Critical Materials: A Compelling Case, Part 2

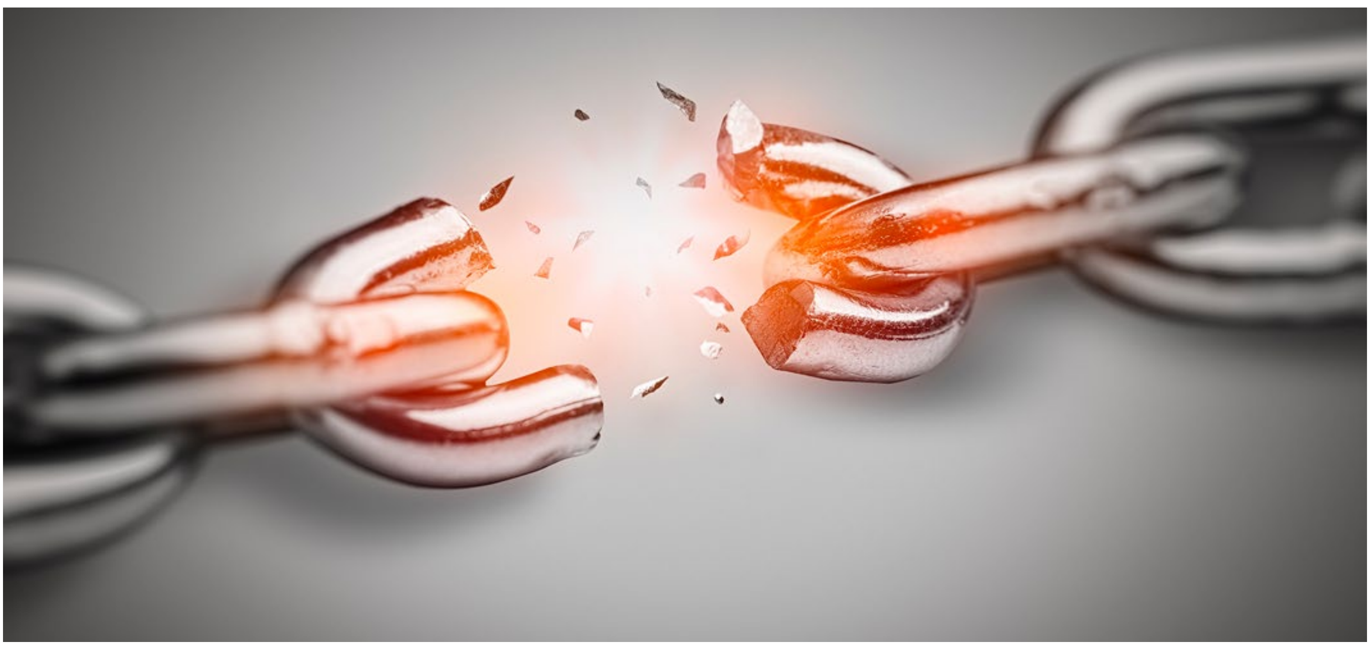
SMT Prospects & Perspectives

by Dr. Jennie S. Hwang, CEO, H-TECHNOLOGIES GROUP

When I wrote Part 1 on this topic in January, the global geopolitical landscape could be characterized as "status quo"—testy, challenging, yet absent of "war" in any region of the world. Now with Russia's invasion of Ukraine, which elevates the peril and uncertainty of metals, minerals and materials into overdrive, the title of the article may warrant: "Critical Materials—A Precariously Escalated Compelling Case."

How uncertain? Take nickel (Ni) as an example. Its price soared on March 8, 2022, reaching the record $100,000 a metric ton on the London Metals Exchange (LME); however, it pulled back later. Its dramatic pricing volatility made the LME pause the trading on March 8 and trading resumed on March 16 (the episode is under review by regulators and LME). Nickel is not a "fancy" metal, but it is a key ingredient for stainless steel and lithium-ion batteries that power electric vehicles (EV), among others. Russia is a major supplier of nickel (China is another supplier), not to mention the oil, gas, and other minerals and materials.

Russia is also a major supplier of precious metals including palladium (Pd), which is an essential element being used in catalytic converters and semiconductor manufacturing. It is reported that about one-third of the world's palladium comes from Russia. Within the semiconductor industry, some sources of production of raw materials are concentrated in Russia and Ukraine. For instance, the two countries are major sources of neon gas, which is used for making circuitry on silicon. It is estimated about one-quarter to one-half



of the world's neon supply comes from Russia and Ukraine. Although neon gas is a small fraction of semiconductor manufacturing in dollar value, a close-knit operation cannot tolerate any missing link in the chain.

Other metals, such as titanium (Ti) that is crucial for manufacturing jet airplanes and military aircraft, has been heavily sourced from Russia. By its high strength, light weight and corrosion-resistance, titanium is a unique metal and cannot be readily substituted. Even though some materials may not risk the direct exposure, indirect impact is expected to trickle down throughout the global supply chain.

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There is a slight bright side. Reportedly, semiconductor manufacturers may not experience the immediate threat resulting from the Russian invasion of Ukraine. The major manufacturers have been compelled to shore up inventory on key supplies by reassessing their supply chains and to improve the way to manage logistics during the coronavirus pandemic to minimize the uncertainties and shortage of supplies.

The escalated vulnerability and uncertainties of essential and critical metals, minerals, and materials may potentially exasperate the adverse impact on the assurance of the nation's economy and national security.

Accordingly, what are the specific metals, minerals, and materials that should be deemed critical to a robust economy and impeccable national security? What should constitute the key strategic tenets? What are effective, logical tactics and, more importantly, the decisive actions to be taken?

Critical Metals and Elements

Criticality of elements, materials, and minerals goes to those that the U.S. has little control of, such as those lacking or absent of domestic natural resources, and those import-centric. Additionally, criticality also goes to those required for mission-critical end-uses.

I have spared no effort to not put the Periodic Table here. Essentially, three of the top groups of elements on my list include:

- Essential elements, such as, Ti, W, Mo, Co, Ni, Cu
- Minor metals and precious metals, such as Ga, In, Te, Li, Pd
- Rare earth elements (REE), particularly the light rare earth elements among the 17 REE

Taking the rare-earths group into examination, the 17-element group valued for their magnetic and conductive intrinsic properties, serves critical functions in a wide range of technologies and applications as the basic materials for making components in smartphones, electric cars, and missile defense systems. It is estimated that China mines a majority of the world's rare earths minerals, which ranges from 55–90%, varying with the source and methodology of estimates. The rare earths' refining process is also dominated by China. Recently, China further enhanced its position by merging rare-earths assets in the nation; this tactic further strengthens its pricing power and avoids infighting among domestic companies.[1]

Strategic Considerations

The essence of the U.S. strategy should focus on the end-game, i.e., how to become less vulnerable, more self-controlled, increasingly self-reliant, and to be positioned for ready access and competitive cost structure to ensure a robust economy and resilient national security.

Here is a strategy to be formulated from 16 vantage points:

1. From a supply-side consideration: Strategy to ensure a dependable, reliable supply of the critical materials where the U.S. does not have adequate or reliable sources, especially for those materials that are abundant in the countries that are or might be deemed existential or potential adversaries.
2. From a demand-side consideration: Strategy to identify the critical metals, minerals, and materials.
3. From a perspective of a new world: Strategy to secure strategic metals by revisiting the criteria in defining strategic metals in the new world in terms of geopolitics and a new landscape in the digital era.
4. From a perspective of import-intense metals: Strategy to "govern" the metals and minerals that essentially rely on imports, i.e., domestic production/mining/refining is scarce or nil; particularly how to ensure resiliently cost-effective sources. This will engage the U.S. Department of Commerce, the International Trade Commission, and other agencies. What are deemed to be productive and effective policies and/or incentives to give companies that are in the position to produce the critical metals/minerals/materials? A farsighted strategic calculus may need to be a variation from those in points 1, 2, and 3.
5. From an economic standpoint: The role and the positioning of technological overmatch for today and the future (e.g., five- or 20-year time horizons). Strategy to cultivate a sustainable ecosystem and infrastructure to transition critical materials to useful products, thus adding value to the national economic well-being.
6. From a national defense and national security standpoint: Strategy to transition the critical materials to the capabilities for national defense and national security including combat capabilities in the new multi-domain combat environment that the U.S. Army and the Department of Defense have recently been focusing on.
7. From a national investment and international trade standpoint: Under the intensifying clean-energy and environment-conscious climate, a strategy for national investment to reach a more self-reliant or less import-dependent conditions calls for an open debate with an open mind. This requires engagement from multiple federal agencies and subordinate agencies.
8. To anticipate potentially emerging conflict minerals (metals) that are naturally abundant in conflict-affected and high-risk areas (countries, regions), and the strategy to "manage" such.
9. From the technology standpoint, to incentivize developing gaming-changing technologies. One good example is the technology that enables the use of less pure-grade (lower cost) nickel for batteries.
10. From an alternative material/element standpoint: Strategy to invest and develop technologies alternative to currently-defined critical materials that can meet the designated criteria.
11. From a viewpoint of competitive race, the plan to leverage new and leading technologies (e.g., AI) to speed up the discovery of new mining deposits of essential metals and minerals (e.g., Co, Ni, Cu, Li).
12. From the "integrated bi-focus" of environment (climate-change) and economics standpoints with pragmatism: Strategy to revisit the priority of recycling

and processing technologies to reduce import dependency and to mitigate foreign-dependent vulnerability.

13. Strategy to advance the recycling technology to build a true closed-loop system: To the environment-enthusiasts, for example, metals such as steel and aluminum are even important for renewable energy (perhaps counter-intuitively).
14. From free-markets point of view, a strategy to ensure that solutions are not worse than the problems—immensely paramount to tackling critical materials.
15. Again, nothing can beat the human ingenuity for breakthrough innovations to either advance the functions or reduce the cost or both. For example, explore the potential of nickel to serve as a catalyst in lieu of palladium to catalyze chemical reactions like cross-couplings. Its success will cut cost tremendously, not to mention the enhanced "security" of resources.
16. For protecting the "brain" that goes into all "modern" commercial and military products, watch diligently for, act prudently on the materials going into the chips (semiconductors) manufacturing. This is a sound strategy for what the role of the government should be and how the government can play effectively.

None of the above should be or can be viewed and attended monolithically. To accomplish (8), the strategy to "manage" the current and potentially future conflict minerals calls for embracing both environmental and geopolitical considerations.[2]

More to Do

Recently, President Biden's executive order identified risks in four key categories of critical materials: semiconductors, rare earth minerals, active pharmaceutical ingredients, and large capacity batteries. Nonetheless, the efficient and effective plan of action is yet to be carved out. Identification is a starting step, not an endgame; a key question goes to the remedies or solutions, both strategically and tactically, in covering near-term and long-term time horizons, to secure or to establish alternate sources of critical metals, minerals, and materials. This calls for a decisive push forward.

As any alternate source of metals, minerals, and materials must go through a rigorous validation and verification process, the question also goes to how long it takes to come up with the plan and action. Is it "fast" enough? Additionally, in the long run, what kind of incentives can justifiably come from the government, federally and locally?

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Multiple initiatives to address the challenges of global supply chain are in the works; yet, the supply chain of knowledge should be fortified, in parallel.

In a nutshell, staying the same is not an option; the reality remains the same: to deliver a holistic, all-encompassing approach by "amalgamating" my 16 points and other envisaged areas to reach a set of executable actions, and to forthrightly act now.

The bottom-line is to not rely on unreliable sources; and the ultimate challenge is to not create solutions that are worse than the problems. SMT007

References

1. "China Set to Create New State-Owned Rare-Earths Giant," by Keith Zhai, Wall Street Journal, Dec. 3, 2021.

2. "Conflict Minerals: A Snapshot," by Jennie S. Hwang, SMT Magazine, March 2013.

Appearances

Dr. Jennie Hwang will deliver a professional development course on "An Overview of PoP and BTC Package and Assembly: Material, Process and Reliability–Part 1 and Part 2," 8 to 11 p.m. May 25 and 26, 20th Electronic Packaging Convention, Asia.

Dr. Jennie S. Hwang—an international businesswoman and speaker and a business and technology advisor—is a pioneer and long-standing leader to SMT manufacturing since its inception as well as to the development and implementation of lead-free electronics technology. Among her many awards and honors, she was inducted to the International Hall of Fame–Women in Technology, elected to the National Academy of Engineering, named an R&D Star to Watch, and received a YWCA Achievement Award. Having held senior executive positions with Lockheed Martin Corp., Sherwin Williams Co., and SCM Corp., she was the CEO of International Electronic Materials Corp. and is currently CEO of H-Technologies Group, providing business, technology, and manufacturing solutions. She has served on the board of Fortune-500 NYSE companies and civic and university boards; the Commerce Department's Export Council; the National Materials and Manufacturing Board; the NIST Assessment Board; as the chairman of the Assessment Board of DoD Army Research Laboratory and the chairman of the Assessment Board of Army Engineering Centers; and various national panels/committees and international leadership positions. She is the author of 600+ publications and several books and is a speaker and author on trade, business, education, and social issues. Her formal education includes four academic degrees, as well as the Harvard Business School Executive Program and Columbia University Corporate Governance Program. For more information, visit JennieHwang.com. To read past columns or contact Hwang, click here.

MIT Launches New Robotics Manipulation Course

Last fall, MIT's Department of Electrical Engineering and Computer Science launched a new course, 6.800 (Robotic Manipulation) to help engineering students broadly survey the latest advancements in robotics while troubleshooting real industry problems. It's a unique course that can provide an inroad into robotics for students with no robotics experience at all.

Students learn fundamental algorithmic approaches to build robot systems capable of autonomously manipulating objects in unstructured environments. Exploring topics like perception, planning, dynamics, and control, students solve problem sets to guide themselves through developing a software stack, typically using the permissively licensed open-source software Drake. Not focused on quizzes and final exams, the course culminates instead with a final project where students can explore any problem in robotic manipulation that fascinates them.

Professor Russ Tedrake's course notes provide students with a window to peer across the professor's own mental landscape of the field. Students say they are unlike any course notes they've ever seen—providing a constantly updated roadmap of what it would take to advance robotics as a field.

He says there's rampant industry interest in engineers skilled in manipulation, and that demand helped motivate him to launch the course. "Manipulation is just kind of exploding in the field," Tedrake says, adding that recently, "it's less of a niche area, everybody's got an eye on making robots do things with their hands." Right now, the big companies are investing. (Source: MIT News)

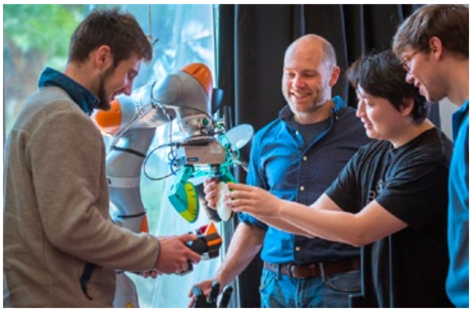

Photo: Professor Russ Tedrake (second from left) examines a robotic arm with students from 6.800 (Robotic Manipulation). Tedrake designed the course in response to the growing need for engineers to survey the latest advancements in robotics while gaining experience in troubleshooting real industry problems. (Photo: Gretchen Ertl)