

FROST & SULLIVAN

CERION NANOMATERIALS

2022
TECHNOLOGY
INNOVATION
LEADER

NORTH AMERICAN
NANOMATERIALS
MANUFACTURING INDUSTRY

Best Practices Criteria for World-Class Performance

Frost & Sullivan applies a rigorous analytical process to evaluate multiple nominees for each award category before determining the final award recipient. The process involves a detailed evaluation of best practices criteria across two dimensions for each nominated company. Cerion Nanomaterials excels in many of the criteria in the nanomaterials manufacturing space.

AWARD CRITERIA	
<i>Technology Leverage</i>	<i>Business Impact</i>
Commitment to Innovation	Financial Performance
Commitment to Creativity	Customer Acquisition
Stage Gate Efficiency	Operational Efficiency
Commercialization Success	Growth Potential
Application Diversity	Human Capital

State of the Nanomaterials Industry

As the dimensional size of a material decreases, its surface area increases relative to its mass. At the nanoscale (1-100 nanometers), surface area of the materials increase exponentially and uncover new or enhanced electrical, chemical, and optical properties to name a few. The need for industrial nanomaterial manufacturing has seen significant demand from commercial companies as they look to harness the unique qualities of nanomaterials to create new and differentiated products.

“Cerion’s ability to offer tailored solutions for nanomaterial design along with transition from the lab to industrial-scale production cost effectively is a key differentiator from its counterparts who offer commercially available nanomaterials with low to zero flexibility for customization.

– Narendra Kumar Singh, Industry Analyst

Leveraging the benefits of nanomaterials almost always requires customization of the material to suit the performance and integration needs of a product developer’s application. However, the nanomaterials industry, broadly speaking, faces three major challenges: a.) being able to rapidly design custom nanomaterials specific to a product or system, b.) preserving the material’s technical attributes and behaviours during scale-up, and c.) manufacturing at industrial-scale – all the while doing it affordably.

Product development teams may at times seek ‘off the shelf’ or commercially available nanomaterials, which represent the products of many firms in the nanomaterials industry. The materials must either work in a product developer’s application out of the box, which is rare, or must be customized for technical performance and integration in to their application. Many nanomaterial companies either do not offer these customization services, or are unable to effectively customize due to limitations in their approach to making the materials. Another route for product development teams is to invest in bringing nanomaterial expertise in-house. This approach can be costly, as it requires specialized personnel from many different disciplines, specially engineered equipment, facilities and infrastructure. It takes considerable investment to reduce to practice this specialty skillset in-house. Effectively building the experience and infrastructure, which is costly, is often not within the scope of a product developers budget or the timeline they need to bring their product to market.

For these reasons, the beforementioned approaches often do not result in technical or commercial success for product development teams looking to use nanomaterials.

Cerion Nanomaterials Provides Differentiated Solution to Product Development and Commercialization Teams

Cerion Nanomaterials, having recently achieved its fifteenth (15th) year in business, has staked out a unique position in the nanomaterials market. The firm does not develop nanomaterial enabled products – which is where most nanomaterial companies focus. Cerion’s business model is focused on providing it’s customer’s product development and commercialization teams with access to advanced expertise in designing and manufacturing nanomaterials. In this role, Cerion serves as the nanomaterial subject matter expert, so that customers can focus on what they do and know best, which is developing products for their specific industry and application area. The firm is focused on a broad class of materials which can be generally described as metals, metal oxide and ceramic nanoparticles.

Due to the firm’s strategy, Cerion does not compete with its customers in the marketplace, and goes as far as making this guarantee contractually. The company focuses solely on advanced expertise in the precise design of nanomaterials, scaling them up while preserving their technical attributes and delivering cost-effective manufacturing capability. The outcome of the firm’s strategy has been that each material it creates for a customer, is unique to the customer’s application. This has been achieved by developing techniques to control both size and technical attributes of the nanomaterial, which in certain applications, are critical to its performance. This includes its composition (single material or an alloy) and surface functionalization (decoration of the surface of the material with other components) to name a few. The namesake of the firm is also to ensure that each material designed in the lab, has been created in such a way that it can scale-up for high-rate manufacturing. Scale-up and manufacturing is classically where the nanomaterial industry has encountered significant challenges towards achieving commercialization and monetization.

An additional differentiator, is the majority of nanomaterial companies focus on a single approach to synthesizing a material. Cerion has invested in perfecting five (5) different commercially viable synthetic methods, including precipitation, hydrothermal and solvothermal, thermal reduction, and high-energy milling. The firm claims ‘One Size Does Not Fit All’ and that each synthetic approach has unique

“Cerion’s three-stage approach to nanomaterial design, scale-up and manufacturing helps product developers and commercialization teams avoid high nanomaterial R&D investments, accelerates their time to market and provides certainty of being able to use these unique materials cost-effectively at scale.”

– Narendra Kumar Singh, Industry Analyst

capabilities which can be weighed and traded off based on a customer’s specific nanomaterial design, cost and manufacturing volume requirements. Using the firm’s experience, they select the synthesis approach based on a wholistic view of the customer’s specific needs. The company’s synthesis know-how allows them to exert precise control over different technical attributes, including but not limited to: particle size, size distribution, surface charge, morphology, and surface functionalization, as well as creating unique compositions such as alloyed, and

core/shell nanoparticles. They additionally deliver those materials in different forms, based on what is best suited for the customer’s product. This can take the form of aqueous dispersions, organic dispersions, powders and pastes.

Their beforementioned synthetic capability is intended to ‘build a nanomaterial from the ground up’ – using highly controlled chemical reactions to assemble the nanoparticle atom by atom to achieve desired features and attributes. The high-energy milling approach is a new and innovative take on the standard approach of ball media milling, where bulk materials are broken down to increasingly smaller sizes. This is the only ‘top-down’ approach the firm employs, which it qualifies as still experimental, but holding great promise for certain customer needs.

A Focus on Manufacturing

Within the marketplace today, product developers have access to many sources for small-quantity, lab-scale materials to prove out basic and early applied research. Competitors and specialized firms of smaller size are well known for supplying the research community with access to these materials – nanomaterials included. Where the challenge remains is easily accessing customization of these ready-made nanomaterials to fit a product developer’s needs. When a customized material is found to work, accessing it at a suitable manufacturing scale or commercially reasonable price becomes an additional challenge.

A strategic competitive advantage of Cerion is its full integration of all the people, equipment and infrastructure in-house to carry a nanomaterial made in the lab through to manufacturing. To date, the firm has invested nearly \$50 Million US Dollars in these capabilities. Cerion’s internal expertise spans both technical and commercial considerations related to nanomaterials including research, development, engineering, analytical characterization, quality control, quality assurance, procurement, regulatory, logistics and financial planning & analysis to name a few.

Cerion, additionally, has a deep focus on quality and cost processes most commonly found only at major manufacturing companies. Their philosophy focuses on lean manufacturing, a practice that seeks to eliminate waste, optimize processes and cut costs - while also investing in new innovations that will reduce time to market for its customers and itself. The firm works to achieve this through both Six-Sigma (6σ) techniques and tools that have been built in-house, as well as employing a strategy of Just-in-Time (JIT) delivery. It additionally employs a rigorous phase gate process focused on commercialization

which begins during their work in the lab and carries through to manufacturing accreditation of new materials. All told, the firm's production capacity today is approximately 150 metric tons of dry-weight material with a goal of scaling to 500 metric tons in the near-term.

Significant Reductions in Nanomaterial Research, Development and Non-Recoverable Engineering Time & Costs through Prototype Manufacturing Strengthens Client Engagement and Retention Ability

The core of Cerion's operation relies on having invested in and reduced to practice a complex set of platforms and processes that enable it to service customers quickly and efficiently at-scale. All the while it has put an intense focus on customization, which is lacking in the market and necessary for the use of nanomaterials in products. The apparent advantage the firm provides its customers is its years of experience and many instances of having created, scaled and manufactured nanomaterials for its customers. For many product developers at mid-cap and large-cap companies, who are the majority of Cerion's clients, this trend of outsourced innovation and supply chain has increasingly become the norm. In today's world, it is often neither commercially prudent or cost effective to build all the capability required for product development and commercialization in-house – especially in areas such as nanomaterials which require such a high-degree of specialization. While there are costs associated with outsourcing, the total overall cost of product development is often considerably less expensive than alternative solutions.

Conclusion

The adoption of nanomaterial-enabled products and systems is on the rise. In the rapidly growing nanomaterials industry, where most manufacturers offer non-custom materials at high prices, Cerion Nanomaterials has carved out a niche for itself providing a cost-effective nanomaterial design, scale-up and manufacturing service. All of this backed by strong technical expertise and state-of-the-art synthesis technology.

With its strong overall performance, customer-centric approach and commitments to quality, cost and innovation - Cerion Nanomaterials earns Frost & Sullivan's 2022 North American Technology Innovation Leadership Award in the nanomaterials manufacturing industry.

What You Need to Know about the Technology Innovation Leadership Recognition

Frost & Sullivan's Technology Innovation Leadership Award recognizes the company that has introduced the best underlying technology for achieving remarkable product and customer success while driving future business value.

Best Practices Award Analysis

For the Technology Innovation Leadership Award, Frost & Sullivan analysts independently evaluated the criteria listed below.

Technology Leverage

Commitment to Innovation: Continuous emerging technology adoption and creation enables new product development and enhances product performance

Commitment to Creativity: Company leverages technology advancements to push the limits of form and function in the pursuit of white space innovation

Stage Gate Efficiency: Technology adoption enhances the stage gate process for launching new products and solutions

Commercialization Success: Company displays a proven track record of taking new technologies to market with a high success rate

Application Diversity: Company develops and/or integrates technology that serves multiple applications and multiple environments

Business Impact

Financial Performance: Strong overall financial performance is achieved in terms of revenues, revenue growth, operating margin, and other key financial metrics

Customer Acquisition: Customer-facing processes support efficient and consistent new customer acquisition while enhancing customer retention

Operational Efficiency: Company staff performs assigned tasks productively, quickly, and to a high-quality standard

Growth Potential: Growth is fostered by a strong customer focus that strengthens the brand and reinforces customer loyalty

Human Capital: Commitment to quality and to customers characterize the company culture, which in turn enhances employee morale and retention

