties, small businesses and foreign nationals in particular, to engage with AIST and gain access either to its technology or its research capabilities.

Despite a few positive observations, several organizational and business culture issues impede AIST's ability to attain global leadership in nanotechnology.

This report goes further into investigating the issues and offers possible solutions to the problem of intellectual property (IP) creation and commercialization of nanotechnology at AIST. We first review specifics of the failure to sustain a global leadership position in nanotechnology. We then offer a number of creative solutions to address the impediments to success.

We follow this with specific recommendations on how to implement a world-class website infrastructure as a means to establish organizational identity, improve access to information, and to create a more effective engagement model between industry and AIST.

II. Japan's Failure to Sustain a Global Leadership Position in Nanotechnology

IIa – Evidence of the Problem

A recent issue of *Newsweek* [Caryl 2007] had on its cover "How Japan Lost Its Groove. The Asian Powerhouse Struggles To Explain Its Stumbles In Hot Technology." Inside the issue, the article entitled "Why Apple Isn't Japanese" went on to further give examples of where Japanese technology recently held a leadership position, and indeed a dominant position in Japan, but failed to become a global leader in that same area, with a subsequent negative impact on the domestic position. The first example that was given was NTT Docomo – a company that dominates the mobile-telecommunication market in Japan. NTT Docomo uses world-class wireless technology, but nevertheless has continuously failed to garner a major

market share in the global telecommunication space. In contrast, Nokia, based in a country with just 5 million people, has a global market capitalization that is twice that of NTT Docomo. As the article notes, the number one wireless company, by market capitalization, in the world is now China Mobile. [Caryl 2007] There are many possible reasons why NTT Docomo has been unable to expand its market dominance in the world's second largest economy into global market dominance but they can be summed up in one fundamental concept: a lack of understanding of the wants and needs of the new globalized market space.

In addition to this lack of global understanding, a number of internal company factors also contribute to the situation, which is why *Newsweek* notes that it is unlikely that a company like Google or Apple would have emerged in Japan today. [Caryl 2007] This is a considerable contrast from just 20 years ago when a Japanese company (Sony) created a similar product that radically transformed societal and cultural consumer behaviors, as well as dominated the market, both locally and globally – The Sony Walkman. Yet today, as the article notes, such innovation leadership has passed to a new generation, even in Japan: Apple's iPod holds 58% market share versus 23% for Sony's latest, digital Walkman. [Caryl 2007]

Why is this the case? Despite USD 130 Billion spent in Japan on R&D, more as a percentage of GDP than either the US or the European Union (EU) [Caryl 2007], Japanese industry is not coming out with innovative products that create entire new industries or product classes. To be fair, world-class companies such as Toyota are leading their industries, but this is an example of incremental advancement in a traditional industry (i.e. the *kaizen* phenomenon) and not an example of innovation that creates new products and services that define new international standards with Japan as the visionary leader. Instead, there is only the steady incremental advancement of the world's second largest economy – an advancement that cannot continue unless it can successfully invent and exploit new technology.

An excellent example of new, indigenous technology that could be exploited is "nanotechnology," which follows a similar trend over roughly the same time frame. In the early 1990's Japan was a recognized leader in this area. Of course the discovery of carbon nanotubes (CNTs) in Japan in 1991 was one of the breakthrough innovations that launched Japan to the forefront. Case in point: a news article in *Nature* [Nature 1994] was headlined "Japan Builds On Global Lead In Nanotechnology." This article presented that, despite the impact of recession at the time, Japan was able to apply its lead in micro-fabrication to new areas of quantum science and technology. Significant research investment from government and corporate sources followed.

Another article, written in September 1993 entitled "Technology Forecasting in Japan" [Bowonder 2003] stated: "[S]ystematic future-oriented thinking helps the government, industry associations and firms to initiate technology development efforts in a coherent way… [T]he Japanese are planning to sustain their technological superiority in photonics, nanotechnology, lasers, robots, and fuzzy logic."

A decade and a half later, Japan is no longer at the forefront of "nanotechnology" or any of its numerous market applications. A commentary in *Nature Nanotechnology* [Hullmann 2006] entitled "Who is Winning the Global Nanorace?" noted that the US is the clear leader in scientific publications and patents related to "nanotechnology" by more than 2 to 1 over Japan. In certain subfields, Japan is behind other major new players. For example China leads Japan by 2 to 1 in the field of nanomaterials. [Hullmann 2006] Even in areas such as

bulk CNT production, potential global leadership is being abdicated by Japanese companies to their competitors in Southeast Asia such as Vietnam. When the impact of papers is measured, buy assessing how often papers are subsequently cited in other works, the article noted that Japan comes in 10th after Switzerland, the Netherlands, the US, Canada, Belgium, Ireland, the UK, Denmark and France. Despite total public funding of nearly USD 1 Billion into all things "nanotechnology," Japan nevertheless is behind several small European countries with budgets barely a fraction of that. [Hullmann 2006]

In terms of economic value creation, as measured by the number of new companies created from nanotechnology-enabled research and inventions, the US has a significant lead. A later paper, again by Angela Hullmann [Hullmann 2007], provides further details, noting the small number of new companies that are created in Japan, relative to other countries, which exploit "nanotechnology." Even the AIST website shows a relatively small number of new businesses, nurtured by the AIST Innovation Center for Startups. Since 2002, there have been a total of 86 new companies that have been created from all AIST-based R&D, and only 2 so far in 2007. [AIST]

Beyond "nanotechnology" other innovative and high technology areas are also being neglected. A recent paper by Robert Kneller [Kneller 2007] reviewed university biotechnology related startups and found a similar trend in relatively few start-ups compared to the US, even discounting for the smaller size of Japan's economy. This paper reinforces our earlier report to AIST [Scheckler 2007] that Japan's overall university technology licensing lags the US both in terms of total license revenue and in average revenue per license. This trend is also true at AIST.

Perhaps it is not surprising that fewer companies are created in Japan than elsewhere. A recent issue of the *Economist* [Economist 2007] included a "Special Report On Innovation" with a section entitled the "Fading Lustre Of Clusters" that showed Japan is ranked last of all countries, in terms of percentage of working age population involved in entrepreneurial activity (at less than 3% compared to the US at 10%). Furthermore, it takes more time to complete the paperwork and registrations to start a business than many other major markets (over 20 days in Japan vs. 6 in the US). A number of other reports show similar trends. [Pasha 2002, Bosma 2006].

Other interesting OECD Science and Technology metrics collected within AIST evidence a low degree of collaboration between industry and either the government or academia in Japan. For example, less than 2% of the R&D in government and academia is funded by business. [OECD 2005] Japan is last among nearly all industrial nations in this regard. This implies that major corporations, who are the most likely to commercialize innovative technologies, get little value from academic and government-supported research.

Furthermore, China is rapidly advancing as a source of nanotechnology innovation. One bibliometric study showed that China's share of nanotechnology related publications reaching 20% by 2004. This contrasts with Japan's share, which stabilized at less than 15% during the same period and the United States with a 30% share [Guan 2007]. One key observation from that study was that China benefited greatly from international scientific collaboration, ensuring that China's emerging research capability was closely aligned to the most advanced research activity.

Lastly, the US and European Union continue to be favored over Japan as a place for filing nanotechnology related patents [Li 2007]. Japan continues to file many patents in the US and Europe, but Japan itself is not seen as an equally important filing location by other

countries. One issue that appears to have caused this is the delay in patent registration after publication, which is unique to Japan compared to the US and Europe. This may be a contributing factor for the poor showing of Japan TLO's that market primarily Japanese patent licenses. This trend also indicates that comparison of Japanese patent filings alone is not a good metric of international success, and Japanese research institutions should therefore consider more aggressive efforts to file US and European patents.

IIb – Common Issues

The western press regularly recites particular features of the Japanese business culture and economy as root causes of the failure to innovate. For example, *Newsweek* [Caryl 2007], touches on several of these paraphrased here:

1) Large, vertically integrated companies with little maneuverability, and a marked disinclination to creativity, dominate the Japanese corporate landscape. This makes it difficult to generate new creative ideas, or to spin-off the results of a particular project as a new business.
2) Clearly defined boundaries between groups, even within companies, impede the free flow of ideas and "cross-pollination" that exist in the most creative international firms, such as Google. This also leads to weak relations between academic and corporate circles, except for special relationships between particular companies and specific professors.
3) Promotion based primarily on seniority results in senior management with insufficient skills in the relevant scientific or technological areas.
4) Japanese companies and research groups tend to excel at team-based incremental change, but regularly fail to deal effectively with individual creativity and genius.

A further paper [Lehrer 2004] also presents how institutions that support national industries must adapt and evolve in order to be effective. Failure to adapt can create a situation where those institutions are actually an impediment to progress.

Indeed exceptions to these observations tend to occur in smaller companies, in areas most free from government intervention, and outside of major centers such as Tokyo. For example, Nintendo's "Wii" game system was invented in Kyoto. An emerging trend dubbed "Cool Japan", with Japanese manga, anime, street fashion, and dance music driving an export industry for Japan-developed content is happening in the complete absence of government direction and support and by a surprising number of young designers, artists, and entrepreneurs with little connection to traditional companies [Nikkei 2007, JETRO 2005].

III. Improving Nanotechnology Research and Commercialization at AIST

IIIa – Leading Change

The first step in driving change within an organization is to establish a sense of urgency. The previous section should provide evidence that Japan has already lost its global leadership position in "nanotechnology." Furthermore, Japan risks being overtaken by aggressive efforts by China and other countries in Asia. But a critical first step is that the organization that will undergo change must understand and accept that change is necessary.

Change methodology within organizations has been studied extensively. A concise approach to leading change has been formulated by John P. Kotter, who was the Konosuke Matsushita Professor of Leadership at the Harvard Business School, in his book "Leading

Change." [Kotter 1996] We outline the important steps here as a guide for AIST leadership who may wish to affect change within AIST. One of the authors has been involved in change leadership at 2 major financial institutions and can present from personal experience that all 8 steps must be followed for the change to be effective. These 8 steps are:

1) **Establish a Sense of Urgency**: As mentioned above, if members of the organization do not see a need for change, there will be resistance at all levels and the change will fail before it even begins.
2) **Create the Guiding Coalition**: The leadership of the organization must enlist key leaders and managers who agree with the need for change and will oversee its implementation in the organization.
3) **Develop a Vision and Strategy**: The leadership must first be clear on where the organization needs to go, i.e. what is the goal (or vision). The next step is to develop and clearly articulate a strategy for achieving that goal.
4) **Communicate the Change Vision**: The leadership must then communicate, to the entire organization, what the change plan is. Team members who do not understand the vision will not be able to achieve it.
5) **Empower Broad-Based Action**: In this step, team members must be given the authority, appropriate to their level in the organization, to execute the strategy.
6) **Generate Short-Term Wins**: Most teams need some validation that things are moving in the right direction early on, or the enthusiasm for change risks disappearing at an early stage. It is important to identify a few clearly achievable objectives that can be implemented in the near term and for which everyone shares in the success.
7) **Consolidate Gains and Produce More Change**: This step is all about keeping momentum and generating positive energy in the organization; that things are moving in the right direction and that the leadership is supportive of the vision.
8) **Institutionalize New Approaches in the Culture**: This last step is critical to ensuring that change is lasting. In large companies or research institutions, rewards and recognition (as well as punishments or admonishments) must be aligned to the goals and strategy of the organization. There are few things more demoralizing than to see people who actively work against the vision and strategy continue to be promoted or recognized. Bluntly, that means that people who are not on-board with the new direction and strategy of the organization, must be removed for the greater benefit of the organization.

In working with AIST for the better part of a year, the authors sense that AIST is still at step 1. There is some understanding of the goals of AIST, but there is not yet a sense of urgency that the results of the organization to date are unsatisfactory. We have not surveyed AIST researchers for this report, but the authors and others [Kneller 2003, Kneller 2007] suspect that the majority does not yet see any reason for change. Until a sense of urgency is established no further improvement can take place.

Of course, the AIST leadership is well positioned to establish the necessary sense of urgency, build a guiding coalition, develop the vision and strategy, and communicate the change vision (steps 1 to 4). Indeed, much of the underlying vision is already well stated in AIST's own mission statements. The challenge will be in translating that into effective action throughout the AIST organization.

The next sections provide additional ideas that can be implemented once steps 1 through 4 of the Kotter change methodology are applied.

Improvement Idea*: Once AIST leadership establishes that there is a need to improve the research culture at AIST, Kotter's methodology should be applied to implement the new vision and strategy. AIST should consider engaging outside management consultants to facilitate this process across all of AIST. The management consultant team must report the President of AIST and be accountable to him for success.*

IIIb – Developing a Robust Culture of Innovation, Risk-Taking, and Entrepreneurship

If we take the view that global leadership in a technology comes from being at the forefront of R&D innovation in that field, then global leadership in commercializing the technology has to come from being at the forefront of transferring R&D innovation from the laboratory to the marketplace. In this regard, Japan's current *san-gaku-kan-renkei* (Industry-Academia-Government collaboration) promotion system, the Independent Administrative Agency (IAA) reforms of the past 5 years, and the rise of the Technology Licensing Offices (TLOs), appear to provide an excellent framework for technology innovation, development and commercialization. Although these government-led reforms help drive technology forward in a coherent way, they do not address the fundamental issues facing entrepreneurial companies.

One of the most dynamic approaches towards promoting R&D innovation and technology transfer is in the creation of technology venture start-ups by academic and government research scientists. In the US "[C]urrently 350 to 400 startup companies are formed from US academic institutions each year. About 3,000 have been formed since 1980, of which about 68% are still operational." [Kneller 2003] Although most of the initial money for the development of these start-ups comes from private sources, those same academic institutions, as well as the US government, also contribute funds. In particular the US government's Small Business Innovative Research (SBIR) Program allows venture businesses to receive peer-reviewed, competitively allocated, project-specific research support of up to USD 750,000. [Kneller 2003] SBIR-based investments usually act to bridge the gap between government/university-sponsored academic research funding and direct private investment.

Unfortunately, a similar strong environment that supports the development of commercially viable research, through the creation of new businesses is lacking in Japan. As Kneller noted in 2003, and recently expanded on [Kneller 2007], the primary problems in the development of such systems in Japan are still:

1) Real and perceived limitations of Intellectual Property (IP) rights funding sponsors can obtain;
2) Real and perceived barriers to the smooth disbursement of corporate research support; and
3) Real and perceived restrictions on the use of such funds to employ and motivate people.

In essence the current set of reforms are not well enforced. As Kneller noted in his latest work: "[S]trong TLOs linked to incubators, university offices that can provide advice on starting a company, etc. provide an alternative to simply passing discoveries to collaborating companies." [Kneller 2007] This issue is one that is not new to Japan: "[T]he technology-transfer issues that confront Japan in part reflect IP issues that were current in the United States in pre-Bayh-Dole, pre-FTTA era. But they also reflect legal and institutional barriers to university-industry cooperation that have not existed for decades in the United States." [Kneller 2003] Even with yearly *san-gaku-kan-renkei*-focused conferences (see for example,

http://www.congre.co.jp/sangakukan/top.html) and high-level support for greater collaboration and cooperation between industry, academia, and the government, the current R&D funding situation for marketable IP in Japan is still perceived, both internally and externally, as being opaque and obfuscated, and biased towards established corporate entities.

For example, it is currently believed in many local and foreign business circles that a majority of Japanese university and government research that leads to new technologies is "informally" transferred into the industrial sector through what are called "donor" corporations, in part to avoid the above issues. Because these "informal" transfers are predominantly based on social networks that are usually closed to certain groups (foreign investors and companies being the most obvious, but indigenous local and start-up corporations are also usually excluded) they are effectively a form of corruption within the current *san-gaku-kan-renkei* system. In particular, as Kneller has noted:

> "The informal pass-through of IP rights to donor companies is biased against small companies, especially startup companies in several ways. First, it favors transfers to large companies rather than startup companies since they are more likely to provide Donation funds and hire students. Second, startup companies need a clear unambiguous chain of title to IP rights in order to obtain private venture funding. Because many inventions attributed to Donations in fact arose primarily under other sources of funding and because of the related fact that contractual transfers of Donation inventions are discouraged, a cloud of uncertainty surrounds the chain of title to inventions attributed to Donations. Third, informal pass-through of IP rights to donors can result in related technologies being disseminated to several companies, technologies that if appropriately bundled, could have formed the core of a successful start-up company." [Kneller 2003]

Even after four years, with the maturing of the TLOs and the other legs of the triumvirate, the situation has only become more difficult for start-up creation and entrepreneurialism:

> "[The] most remarkable aspect of the new system is the rapid continuous rise in the number of joint research agreements… [T]he growing prominence of joint research is not so much an achievement of the new system as the continuation of the old – a system that allows direct transfer of inventions from a professor's laboratory to collaborating companies, where the terms of transfer are worked out largely between the professor and the company, and where the company is under few obligations to develop the discoveries or to pay substantial royalties. Moreover, this reconstituted old system circumscribes the new system – *limiting the inventions the TLOs can manage and limiting growth opportunities for startups*. [Emphasis added]" [Kneller 2007]

The current situation basically leads to the destruction of any positive business environment for the development of startups, as well as limits smaller companies, be they foreign or domestic, from actively engaging in marketing local R&D. It is effectively a form of corruption that is due to the weakness of enforcing the current IP licensing and technology transfer system, as well as a lack of support for, and understanding of, business failure. The current triumvirate of reforms is designed to harness the creative talent of scientists and researchers, but many who have a reflexive need to adhere to out-dated bureaucratic norms of economic and business creation are overwhelming its full potential. If such behaviors continue unabated, the next revolution, be it nanotechnology or something else, will be lost.

***Improvement Idea**: Kneller provides several suggestions on page 454 of his article [Kneller 2007]. Among the most important is to "either eliminate the provision in article 35 of Japan's*

patent law that requires agreement of all patent co-owners to any license . . .” The effect of this provision is that for government/academia joint inventions, companies retain an effective exclusive right that stifles other opportunity. AIST should require clauses in all joint research agreements that include AIST that bypass the provisions of article 35.

***Improvement Idea**: Given that a major issue with venture company creation in Japan is lack of access to capital, consider establishing a consortium of venture investors specifically tasked with nanotechnology-related investment, perhaps with government matching grants. AIST could facilitate the creation of this group, as well as introduction of qualified researchers who are interested in founding companies based on AIST technology. An important point here is that these venture investors must invest money, and there must also be a process for guiding these new companies through the stages of investment required during there first several years of operation.*

***Improvement Idea**: It has been said that entrepreneurial-minded researchers do not join AIST. To counter this, create opportunities for technically minded entrepreneurs to work with AIST researchers in partnership.*

Another example of stagnation that we noticed in Japanese nanotechnology-focused R&D is that the professors and managers who were specifically mentioned in 1994 [Nature 1994] as being at the forefront and global R&D leaders are exactly the same people today, 13 years later. There has been almost no change in leadership, or are there many new names at the top of the hierarchy of nanotechnology-related R&D in Japan. This does not mean that these leaders are not managing large organizations or grants effectively. However, it is impossible for true innovation and creativity to result if there is absolutely no turnover of research leadership over time. The downside of the current situation is that new researchers and creative talent are unlikely to pursue a career in a field where they see no hope of advancement into becoming leaders themselves.

***Improvement Idea**: To encourage young researchers, define specific grants that can only be won by new talent who have not been major grant recipients in the past. These grants should be explicitly designed so that these researchers are given the same status within AIST as senior researchers. Additionally, the panel for awarding these grants should be made up of industry leaders, who have skill in evaluating grant proposals, but who are not part of the mainstream leaders in nanotechnology currently. An interesting example of such a grant system would be on the lines of the MacArthur Genius Awards.*

***Improvement Idea**: AIST could do more to support Japanese scientists who are returning from overseas. The Chinese Academy of Sciences (CAS) actively recruits overseas Chinese by offering research positions and career opportunities to those who agree to return full-time. AIST could copy this approach.*

***Improvement Idea**: To identify new ways of running research laboratories, pilot professional outsourced lab management at AIST. For example, perhaps a distressed corporate or government laboratory in Japan, that is otherwise at risk of closure, could be taken over by AIST and then the management outsourced to an organization such as Battelle.*

***Improvement Idea**: Japan is well placed to attract top scientific and research talent from around the world since there are many people who are interested in Japan generally, and who would enjoy living in Japan specifically. However, efforts must be made to offer truly career-oriented positions that have potential for leadership advancement regardless of national origin, and regardless of ability in the Japanese language. AIST could offer*

permanent positions (as opposed to short-term contract positions) to researchers from around the world, and could include all researchers in advancement and promotion opportunities based solely on proven research and administrative success. Note also [Osborne 2007] for examples of problems facing foreign researchers in Japan.

Improvement Idea: *AIST is no longer a part of the government and its employees are no longer civil servants. Thus they are no longer truly bound to the traditional rotations and requirements placed on government employees. Long-term positions should be offered to highly skilled businesspeople who can lead the development of an entrepreneurial spirit within the organization and promote the business of research.*

Improvement Idea*: to really shake things up, recruit the next president of AIST from outside of Japan. Identify someone with proven national laboratory leadership experience, even if that person does not speak Japanese, and give him or her the necessary freedom to strengthen what works and creatively destroy what doesn't.*

As a positive counterexample in Japan, in Kyushu there has been much more ability to get past these issues, in part due to strong local support for venture investing (e.g. Kyushu Venture Partners), government incentives for locating buildings and offices in industrial parks in Fukuoka and Kita-Kyushu areas, and a strong focus on technology transfer at Kyushu University. AIST could for example play a strong role in encouraging such partnerships in locations where emerging ecosystems for entrepreneurship and technology transfer are already taking place. Two of the authors of this report had an opportunity to attend the Asia Innovation Initiative conference in Fukuoka, Japan during June 6 and 7, 2007. This conference was organized by N. Idei, former CEO of Sony Corporation, with an express goal of investigating ways to improve innovation and collaboration in high-tech industries across Asia. This meeting brought together experts in business, investment banking, venture capital, and government, who participated in a number of panel discussions covering a wide range of topics. AIST could use this forum as an example to support knowledge transfer.

Improvement Idea*: Participate actively in the Asia Innovation Initiative organized by N. Idei, including sponsorship, participation in creating the agenda, and in facilitation of the events, including assisting in providing continuity year on year.*

<u>IIIc – The Danger of Inappropriate Use of the Term "Nanotechnology"</u>

In recent years there has been considerable investment in research that is called "nanotechnology." Additionally, there has been considerable press on the potential dangers associated with such research, including a recent editorial in the *Asahi Shimbun* [Asahi 2007] that goes so far as to compare the risks from nanotechnology to nuclear weapons and genetic engineering. Add to this, the return on nanotechnology-related research investment remains quite small. For example, at AIST, the revenue from technology transfer of research labeled nanotechnology is less than a few percent of the total research investment, leading one technology leader to exclaim, "[W]e have nothing to show after 3 years of effort." [Schekler 2007]

We believe that a significant part of the problem is the misuse of the term "nanotechnology," which has lead to a dangerous level of hype and misinformation. There is a risk that incorrectly calling work "nanotechnology research" will achieve nothing more than to degrade and obfuscate the lexicon that is nanotechnology. Furthermore, much valid research in this area risks being unfairly associated with the failures of misnamed activity. Lastly, there is the risk that the benefits of nanotechnology research are oversold; creating unreal expectations.

So what are researchers in nanotechnology actually doing? Our view is that true nanotechnology research is best defined as research into technologies that enable other disciplines to access the sub-micrometer scale. The field that is known as nanotechnology is an extension of established fields in the semiconductor, materials science, chemistry, and pharmacology fields, to name a few. It is primarily the result of the inevitable movement down the length scale.

For example, the semiconductor industry has been producing products that are at or below the 1 micrometer (1 μm) length scale for the better part of a quarter century, yet no one in the industry felt the need to say they were doing nanotechnology-enabled work or creating "nanotechnology-based" products. For example, one of the authors published several papers during the early 1990's in the field of sub-0.25 μm lithography for semiconductor manufacturing, but did not once use the term "nanotechnology," even when line widths of less than 0.01 μm were presented. [Scheckler 1994] Also, chemists around the world have been developing fine grain powders for generations. The Indian cosmetic kajal for example was recently found to be largely composed of CNTs, [Indian Express 2005] yet chemists never said they were, or called themselves, "nanotechnologists."

So why now do we have such a fixation on identifying such work with a new term? Perhaps it is due to the inherent need for money to do research - the common desire of researchers to be doing something "cutting edge" - as well as the cultural requirement to collectively label that which has the potential to radically alter our lives with new words that instill "fear and dread." Whatever the reason, nanotechnology has become part of the daily language and it cannot be ignored. The challenge is separating the hype from the reality.

One of the biggest problem with the term "nanotechnology" is that is so often misused by both the scientific community, and the public, so that when it comes to development/commercialization opportunities, the hype overshadows the reality. Thus, we strongly encourage all of those engaged in research, policy-making, and commercial activity involving objects at the sub-micrometer scale, to step back with a skeptical eye as to what is truly being called nanotechnology as opposed to unnecessary hype. If you can measure or manipulate something at the sub-micrometer scale, then you are probably doing something that can be called nanotechnology. Everything else, is probably something that should best be viewed from the perspective of its own discipline, be that a branch of science, a commercial activity, or a policy or legal regime. Anyone who says he or she is a pure nanotechnologist has probably succumbed to the hype, and is probably not focused on the nitty-gritty of what it really takes to create practical engineering solutions in the sub-micrometer regime.

Those who are pursuing the most productive and interesting work at these incredibly small length scales are probably not trying to create "molecular assemblers" and other exotic inventions that have contributed to inflated expectations and irrational fears. The best nanotechnology-labeled research and commercialization is based on fundamentals; the success/failure of fundamental research and development for the product, the fundamental cost/risk analysis of the product in the marketplace, the fundamental public perception of the market strategy for the product, and so on. These scientists and engineers realize that the term "nanotechnology" is nothing more than a marketing tool used to tie together varied marketplaces into a new, linked, economic playing field. It is, the tail wagging the dog, causing wasted time and delaying definitive marketable actions, especially those that may help minimize the religiosity that has come to grip those who preach economic, technical, social, and even political salvation through the embracing of the religion of the very small. A

skeptical view, based in measurable observations and rigorous test results, will go a long way towards separating the hype from the reality.

Improvement Idea*: AIST is well positioned to champion effective use of the term "nanotechnology" to ensure that the term is appropriately focused on underlying enabling technologies, and more importantly to ensure that the term is not misapplied to the many applications the benefit from nanotechnology as an enabler.*

IIId – A Sound Regulatory Framework for Issues of Concern (e.g. Environmental Health and Safety)

Beyond issues with terminology, the lack of public knowledge concerning the Environment, Health, and Safety (EHS) issues related to nanotechnology-enabled products is troublesome. When a recent survey noted that:

> "[T]wenty percent of the scientists responding to the survey indicated a concern that new forms of nanotechnology pollution may emerge, while only 15 percent of the public thought that might be a problem. More than 30 percent of scientists expressed concern that human health may be at risk from the technology, while just 20 percent of the public held such fears." [Nature 2007]

the lack of effective communication and knowledge transfer about the issue comes to light. The opportunity for scientists and researchers to really affect change in this area is enormous; but it requires a radically re-thinking of the current outreach process. In short, scientists and researchers should be helping to frame the discussion, but a professional public relations firm handling the outreach/media campaign is a necessity in this new research climate. As the authors of the article noted, "[S]cientists tend to treat communications as an afterthought. They're often not working with social scientists, industry, or interest groups to build a channel to the public." [Nature 2007]

The reason for such a radical re-think is due in part to the current state of the commercial environment for nanotechnology-enabled products. We already live in a world awash in materials, products, and consumables that contain nanostructures. The lack of public understanding about this situation shows that it is important to discuss the environmental and/or health impact of these products as a separate regulatory item. However, in particular, to focus solely on the sub-micrometer scale is to limit and restrict our options, both regulatory and commercially, within the larger context of general environmental, health and safety issues. We need to also look at how these materials, products, and consumables that have nanostructures can be, and in some cases already, regulated under existing protocols.

To begin, it is important to understand the scope of the issue. In a recent edition of the journal *Science* it was pointed out that "nanomaterials [are] already a part of 500 commercial products." [Science 2007] If one considers semiconductors and other chemical materials that are smaller than 1 micrometer, that number increases exponentially. In such a climate of plenty, EHS issues become interlocked with market standards. Standards are one of the easiest ways to lay claim to vast sections of any new economic landscape. However, counter to current bureaucratic thinking in Japan, because of the current interdependence and globalization of the various economies (India, United States, Brazil, etc.) in the supply change of various products, we believe that it is highly likely that market forces, not governments, will drive the development of internationally recognized standards so that nanotechnology-enabled products made in one country can be sold in another with minimal adjustment. Yet it is also our belief that when problems occur with these products,

technologies, and materials that have been labeled, correctly or incorrectly, as nanotechnology under such standards, there will be an inevitable call for even more stringent EHS protocols to regulate the sale of such items in the local market. Unfortunately, in the current environment, the general population is either under-educated about the risks associated with this new set of technologies, or is overly-fearful of anything remotely labels as nanotechnology.

In more detail, it is our contention that government-based proposals for a current set of standards for nanotechnology-enabled materials is currently being driven, in part, by the desire for market control (or market protection) based on the hyperbole surrounding "nanotechnology" and its preaching of a new marketplace. This move is also being driven, in part, to counter the already established set of standards, in mature markets such as semiconductors, which are used to describe the manufacturing technology inherent in those industries. However, in regards to EHS, the quality of the information being disseminated by governmental bodies and commercial organizations, just to name a few, about these products is not being influenced enough by the hype surrounding the term "nanotechnology!" Too few people understand the true nature of nanotechnology-enabled products, even after more than two decades of public consumption of the term "nanotechnology." The best way to resolve this issue is to more strongly promote that source of scientific information most trusted by the general public – the research scientist.

Simply put, it is our contention that scientists in Japan are more often on television or commenting in a public space than in the US. In this way, the innate trust that people have in the words spoken by such researchers and medical doctors, combined with the deference to teachers and those of high education, can be exploited to promote and shape the public discourse about nanotechnology-related EHS issues. But, what this means is that AIST needs to step up and get out of the way of the message. Outreach in this field needs to be handled by professionals skilled in shaping public opinion. AIST should supply such a group with intelligent and competent scientists in the field (such as Dr. Junko Nakanishi, now a member of AIST and a leader in environmental, health, and safety research) and should be making the talking points, helping frame the discussion, but it should release control of the outreach/media campaign to a private organization skilled in handling the media. Again, what we see in AIST, and indeed most research organizations throughout the world, is not a failure in understanding the issue, but in a failure to execute in shaping the public's perception of the issue.

***Improvement Idea**: Allocate part of the AIST budget for nanotechnology to the hiring of a professional public relations firm to help craft and present an effective message in the best possible way.*

<u>IIIe – Effective Knowledge Transfer</u>

In frequent visits to AIST, and in a review of materials, conferences, and especially websites produced at AIST, the authors have noticed that very few activities are outsourced to professionals in the fields of conference management, public relations, and web design. While AIST's staff is certainly competent and well intentioned, this failure to leverage the full range of skills available in the market place can result (and likely has resulted) in a less than effective ability to share information.

We believe that the problem is so serious, that we have devoted an entire section to ideas on how to improve communication via a vastly improved website environment.

IV. How AIST Can Deploy Best Practice Website Solutions for Improved Communication

The AIST Technology Information Department is the office within AIST responsible for all communications and promotion of AIST research activities to the general public and industry. It also provides for intra-office communications among AIST research centers and its researchers. The Technology Information Department publishes documents and reports of AIST activities, organizes official conference events, travels abroad to represent AIST to the international research community, and maintains the AIST web site. In total the responsibility is substantial for an organization that spends more than USD 1 billion per year on research and advanced development. Effectively, the Technology Information Department of AIST is the face of AIST. It is the channel through which contact and interface with AIST is conducted. Given the substantial responsibility and importance of the role of this office of AIST to the entire AIST research community, we expected to find that the office would be well equipped to handle the duties and tasks that it is called upon to deliver. What we found however was an administrative office that is resource constrained in several ways.

When we look around the world at other similar research organizations we can observe that the Information Office in these world class organizations are well funded and maintain a high status within their respective organizations. They work very hard to reach the public and industry using industry best practices and tools that aid the transfer of knowledge and technology. They use professional marketing and PR services to promote their organization. They often rely upon outside expert organizations to develop their PR programs, build and maintain their web sites, and organize events. These world-class organizations understand the importance of a strong and effective marketing program to communicate to their people and industry partners. They hire professionals in the PR field to run and manage their information offices and outsource where possible to professional firms that specialize in particular aspects of promotion and event production.

There is nothing special about using professional services in PR, marketing and event production. Commercial enterprises often do so and it provides the basis for the PR firm to exist. Commercial enterprises know what they are good at and what their core business is. They get professional help in the other areas that they need from time to time to support their non-core business operations. AIST needs to adopt the very standard business of running their research organization in a similar manner. AIST is a professional research organization; it requires professional promotion services to run its Information Office.

The Technology Information Department does an admirable job under the current circumstances. It uses all available resources and tries its best to publish quality reports, produce interesting and informative events and provide access to AIST research through its web site. In fact the AIST web site is full of useful information about the AIST organization, its research activities and researchers. However, the experience to access the AIST organization via the web portal often fails to meet our expectation. Why?

Why is it difficult to navigate the web portal and quickly find information that I want or to understand how information is organized? Why is the organization of information so different from what we find on major research centers in the US or Europe? Certainly information organization should have a logical structure to it. And certainly such a structure should reflect the type of information produced and how that information is to be used. The information design should quickly and consistently communicate what the organization is, what its products are, and what value they can offer to me as a customer of their product.

Our impression of the AIST main web site and the affiliated web sites organized by each research group within AIST is that there is much information without a clear purpose of being. There is no clear structure that makes us understand how AIST would like to communicate to the world about itself. What is the purpose of AIST? I can read a mission statement, but I cannot find information that is organized in direct support of the their mission. Why not? How does the organization of the ASIT web sites help AIST achieve its overall mission and objectives as a research organization? Conversely, does the current design of its information portals prevent AIST from achieving its overall mission?

As a communications tool, what message does the AIST collection of web sites deliver to industry and the public who may access these information portals seeking information about AIST activities? Why is there so much variety of design and information content among the many web sites that represent each research group? What does the design and content variance imply about the identity of AIST as an integrated research organization?

We suggest that so long as AIST sees itself more as a collection of academic research groups and less as a professional research organization, then poor information design and management may be acceptable. However, any professional organization that expects to be perceived by its customers (industry and the general public) as a professional organization must look and act like one with a high degree of consistency through every channel that contacts its customers.

As a professional organization AIST seeks a return on its research in terms of technology transfer into industry. The measure of the return on research is counted in terms of technology licensing revenues from patents licensed or sold to industry. There may be joint development efforts that are partially funded by industry. There may be new venture businesses that are created by researchers within AIST that seek commercial opportunities from their work. How does the information design of AIST information portals impact these performance measures?

While it is true that the factors that contribute to the overall goals of AIST are many more than simply a good web site, the idea that information design drives the basic identity of an organization is fundamental. This concept is no different than what we experience when dining at a fine restaurant. An appropriately well-managed and structured kitchen that is organized to deliver the fine dining experience will support an elegant dining experience. There is a consistency of structure in organization, identity and the communication of these elements to the customer.

There are several specific ways to approach the problem of effective information design for an organization. A formal starting point begins with the organization mission statement and a review of all marketing, branding and communication materials to determine to what degree their design is aligned with the mission statement. From this point it is possible to determine what steps should be taken to correct mis-alignments. The next step should be to establish a formal program for improving the overall PR and marketing of AIST through the creation of an integrated information design plan. Such a plan will be applied to all parts of AIST, at every level of the organization to create a unified identity, mission, description of activities, and method of engagement with AIST.

V. Summary

In conclusion, the authors believe that despite the current stagnation of Japan's global leadership in nanotechnology, many elements are in place that do provide a strong foundation for improvement. Fundamental among these is the potential for AIST to leverage its experience and resources to provide leadership and coordination overall. The core principles can perhaps best be summarized as follows:

1) AIST must seriously consider whether its current internal culture is aligned with the stated goals of the organization. If not, a structured change methodology based on a well-defined "bias for action" must be driven and supported by top leadership.

2) AIST is well positioned to pilot a number of ideas to determine whether they will address problems that have been historically observed. Some of these issues have been repeated so often that they have almost become cliché in the Western press. Nevertheless, where evidence exists that an issue is a likely impediment to progress, the Improvement Ideas presented throughout this paper provide potential solutions.

3) AIST must not hesitate to engage outside, professional expertise for administrative and communication functions that support the overall research goals and mission of the organization. AIST should provide the leadership and direction, but specialists with proven expertise are the best to handle the implementation. This is particularly true for AIST websites, which we believe must be fundamentally redesigned from the beginning.

Once a sufficient number of AIST staff become engaged in activities for positive improvement, we have no doubt that significant progress will take place.

References

[Asahi 2007] "EDITORIAL: Nanotechnology," Asahi Shimbun, 7 September 2007.

[AIST] http://unit.aist.go.jp/incs/ci/list/venture2.html

[Bosma 2006] Niels Bosma and Rebecca Harding, *Global Entrepreneurship Monitor 2006 Results.* London Business School.

[Bowonder 1993] B. Bowonder and T. Miyake, "Technology Forecasting in Japan," Futures, September 1994, pp. 757-777.

[Caryl 2007] Christian Caryl, "Why Apple Isn't Japanese," Newsweek, December 10, 2007.

[Economist 2007] Vijay Vaitheeswaran, "Something new under the Sun, a special report on innovation," The Economist, October 13, 2007.

[Guan 2007] Jiancheng Guan, Nan Ma, "China's emerging presence in nanoscience and nanotechnology, A comparative bibliometric study of several nanoscience giants," Research Policy 36 (2007) pp 880-886.

[Hullmann 2006] Angela Hullman, "Who is winning the global nanorace?"Nature Nanotechnology, vol 1, November 2006, pp. 81-83.

[Hullmann 2007] Angela Hullman, "Measuring and assessing the development in nanotechnology," Scientometrics, Vol. 70, No. 3 (2007) 739-758.

[Indian Express 2005] Rao Jaswant Singh, "The nano science of kajal," The Indian Express, December 11, 2005.

[JETRO 2005] ""Cool" Japan's Economy Warms Up," Economic Research Department, Japan External Trade Organization, March 2005.

[Kneller 2003] Robert Kneller, "University-Industry Cooperation and Technology Transfer in Japan Compared with the United States: Another Reason for Japan's Economic Malaise?" University of Pennsylvania Journal of International Economic Law, Summer 2003.

[Kneller 2007] Robert Kneller, "The beginning of university entrepreneurship in Japan: TLO's and bioventures lead the way," Journal of Technology Transfer (2007) 32:435-456.

[Kotter 1996] John P. Kotter, "Leading Change," Harvard Business School Press 1996.

[Lehrer 2004] Mark Lehrer, Kazuhiro Asakawa, "Rethinking the public sector: indiosyncracies of biotechnology commercialization as motors of national R&D reform in Germany and Japan," Research Policy 33 (2004) 921-938.

[Li 2007] Xin Li, Yiling Lin, Hsinchun Chen, Mihail C. Roco, "Worldwide nanotechnology developoment: a comparative study of USPTO, EPO, and JPO patents (1976-2004)," Journal of Nanoparticle Research (2007) 9:977-1002.

[Nature 1994] "Japan builds on global lead in nanotechnology," Nature vol. 371, 22 September 1994.

[Nature 2007] "Scientists worry about some risks more than the public," Nature Nanotechnology vol. 2, No. 12, December 2007.

[Nikkei 2007] "Cool Japan takes wing in Asia," Nikkei Weekly, November 26, 2007.

[NNI 2005] President's Council of Advisors on Science and Technology, "The National Nanotechnology Initiative at Five Years: Assessment and Recommendations of the National Nanotechnology Advisory Panel," May 2005.

[Osborne 2007] Peter Osborne, "Japanese system stifles foreign scientific talent," The Japan Times, June 5, 2007.

[OECD 2005] "OECD Science, Technology and Industry: Scoreboard 2005," Industry, Services & Trade vol. 2005, no. 30, pp. 1 – 214, 2005.

[Pascha 2002] Werner Pascha and Stephan Mocek, "Japan's venture capital market from an institutional perspective," Duisburg Working Papers on East Asian Economic Studies No. 64, 2002.

[RCNOS 2006] *The World Nanotechnology Market (2006),* published by RNCOS.

[Scheckler 1994] Edward Scheckler, "Molecular Scale Resist Process Simulation for Sub-250nm Lithography," Journal of Photopolymer Science and Technology, Vol. 7, No. 3, 1994.

[Scheckler 2007] Edward W. Scheckler, Todd Tilma, Thomas Giuffre, "An Investigation into Technology Transfer Processes for Nanotechnology at the Japan National Institute for Advanced Industrial Science and Technology as Compared to Global Best Practice," AIST Publication.

[Science 2007] "Science Scope," Science, Vol. 316, No. 5828, May 25, 2007.

Author Profiles

Edward W. Scheckler, PhD, （工学博士 エドワード W シェクラー）is currently a Senior Associate with Monolith Corporation based in Tokyo. In 1991, Dr. Scheckler earned a Ph.D. in Electrical Engineering from the University of California at Berkeley, with a research focus on 3D simulation of etching and deposition processes for semiconductor manufacturing. Dr. Scheckler then came to Japan as a visiting researcher at Hitachi, Ltd. Central Research Laboratory, where he developed techniques for simulation of advanced lithography at the nanometer scale. Dr. Scheckler also holds bachelor's degress in Electrical Engineering and in Modern Languages, earned in 1987 from the University of Notre Dame, in Indiana.

In 1994, Dr. Scheckler moved into information technology management in the financial services sector. He was at Credit Suisse First Boston from 1994 to 2004 where he had both Japan and Asia Pacific wide responsibilities. From 2004 to 2006, Dr. Scheckler was head of Technology Infrastructure for the Japan region at Citigroup. Dr. Scheckler is now active as a consultant to businesses and the investment community, with a particular interest in new business incubation and venture investment.

Todd Tilma, PhD, （理学博士 トッド ティルマ） in addition to working with Monolith Corporation as a part-time Associate, is a researcher at the National Institute of Informatics (NII), and an affiliated researcher in the Center for Complex Quantum Systems at The University of Texas at Austin. Previously, Dr. Tilma was a technology analyst with the Asian Technology Information Program (ATIP), and a visiting scientist at the Institute of Physical and Chemical Research (RIKEN), as well as a post-doctoral researcher at the University of Texas in Austin, working on developing mathematical models for nano- and quantum-scale systems.

Dr. Tilma graduated from The University of Texas at Austin with a Ph.D. in mathematical physics and a minor in modern Japanese studies. He currently focuses his time on analyzing nanotechnology, high-performance computing (HPC) and quantum information technology in the Asia/Pacific region.

Thomas Giuffre （トーマス ジュフレ）is CEO and Founder of Monolith Corporation, an IT management and technology business advisory firm. Established in 1992 in the US and Tokyo, Monolith Corporation has a history of developing large-scale IT infrastructures for multinational firms, particularly in the financial services industry. The firm also provides advisory and due diligence on technology M&A, restructuring, and venture investing. Mr. Giuffre has actively participated in numerous technology venture projects, having established and sold several technology based companies since the establishment of Monolith.

Prior to Monolith, Mr. Giuffre began his career in the defense communications sector for major US defense contractors Harris Corporation and Litton Industries. Mr. Giuffre also worked in the semiconductor industry for Emerson Electric and in radio communications R&D in Japan with several of the major Japanese corporate and government research and development centers. Mr. Giuffre holds a BS in Electrical Engineering and Physics from Clarkson University of New York.

---End Report--