Sifting for Gold in Used Electronics

Technologies to recover and recycle precious metallic resources from used electronic equipment are becoming increasingly sophisticated in Japan, thanks to joint efforts between government ministries and private enterprises. Centering upon research being conducted at the various national institutes of Japan, **Chris A. Pomeroy** reports.

Marco Polo—the thirteenth-century Venetian whose voyage to eastern lands was chronicled in a pre-Gutenberg "million-seller" (*The Travels Of Marco Polo*)—spoke of "the islands of Gold and Silver" called Zipang, meaning Japan. In the medieval Western world where there were still alchemists looking to turn one element into another (more precious) one, this story spawned attempts by Columbus and others to search for the isles full of treasure troves. It certainly was true that Japan of yore, due to volcanic activities, was an archipelago that one need not resort to mining upon gathering precious ores. The yields of these bounties were used to produce splendorous structures, as exemplified by the golden buildings that could be found in Hiraizumi, an ancient city located to the far northeast of the present-day capital city of Japan, Tokyo.

But even today, according to calculations conducted by Dr. Kohmei Halada, managing director of the Innovative Materials Engineering Laboratories and concurrently of the Strategic Use of Elements Interdisciplinary Cluster at the National Institute for Materials Science (NIMS), Japan is still a country "rich in natural resources" when the amount of precious metals found in recyclable form is included in statistical figures. As part of his efforts to study the depletion of mineral resources, the NIMS researcher said a calculation using an "Inverse Matrix" method based upon the materials flow data and trade figures from the Japan Oil, Gas and Metals National Corporation (JOGMEC) shows that Japan has an enormous amount of elements like gold and silver among other things "bound" in consumer as well as industrial products such as computers and mobile phones.

Indeed, Japan is filled with "stuff" that has led to the recycling industry's expansion to its tremendous size today. "That Japan is filled with used goods can be borne out by many statistics," said writer Norihiro Kawaguchi. "But without counting metal products such as used vehicles and related parts to be found on the market, there is in particular a large stream of small electrical appliances to be espied therein," notes the recycling-industry expert. "Nevertheless, these require much costly processing in order to recycle." This has been a major stumbling block to availing wide currency to the process of removing precious/rare metals from used goods, which had been coined as the term "urban mining" many years ago by Professor Michio Nanjo at Tohoku University.

This perspective is supported by the rare-metals consultant, Kosei Kada, who asserts that Japan as an electronics powerhouse has from the past been strategically attempting to build up its stock of rare metals that are vital to its industry. "Trying to recycle metallic pins from semiconductor chips, which may be characterized as the starting point in Japanese efforts to recycle rare metals, entailed much work. This was the impetus behind the 'design for disassembly' drive by government but manufacturers have not been able to fully absorb the costs involved." However, he views plans that involve a curtailing in the amount of processing needed for extracting metals from such small appliances

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—Dr. Kohmei Halada, managing director of the Innovative Materials Engineering Laboratories

COURTESY OF KOHMEI HALADA

could help promote the removal of "urban ores" from cities filled with unexploited used electronic products.

NIMS and the "Ibaraki Model"

But first, regarding the institution to which the aforementioned Dr. Halada is attached, it is Japan's sole Independent Administrative Institution (IAI) focusing upon materials science. NIMS has within its purview basic research and development of materials science, along with the advancement of the level of expertise in the fields it covers. It was formed in 2001 upon the merger of the National Research Institute for Metals (NRIM)—which had been established to conduct basic and comprehensive research as well as testing related to metal material technologies, thereby contributing to the improvement of the quality of metal materials used in all fields—and the National Research Institute for Research in Inorganic Materials (NIRIM) in order to realize an integrated research institute specializing in inorganic materials research which also includes research on metals as well as elements such as rare earth. (The two predecessor institutes were under the umbrella of the former Science and Technology Agency of Japan and thus now NIMS is operated under the auspices of the Ministry of Education, Culture, Sports, Science and Technology.)

In light of assessments provided by Dr. Halada, the Japanese government (as spearheaded by the Ministry of Economy, Trade and Industry and the Ministry of the Environment, not to mention the Cabinet Office) has been endeavoring recently to enhance the recovery and recycling of metallic resources in urban areas. The abovementioned two ministries for example have jointly set up model efforts in three localities (Odate town in Akita Prefecture, Hitachi city in Ibaraki Prefecture and Ohmuta city in Fukuoka) as to recovery of small electronic equipment encompassing mobile phones, music players and digital cameras. This thrust involves support provided not only by NIMS but also the National Institute for Environmental Studies and the National Institute of Advanced Industrial Science and Technology.

Since NIMS is headquartered in Tsukuba, Ibaraki Prefecture (while still maintaining its outpost at the former NRIM headquarters in Tokyo), it seems to be working closely with the prefectural government in Ibaraki in order to establish the "Ibaraki Model" of recovery. The main approach here has been to recycle, in cooperation with private companies such as Ibaraki-based Re-Tem Corp., rare metals from used mobile phones—as Kawaguchi puts it, "mobile phones have very short life cycles due to fashion fads and incessant advances in functions"—(the music player and digital camera categories to be concentrated on later in the trial) by utilizing less costly processing methods. [For more information on Re-Tem, see the October 2007 issue of Highlighting Japan through articles.]

Speaking of mobile phones, one Japanese mobile carrier uses the service name "Au" which, as anyone who has been taught the periodic table in high-school science class knows, refers to gold. Indeed gold and other rare metals are in use, albeit in minute amounts, in all types of mobile phones. In this respect, it is understood that the Ministry of Internal Affairs and Communications has also been supporting the telecommunications carriers and phone equipment manufacturers upon gathering and recovering used equipment. Thus, this and other major companies have been pushing to increase the recycling rate of rare elements that are to be found "embedded" within such products. Nevertheless, the situation is that the recovery rate needs to be improved much further.

Without just considering financial incentives, transforming waste ("bads") into "goods" is a topic which has drawn huge attention from around the world due to environmental concerns. Nevertheless, Dr. Halada said that an estimate in monetary terms has also been provided in hopes of attracting companies to related business fields. Even after precious metals could no longer be found by the roadside, Japan had adopted and refined mining technology (as can be witnessed at the Iwami-Ginzan Silver Mine World Heritage site) to enable exploitation of one of its few natural resources—so Japanese mining firms have built up a wealth of experience and know-how that should be put to good use in improving the recovery rate of the rare commodities.

Urban Mining, Urban Ores, Urban Concentrates

Thus, regarding recycling of such metals, Dr. Halada has come up with a method of extricating "urban ores" (the definition of ores being "mineral deposits from which constituents, especially metal elements, can be profitably extracted") out of used electronic equipment without human intervention. Simply put, it is a recycling technique for scarce elements in the form of "urban concentrates" through application of small-scale distributed treatment, for example by use of automated ball-mill equipment. Considering that one of Japan's fortes is equipment and machinery production, the grafting of this technology to the accumulated know-how possessed by the mining industry is thought to be a powerful means of driving up the overall recovery/recycling rate.

The ball mill has been widely used as a powder manufacturing technology to date. However, by overturning common convention and charging large objects of a size exceeding the crushing limit into ball mill, it is possible to selectively separate parts such as junctions, ceramics, plating and the like, while leaving behind structural parts such as plastics and aluminum which are difficult to crush (**figure**). Furthermore, these separated materials are pulverized by the essential effect of the ball mill. In addition to the fact that this method is possible using simple equipment, namely the ball mill, there are few environmental and siting restrictions, as it basically does not require heat or water. From this viewpoint, it is suited to small-scale distributed type production of "urban ores" containing concentrated scarce metals. For more effective practical application, joint study of the ball/rotation conditions and such items that corre-

spond to the treatment scale, work is underway with private companies.

For almost all cases, the recycling processes used in Japan up to the present comprised disassembly and sorting, followed by crushing and other processes. Much effort had to be expended in order to develop an effective method of disassembly and sorting without manual intervention. By contrast, rather than applying manual work or "brute-force" technologies to disassemble groups of products that had been provided inadequate effort as to "design for disassembly" which is essentially a responsibility of the product manufacturer, the electric devices are considered in practice to be "mixed materials" and brought in collectively to the process. These are then separated by taking advantage of the physical properties of the substances themselves and the connecting parts.

In a nutshell, the crushing capacity and characteristics of the ball mill enable electric devices crushed into pieces a few centimeters in length to be charged and treated without sorting for selective separation/pulverization of the components and plating. The result is the formation of a powder less than a millimeter in size, wherein scarce metal components have been concentrated for facilitated treatment by flotation, melting and other processes. Since the method leaves plastics, aluminum and copper-containing boards in sheet form, the non-pulverized remnant can also be easily sorted.

Patents Pending

An exclusive NIMS patent application for "Crushed material obtained from electronic equipment" and a joint patent application with the previously mentioned Re-Tem, a metallic parts recycler which actually is a company that has been operating in the Tokyo area for a hundred years as of this year, for "Electronic equipment crushing method" have been filed in connection with these results. On December 12, 2008, the aforementioned achievements were announced at an urban concentrates workshop, which was held under the sponsorship of the Ecomaterials Forum led by Dr. Halada, under joint sponsorship of the NIMS Strategic Use of Elements Interdisciplinary Cluster.

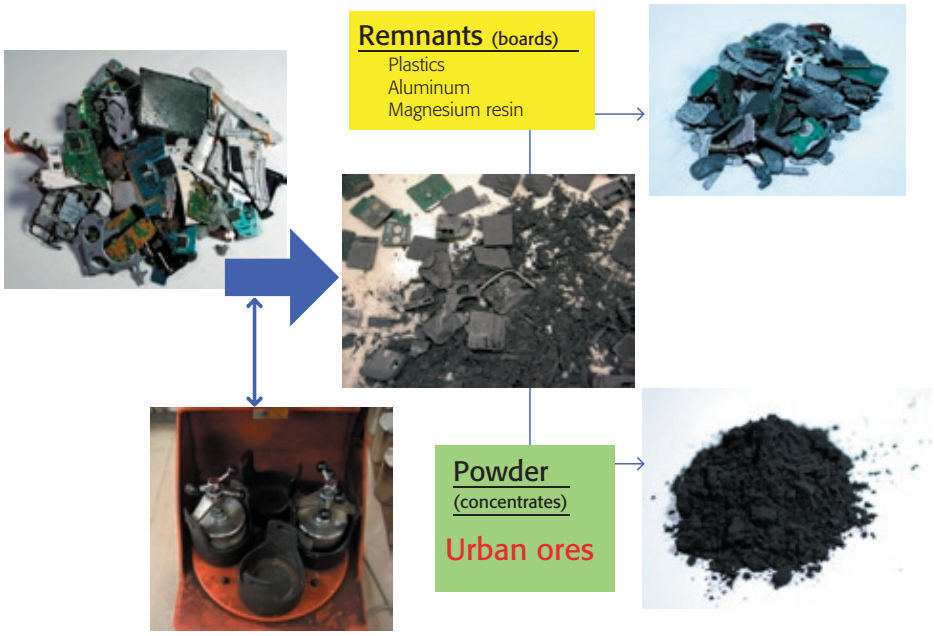
Incidentally, for collaboration efforts, NIMS has adopted the phrase "The true value of materials is in their use" as its motto. The institute has been actively promoting collaborative research with private industry in connection with its research results having a high potential for practical applications. Since NIMS became an IAI, funding for collaborative research provided by private companies has increased dramatically. The number of technical consultations has also increased steadily as highlighted by the fact that it has been working closely with corporations big (for example, Rolls-Royce) and small.

Turning back to the calculation which forms the basis of his efforts, NIMS made use of determinants as to the value of "mineral deposits" to be found throughout Japan, explained Dr. Halada. However he notes that this calculation is part of a comprehensive effort to formulate a strategy aimed at finding substitutes to resources required upon sustaining civilization, in part because many of the essential metals are foreseen being exhausted by the year 2050. The Doctor of Engineering underscored that the identification and substitution aspects should be kept in mind even while promoting recycling.

A three-pronged effort comprising said strategy is to search out, use as substitute and then recycle, and although the recycling portion was highlighted as constituting a virtual mine by the general media, Dr. Halada stated unequivocally that the need to search and substitute is just as essential. "While considerations as to the energy used and other related costs are necessary, it is easier to produce artificial concentrates from manufactured products such as mobile phones and computers than to extract ores from the ground in order to select and refine into usable form."

Yet, Dr. Halada adds that the identification and substitution aspects should be kept in mind even while promoting recycling. The scientist-cum-strategist underscored that he sees the added need to review the approach in general periodically so as to adjust the process accordingly. In summation, the NIMS researcher concludes that an overall perspective, from the procedures involved to the impact on the total environment, is a must in considering the resources available for value addition in Japan.

Separation of parts using ball mill



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