Deloitte.

Article 5 in a series of 7
February 2024

Semiconductor sustainability trends

Strategy 4: Reengineering semiconductor products, logistics, and business models for circularity

Series overview

As illustrated in the graphic below, through our experience in the industry, Deloitte is seeing four broad sources of pressure toward increased sustainability in the semiconductor sector. Companies' responses are coalescing into six next-generation semiconductor sustainability strategies.

Sustainability pressures and strategies in today's semiconductor sector

Internal pressures

Pressure 1: Semiconductor manufacturers have a **growing sense of urgency** as early progress towards sustainability goals has slowed

Pressure 2: Semiconductor manufacturers realize the need for more sophisticated **supply chain** and ecosystem **engagement**

External pressures

Pressure 3: Key markets are introducing **regulation** that increases sustainability performance and transparency requirements and links these to **cost of market access**

Pressure 4: **Expectations** of stakeholders **have increased.** Semiconductor **customers** frequently expect suppliers to adhere to sustainability goals. **End consumers, shareholders, and employees** also regularly factor sustainability into decisions

Leading to the development of **next-generation sustainability strategies**

Semiconductor sustainability strategies

Strategy 1: **Further address direct emissions from semiconductor manufacturing**
Redouble efforts to reduce direct Scope 1 and 2 emissions and other direct environmental impacts from manufacturing

Strategy 2: **Reduce business ecosystem emissions**
Address supply chain, procurement, and other business ecosystem Scope 3 emissions

Strategy 3: **Reduce products' life cycle energy use**
Design products to reduce energy use and emissions throughout their whole life cycle, including during their application by end users

Strategy 4: **Reengineer for circularity**
Reengineer products, logistics, and business models for circularity

Strategy 5: **Make sustainability a business value driver**
Develop new sustainability-related brand value, businesses, and revenue streams

Strategy 6: **Sharpen and integrate sustainability strategy**
Revise and integrate sustainability strategies into businesses

This article discusses the specific drivers and the distinct solutions that companies are implementing to pursue Strategy 4: Reengineering semiconductor products, logistics, and business models to support circularity.

Context

Elements such as gallium, germanium, and tantalum are essential to making semiconductors. Their sources can have significant environmental and social footprints, and often come from locations with geopolitical or other trends that can put continuity of supply at risk. Achieving better environmental performance and supply chain resilience requires new approaches to semiconductor products' end of life: Every gram that is recovered instead of being thrown away doesn't need to be sourced, mined, or smelted.

Across the semiconductor sector, leading firms are implementing circularity principles to extend product life cycles or unlock second life cycles for the components and materials that make up their products. Circularity strategies tend to rely on multiple disposition paths to divert products from final disposal, including recycling, repair, and product return for resale or reuse. This has implications for semiconductor design, manufacture, marketing, and logistics/reverse logistics that companies are increasingly addressing. Successful strategies drive business value—whether it's getting ahead of regulations, increasing supply chain resiliency, or creating new circularity-related revenue streams—while dramatically reducing e-waste through these alternative disposition paths.

Drivers

How are pressures for circularity manifesting for semiconductor manufacturers?

Internal drivers

Driver 1: Supply chain disruptions during COVID-19 pandemic exposed the **vulnerability of semiconductor companies**

Driver 2: **Continued progress** toward net-zero goals **requires engaging customers** to address scope 3 emissions

External drivers

Driver 3: **Stakeholder awareness** of product disposal challenges at end-of-life is leading to pressure for action

Driver 4: **Regulation** related to recycling, reuse, and the "right to repair" is increasing

Leading to implementation of **semiconductor product circularity solutions:**

Solution 1: **Designing semiconductor products** to enable reparability, reuse, and/or recyclability

Solution 2: Creating **business incentives** for reparability, reuse, and/or recyclability

Solution 3: Building resilience through **return and reuse logistics** capabilities

Deloitte's experience suggests that the varied pressures to address end-of-life sustainability challenges can be expressed via four drivers:

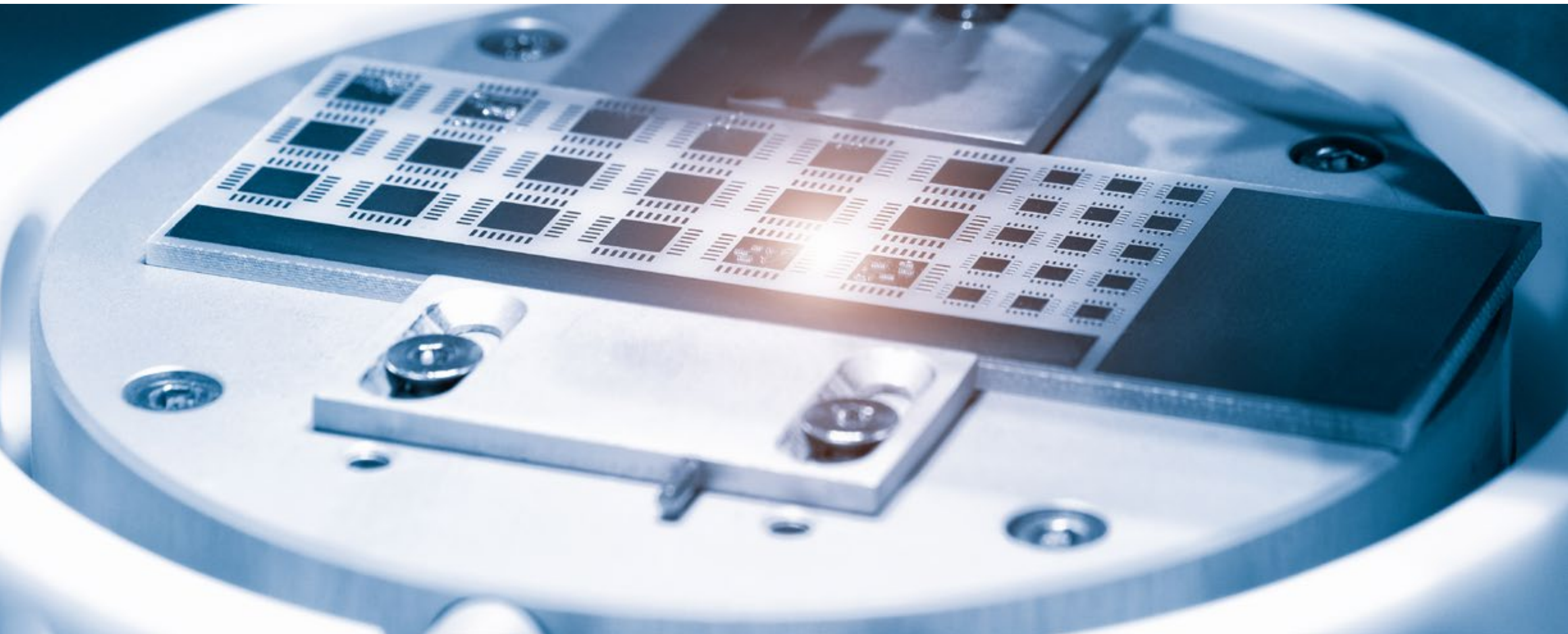
Driver 1. Supply chain disruptions during the COVID-19 pandemic exposed the vulnerability of semiconductor companies

Many of us experienced shortages during the COVID-19 pandemic and its aftermath. While the availability of chips to auto manufacturers perhaps received the greatest press coverage, disruptions were widespread, and this led businesses to revisit how they design, manage, and engage their supply chains. Although raw materials were not the main bottleneck during the pandemic, manufacturers now see material reuse as an essential capability for business longevity amid growing uncertainty around finite (or politically acceptable/reliable) mineral supplies.

Driver 2. Continued progress toward net-zero goals requires engaging customers to address Scope 3 emissions

Many semiconductor companies were quick to embrace efforts to reduce Scope 1 and 2 emissions because these emissions are under their relatively direct control, and it makes business sense as initiatives to reduce emissions from facilities often coincide with efficiency gains and operational cost savings. To this end, many semiconductor manufacturers reviewed their facilities energy use and sourcing and implemented initiatives such as smart building technologies, which power down lighting and air conditioning in unoccupied areas, installed onsite solar generation, and entered into renewable energy sourcing contracts where this is available. As discussed in the second article of this series, semiconductor companies are also incorporating investments to reduce energy and gas-related climate emissions, as well as other environmental impacts such as water use, from their fabrication processes and packaging facilities in their capital expenditure plans.

In contrast to these direct energy use and process emissions, Scope 3 emissions are more challenging to address since companies tend to have less control over their supplier and customer networks. Semiconductor companies increasingly recognize that continued progress toward their emissions reduction goals requires developing the capability to address Scope 3's category 11 (use of sold products) and category 12 (end-of-life treatment of sold products). This is heightened by the growing number of regulators that are beginning to require companies to disclose their Scope 3 emissions and the business risks associated with those emissions. The Corporate Sustainability Reporting Directive (CSRD), Directive on Corporate Sustainability Due Diligence (CSDD) in Europe, and recent passing of Senate Bills 253 (Climate Corporate Data Accountability Act) and 261 (Greenhouse Gases: Climate-related Financial Risk) in California are examples of this in markets that are critical to semiconductor corporations.[1]



Driver 3. Stakeholder awareness of product disposal challenges is leading to pressure for action

Both business and consumer end users are increasingly aware of the challenges of acceptably disposing of end-of-life semiconductor products. Press coverage has raised understanding of the environmental and social cost of poorly disposed semiconductor products, while municipalities have introduced increasingly stringent waste disposal and recycling expectations of businesses and households. Consequently, successful efforts to improve reusability and recyclability of semiconductor components and products have been rewarded with pricing premiums in business, consumer, and secondhand markets.

Driver 4. Regulation related to repair and the 'right to repair' is increasing

In addition to waste disposal restrictions, regulators have also been responding to consumer and business concerns about the usable life and repairability of products. The European Parliament, for example, has recently adopted resolutions including proposals to "make repairs systematic, cost-efficient and attractive."[2] Designing for repairability and enabling repairability at end of use is becoming important to anticipating and complying with changing regulations.

Solutions

In response to these drivers, semiconductor companies are pursuing a strategy of designing their products, logistics, and businesses to enable circularity. What solutions are they pursuing?

Solution 1. Designing semiconductor products to enable repairability, reuse, and/or recyclability

Product design is a key factor that determines repairability. The EU's action plan for the circular economy sets out eco-design criteria to ensure that semiconductor products such as servers and data storage devices (1) are made durable and repairable, (2) enable extraction of key components and critical raw materials (CRMs) such as gallium, germanium, and tantalum as well as gold and platinum, (3) have functionality for secure data deletion, and (4) support provision of latest available versions of firmware.[3] The uptake of repairability depends on the ease of repair, the amount of labor required, and the cost. Cost is a leading reason why customers choose not to repair electronic devices and components.

Framework, a laptop manufacturing company, has partnered with semiconductor companies to demonstrate the importance of modular design to repairability. Framework builds modular laptops that allow for individual components including the RAM, SSDs, the motherboard, and processor unit to be easily and safely swapped out, repaired, or upgraded without specialist knowledge or specialized tools.[4] Modular designs support repairability at the end-of-use phase, where original equipment manufacturers (OEMs) need to equip independent repairers and consumers with spare parts and maintenance information.

For companies based in the European Union or with customers located in the EU, designing for repair and assuming responsibility for the prevention of e-waste is becoming a high priority.

Solution 2. Creating the business incentives for repairability, reuse, and/or recyclability

The potential negative impact of circularity on future new product sales revenue highlights a tension in circularity strategies that requires organizations to assess their business models, incentive structures, and customer and marketing strategies. Repair can enable customers to keep products in use longer, potentially delaying or forgoing new device purchases. This meets the goal of slowing the use of materials and reducing emissions from product manufacturing—potentially at some cost to future profits.

Since repairability may have implications on revenue from new products sold, semiconductor corporations need to architect and implement redesigned and realigned incentive structures to support sustainability goals and encourage repairability. Potential revenue reductions might be offset through greater consumer and enterprise willingness to pay for circular products, and the development of new repair and reuse businesses. This, in turn, prompts companies to assess their customers' willingness to pay for repairability, to explore innovative ways to communicate the new value of repairable products with extended life cycles to their customers, and to pilot new repair and resale business models and revenue streams.

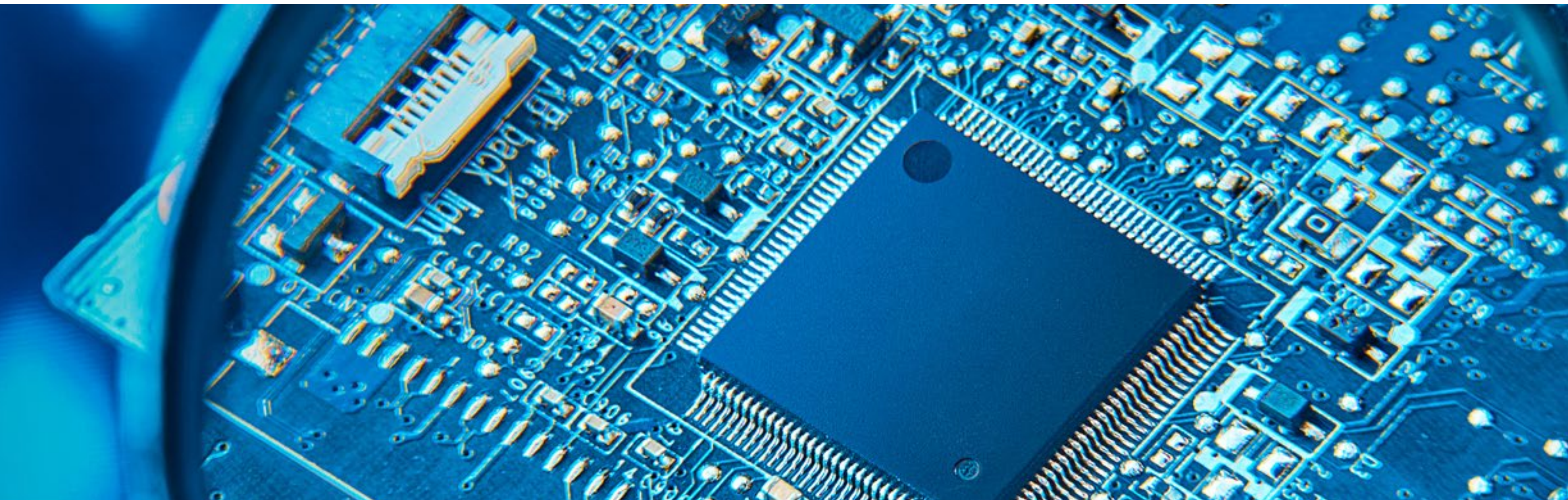
Solution 3. Building resilience through return and reuse logistics capabilities

Return and reuse is a process in the reverse logistics loop where products are sent back to the OEM or a circularity service provider at the end of use. The product or its components are then resold, recycled, or reused. Return and reuse is common in business-to-consumer companies. A leading example of this in semiconductor products is Apple's trade-in program. Apple's customers can return their consumer electronics to Apple and receive a discount or credit toward a new purchase, while Apple can reuse or recycle valuable materials such as gold, palladium, cobalt, and lithium in the returned device.[5]

Similarly, semiconductor companies are partnering with their business-to-business (B2B) customers to return and reuse products. AMD partnered with Microsoft to launch a pilot product takeback campaign in Indonesia and Vietnam where customers traded in their used electronics and upgraded to a new Windows 11 PC powered by a new AMD processor.[6] Through this partnership, both AMD and Microsoft sold new products and recovered valuable components and materials that can be difficult to procure given supply chain constraints. Dell and Seagate also piloted a return-and-reuse model through the Circular Drive Initiative, successfully recycling 1.6 tons of scrap magnets from hard-disk drives.[7] Through advanced recycling techniques, the scrap magnet material could be reused. The increasing uncertainty of supply of rare-earth elements (REE) due to geopolitical trends highlights the supply chain resilience benefits of programs such as this.

Raw material acquisition and pre-processing (RMAP) accounts for a significant amount of the life cycle carbon emissions of semiconductor equipment and requires critical mineral mining. By keeping existing hardware components in circulation, companies can reduce the risks of relying on limited raw materials and complex commodity value chains can be reduced. This return-and-reuse model can create a dual benefit in B2B arrangements. Just as Apple's customers receive credit toward a new iPhone through the trade-in program, semiconductor companies can offer discounts or credits to their commercial customers for new products, due to the reuse or recycle value of the returned products.

Return-and-reuse models require strong reverse logistics capabilities. Specifically, semiconductor companies need to be able to maintain and guarantee their chain of custody for all IT assets. They also need to ensure data deletion and cybersecurity to a standard acceptable to the business returning their IT assets. A tiered system of industry standards has emerged to enable this. The reverse logistics processes need to be supported by real-time visibility and traceability and embedded with internal security controls. These capabilities can be built in partnership with an e-waste vendor or IT Asset Manager (ITAM) vendor. NVIDIA partners with a third party to ensure all e-waste is tracked, decommissioned, and recycled properly. The company is also developing internal inventory management processes to improve visibility of all IT assets as they are deployed for reuse internal to NVIDIA.[8]



In conclusion

Customer awareness, regulatory demands, and business imperatives such as supply security are motivating semiconductor companies to begin transforming the value chain toward circularity. This involves holistic reengineering of product design, manufacturing, logistics, and business models. It will likely be a challenging journey. Lessons are accumulating from early pilots, and we can anticipate elements of circularity to increasingly permeate the sector in the coming years.

Authors and contacts

Steve Watkins
Deloitte Consulting LLP
stewatkins@deloitte.com

Steve is a leader in Deloitte's Sustainability Strategy practice, where he focuses on helping corporate leaders to create value by integrating sustainability into their business strategies and operations. He serves clients in the semiconductor, high-tech, financial services and related industries, drawing on past roles ranging from financial journalism to banking to building his own business and growing several sustainability NGOs. Steve has a BA (honors) and an MA in economics from the University of Cambridge and an MBA from the Kellogg Graduate School of Management. He has completed a Sawhill Fellowship at the University of North Carolina, taught the Masters in Communications course at the University of Texas El Paso, and regularly publishes and speaks on topics at the intersection of business and social good.

Duncan Stewart
Deloitte Canada
dunstewart@deloitte.ca

Duncan is the director of Technology Sector Research for Deloitte Canada, the lead researcher on semiconductor topics for Deloitte's US Technology, Media & Telecommunications (TMT) Center. Duncan has 33 years of experience in the TMT industry. As a portfolio manager, he made investments in the tech and telecom sector and won the Canadian Technology Fund Manager of the Year award in its inaugural year. In his time as an investor he deployed a cumulative $2 billion of capital into global TMT markets, in public and private companies. He is a CFA® charterholder and holds a BA in Political Science from the University of British Columbia.

Bobby Mitra
Deloitte Consulting LLP
bobbymitra@deloitte.com

Dr. Bobby Mitra is managing director and consulting leader for Deloitte's Global Semiconductor & High Tech Manufacturing, Supply Chain and Engineering practice. He brings years of both strategic vision and proven hands-on semiconductor experience to partner with customers to accelerate manufacturing and supply chain transformation. Dr. Mitra is an IEEE Fellow and chairman of SEMI Global & Americas Smart Manufacturing. He holds a B.Tech degree in electronics and electrical communications engineering and a PhD in computer science and engineering from the Indian Institute of Technology (IIT). He also holds an Executive MBA from the University of Texas at Austin, where he was a recipient of the Dean's Award for Excellence.

Fabian Pineda, Mackenzie Schnell, Pete Edmunds, Kayla Cherry, and Erle Monroe also contributed to the content of this article.

Endnotes

1. Semiconductor Industry Association, Comments of the Semiconductor Industry Association on the Proposal of the Securities and Exchange Commission: *The Enhancement and Standardization of Climate-Related Disclosures for Investors*, June 17, 2022.
2. European Parliament, "Right to repair," 2022.
3. European Commission, Commission Regulation (EU) 2019/424, March 15, 2019.
4. Framework, About page, accessed January 17, 2024.
5. Apple, 2023, "Apple Will Use 100 Percent Recycled Cobalt in Batteries by 2025," Apple Newsroom, April 13, 2023.
6. AMD, *2022–23 corporate responsibility report*, 2022, p. 35.
7. Seagate, "Seagate Product Take Back Program," accessed January 17, 2024.
8. NVIDIA, *2021 NVIDIA corporate social responsibility report*, 2021.

About Deloitte's *Semiconductor Sustainability* series of articles

Clients and other industry actors are interested in learning about the broad trends and patterns that we see in our work in the semiconductor sector, and interest is especially high in the critical task of driving sustainability through their operations and ecosystems.

Deloitte's series of short Semiconductor Sustainability articles responds to this interest by summarizing emerging sustainability strategies that Deloitte is seeing through our work with clients. Each article is intended to be a short, accessible summary that can be read in less than 20 minutes. We hope that the series proves useful to anyone interested in how the semiconductor sector is working to address its sustainability challenges.

Below is a list of all the articles in this series, in order of publication:

Series overview: Current sustainability pressures and next-generation sustainability strategies in the semiconductor sector

Strategy 1. Further address direct emissions from semiconductor manufacturing
Semiconductor companies are redoubling efforts to reduce direct Scope 1 and 2, greenhouse gas emissions, other environmental impacts from manufacturing.

Strategy 2. Reduce business ecosystem emissions
Semiconductor companies are addressing supply chain, procurement, and other business ecosystem Scope 3 emissions.

Strategy 3. Reduce products' life cycle energy use
Semiconductor companies are designing products to reduce energy use and emissions throughout their full life cycles.

[This article] Strategy 4. Reengineer for circularity
Semiconductor companies are reengineering products, logistics, and business models for circularity.

Strategy 5. Make sustainability a business value driver
Companies in the semiconductor sector are developing new, sustainability-related brand differentiation, businesses, and revenue streams.

Strategy 6. Sharpen and integrate sustainability strategy
Semiconductor leaders are strengthening sustainability strategies and integrating them into the businesses.