

F R O S T & S U L L I V A N

FROST & SULLIVAN BEST PRACTICES AWARD

QUANTUM DOTS APPLIED TECHNOLOGY FOR  
AGRICULTURE - AMERICAS

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New Product Innovation 2019



F R O S T & S U L L I V A N

2019

BEST  
PRACTICES  
AWARD

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## Background and Company Performance

### *Industry Challenges*

Climate change reports published during the past decade outline various estimations regarding how to solve the principal environment-related issues, largely food scarcity and energy utilization, across different global scenarios. Nevertheless, the grand challenge is finding the best-suited option to decelerate global temperature increment while improving energy efficiency across all industries. Novel technologies that make sunlight energy utilization more precise and help to increase the amount of food produced, even in areas of difficult plant cultivation, are critically needed.

Colloidal semiconductor nanocrystals, often referred to as quantum dots (QDs), can significantly contribute to overcoming this challenge by imparting new absorption/emission spectra into a diverse range of ordinary products. QDs are onion-like structured nanoparticles whose consecutive layers constitute shells that protect the inner light-emitting core material, whereas hair-like organic molecules cover their outer surface. Their small size and typical structure make QDs exclusively valuable in terms of high efficiency and size-tunable photoluminescence over a comprehensive color gamut. Conversion of the broad spectrum of absorbed energy into single-color-emitted light results from size control during manufacturing.

Therefore, the optimal adjustment of manufacturing conditions for tuning the size and composition of QDs represents one of the most challenging aspects in QD production as their tunability strongly depends on processing techniques, which augment existing functionality across a wide range of products. Moreover, such capability to modify the solar spectrum constitutes a paramount milestone in the agricultural sector. Indeed, lighting is not only one of the major costs of indoor farming, but also one of the most compromised services. Companies excelling in the QD space by delivering cutting-edge, clean nanotechnology solutions are expected to play a decisive role in the present and future of agriculture, as well as in many other industries and sectors.

### *New Product Attributes and Customer Impact*

#### **Match to Needs**

One of the major discoveries directly influencing customers' decisions related to the use of lighting sources for indoor farming is the fact that some wavelengths of visible light are significantly more useful than others. This means that some colors, for instance, magenta, may benefit green plants more directly than other colors, such as blue. In fact, scientists have discovered that QDs can be tuned during their manufacture to specifically emit light in a single color (e.g., magenta) to dramatically improve light efficiency for a particular application.

Headquartered at Los Alamos, New Mexico, US, UbiQD is precisely meeting customer needs by directly influencing its product's capabilities. In November 2018, UbiQD launched its first commercial QD-based product, the UbiGro™ greenhouse film, with the aim to deliver real-world solutions to the agriculture space. UbiQD developed and patented the UbiGro™ greenhouse film after realizing that light spectrum augmented by QDs can

remarkably stimulate faster plant growth, in terms of both size and growth cycle. By deploying the UbiGro™ greenhouse film, UbiQD's customers can select specific wavelengths during early plant development, and then program slightly different wavelengths during mature plant evolution.

According to its latest investigations in both QD technology and cleantech-based agriculture, Frost & Sullivan emphasizes the benefits of using QDs in comparison to standard LED lights used by UbiQD's competitors. QDs are ideal candidates for optimizing the light spectrum for plant growth systems because they can be easily tuned to any color of the spectrum by absorbing the energy and re-emitting the light in a different color, depending on the size of the particle. This advancement represents a huge disruption to traditional grow lighting solutions, such as LED fixtures. UbiGro™ customers are not only able to see their plants' accelerating growth rate, but also enjoy increases in overall crop yield. The future implications of UbiQD's greenhouse film technology are impressive: in addition to the direct production of vast amounts of food, numerous agricultural projects can be initiated in places not typically conducive to farming, such as metropolitan and desert areas.

### **Reliability**

UbiGro™ is a line of luminescent greenhouse retrofit films that use QDs capable of modifying the solar spectrum to absorb some of the ultraviolet (UV) and blue portions of sunlight while emitting an orange glow over the plants. As a result, light quality is significantly enhanced to enable more efficient plant growth and speedy grow cycles, which results in greater annual crop yields.

UbiQD's reliable product has fascinated customers by providing a leading-edge, but simple-to-deploy, technology that tailors the natural light spectrum to perfectly support crop health, dramatically improving both the grow cycle and production rate.

### **Quality and Positioning**

The UbiGro™ greenhouse film is the first-ever product of its kind. UbiQD's reliable, best-in-class quality technology constitutes a unique solution for indoor farmers. The UbiGro™ greenhouse film is composed of cadmium-free, safe, inexpensive semiconductors belonging to the I-III-VI class of materials. One of the most relevant characteristics of these materials is their capability to be alloyed so that the optical spectrum can be tuned by both size and composition to provide superior flexibility. Such capability represents a supreme advantage over the materials used by UbiQD's competitors.

### **Customer Purchase Experience**

UbiQD's retrofit luminescent film constitutes the most optimal solution that addresses indoor farmers' unique needs and unique constraints. By simply hanging over crops, UbiGro™ can be easily mounted and rapidly deployed in an existing greenhouse. With installed greenhouse facilities across New Mexico, Oregon, Colorado, California, Arizona, the Netherlands, and Spain, UbiGro™ film is propelling greenhouse agriculture by providing optimized, controlled, and specific portions of the sunlight spectrum to ideally

match an imperative season and climate.

UbiQD's customers find the UbiGro™ greenhouse film extremely reliable, safe, and environmental-compliant. Indeed, in 2018, the US Environmental Protection Agency (EPA) granted UbiQD approval to start large-scale commercial production of its QD technology, hence distinguishing UbiQD as one of the few nanotechnology companies allowed to advance research and development (R&D) production toward commercial deployment. Frost & Sullivan understands that this grant represents an important recognition of the innovative role nanotech companies play in the agricultural space based on the technology synergy of various disruptive discoveries to provide real-world solutions related to environmental and economic sustainability.

### **Customer Ownership Experience**

UbiQD's proprietary UbiGro™ greenhouse film technology was entirely conceived to optimize sunlight by modifying the solar spectrum in benefit of agriculture programs. Customers' expectations have been met and even exceeded as evidenced by improved annual crop yields, early fruiting triggering, shorter crop cycles, plant environment customization, and sunlight direction and diffusivity manipulation, among many other unique features. Furthermore, the UbiGro™ greenhouse film holds versatile presentation options as either glass, rigid plastic, or flexible film. Additionally, the film can be combined with glass and photovoltaics sources in order to generate electricity, which makes the UbiQD platform technology extremely flexible and customizable in terms of deployment and operation.

### **Commitment to Sustainability**

Frost & Sullivan remarks the significant role of UbiQD as one of the main contributors to supporting the planet's sustainability and exemplifying industry best practices. The implementation of the UbiGro™ greenhouse film and related suite of products in indoor farming leads directly to the production of more food obtained in an impressive cost- and time-efficient manner, hence meeting several of the sustainable development goals (SDGs) toward 2030 agreed upon by the United Nations, including affordable and clean energy; industry, innovation and infrastructure; sustainable cities and communities; responsible consumption and production; and climate action.

## *Conclusion*

Rising awareness about global sustainability challenges has led many companies across industries to look for new ways to respond to inter-related economic, environmental, and social risks, in consideration of the numerous technology innovation opportunities. Headquartered in Los Alamos, NM, UbiQD is licensing technology developed at Los Alamos National Laboratory and Massachusetts Institute of Technology (MIT) to commercialize innovative QD technology-based products across several industries. In particular, UbiQD's proprietary UbiGro™ platform technology has disrupted the QD market as a superior-quality photoluminescence mechanism that is exceptionally suitable for cutting-edge, promising cleantech-based agriculture applications. UbiQD's safe and flexible technology provides customers with a full complement of features and functionalities based on retrofit, luminescent greenhouse nanofilms capable of increasing food production by mimicking highly specific features of sunlight.

For its strong overall performance, UbiQD has earned Frost & Sullivan's 2019 New Product Innovation Leadership Award.



## Significance of New Product Innovation

Ultimately, growth in any organization depends upon continually introducing new products to the market and successfully commercializing those products. For these dual goals to occur, a company must be best-in-class in three key areas: understanding demand, nurturing the brand, and differentiating from the competition.



## Understanding New Product Innovation

Innovation is about finding a productive outlet for creativity—for consistently translating ideas into high-quality products that have a profound impact on the customer.

## Key Benchmarking Criteria

For the New Product Innovation Award, Frost & Sullivan analysts independently evaluated two key factors—New Product Attributes and Customer Impact—according to the criteria identified below.

### New Product Attributes

- Criterion 1: Match to Needs
- Criterion 2: Reliability
- Criterion 3: Quality
- Criterion 4: Positioning
- Criterion 5: Design

### Customer Impact

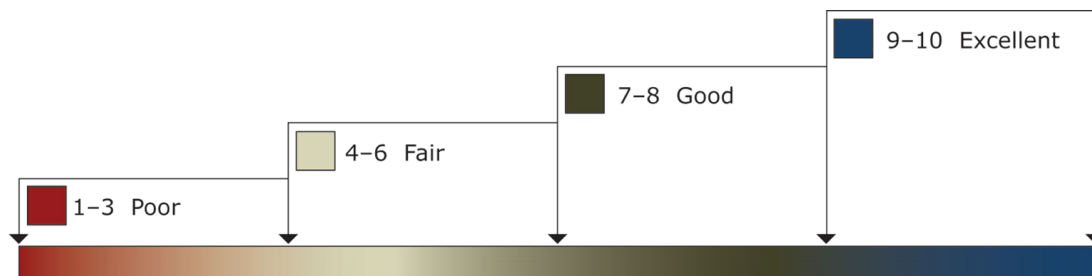
- Criterion 1: Price/Performance Value
- Criterion 2: Customer Purchase Experience
- Criterion 3: Customer Ownership Experience
- Criterion 4: Customer Service Experience
- Criterion 5: Brand Equity

## Best Practices Award Analysis for UbiQD, Inc.

### Decision Support Scorecard

To support its evaluation of best practices across multiple business performance categories, Frost & Sullivan employs a customized Decision Support Scorecard. This tool allows our research and consulting teams to objectively analyze performance, according to the key benchmarking criteria listed in the previous section, and to assign ratings on that basis. The tool follows a 10-point scale that allows for nuances in performance evaluation. Ratings guidelines are illustrated below.

#### RATINGS GUIDELINES



The Decision Support Scorecard is organized by New Product Attributes and Customer Impact (i.e., These are the overarching categories for all 10 benchmarking criteria; the definitions for each criterion are provided beneath the scorecard.). The research team confirms the veracity of this weighted scorecard through sensitivity analysis, which confirms that small changes to the ratings for a specific criterion do not lead to a significant change in the overall relative rankings of the companies.



The results of this analysis are shown below. To remain unbiased and to protect the interests of all organizations reviewed, we have chosen to refer to the other key participants as Competitor 2 and Competitor 3.

<i>Measurement of 1–10 (1 = poor; 10 = excellent)</i>			
<b>New Product Innovation</b>	New Product Attributes	Customer Impact	<b>Average Rating</b>
<b>UbiQD</b>	<b>9.8</b>	<b>9.8</b>	<b>9.8</b>
Competitor 2	5.4	4.8	5.1
Competitor 3	4.7	3.9	4.3

### *New Product Attributes*

#### **Criterion 1: Match to Needs**

Requirement: Customer needs directly influence and inspire the product's design and positioning.

#### **Criterion 2: Reliability**

Requirement: The product consistently meets or exceeds customer expectations for consistent performance during its entire life cycle.

#### **Criterion 3: Quality**

Requirement: Product offers best-in-class quality, with a full complement of features and functionalities.

#### **Criterion 4: Positioning**

Requirement: The product serves a unique, unmet need that competitors cannot easily replicate.

#### **Criterion 5: Design**

Requirement: The product features an innovative design, enhancing both visual appeal and ease of use.

### *Customer Impact*

#### **Criterion 1: Price/Performance Value**

Requirement: Products or services offer the best value for the price, compared to similar offerings in the market.

#### **Criterion 2: Customer Purchase Experience**

Requirement: Customers feel they are buying the most optimal solution that addresses both their unique needs and their unique constraints.

#### **Criterion 3: Customer Ownership Experience**

Requirement: Customers are proud to own the company's product or service and have a positive experience throughout the life of the product or service.

#### **Criterion 4: Customer Service Experience**

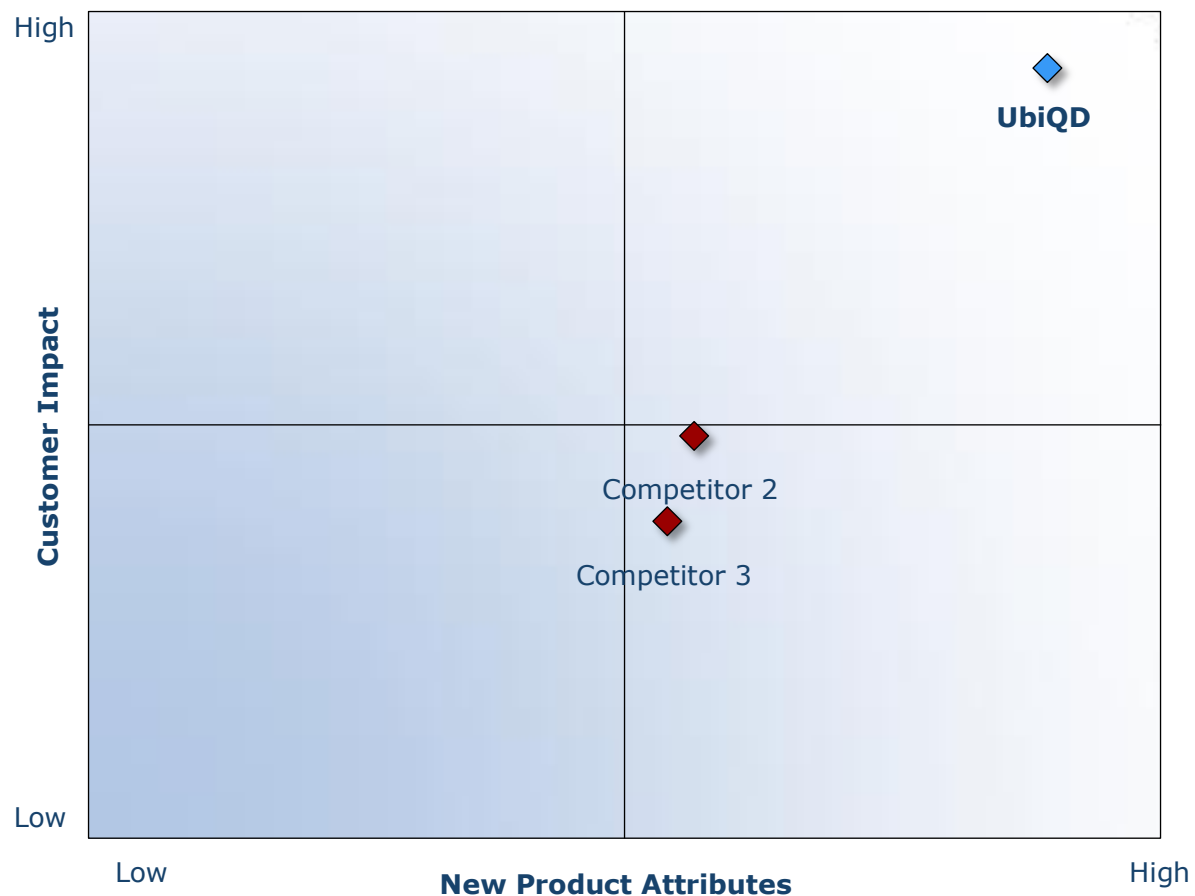
Requirement: Customer service is accessible, fast, stress-free, and of high quality.

#### Criterion 5: Brand Equity

Requirement: Customers have a positive view of the brand and exhibit high brand loyalty.

#### Decision Support Matrix

Once all companies have been evaluated according to the Decision Support Scorecard, analysts then position the candidates on the matrix shown below, enabling them to visualize which companies are truly breakthrough and which ones are not yet operating at best-in-class levels.



## Best Practices Recognition: 10 Steps to Researching, Identifying, and Recognizing Best Practices

Frost & Sullivan analysts follow a 10-step process to evaluate Award candidates and assess their fit with select best practice criteria. The reputation and integrity of the Awards are based on close adherence to this process.

STEP	OBJECTIVE	KEY ACTIVITIES	OUTPUT
1 <b>Monitor, target, and screen</b>	Identify Award recipient candidates from around the globe	<ul style="list-style-type: none"> <li>Conduct in-depth industry research</li> <li>Identify emerging sectors</li> <li>Scan multiple geographies</li> </ul>	Pipeline of candidates who potentially meet all best-practice criteria
2 <b>Perform 360-degree research</b>	Perform comprehensive, 360-degree research on all candidates in the pipeline	<ul style="list-style-type: none"> <li>Interview thought leaders and industry practitioners</li> <li>Assess candidates' fit with best-practice criteria</li> <li>Rank all candidates</li> </ul>	Matrix positioning of all candidates' performance relative to one another
3 <b>Invite thought leadership in best practices</b>	Perform in-depth examination of all candidates	<ul style="list-style-type: none"> <li>Confirm best-practice criteria</li> <li>Examine eligibility of all candidates</li> <li>Identify any information gaps</li> </ul>	Detailed profiles of all ranked candidates
4 <b>Initiate research director review</b>	Conduct an unbiased evaluation of all candidate profiles	<ul style="list-style-type: none"> <li>Brainstorm ranking options</li> <li>Invite multiple perspectives on candidates' performance</li> <li>Update candidate profiles</li> </ul>	Final prioritization of all eligible candidates and companion best-practice positioning paper
5 <b>Assemble panel of industry experts</b>	Present findings to an expert panel of industry thought leaders	<ul style="list-style-type: none"> <li>Share findings</li> <li>Strengthen cases for candidate eligibility</li> <li>Prioritize candidates</li> </ul>	Refined list of prioritized Award candidates
6 <b>Conduct global industry review</b>	Build consensus on Award candidates' eligibility	<ul style="list-style-type: none"> <li>Hold global team meeting to review all candidates</li> <li>Pressure-test fit with criteria</li> <li>Confirm inclusion of all eligible candidates</li> </ul>	Final list of eligible Award candidates, representing success stories worldwide
7 <b>Perform quality check</b>	Develop official Award consideration materials	<ul style="list-style-type: none"> <li>Perform final performance benchmarking activities</li> <li>Write nominations</li> <li>Perform quality review</li> </ul>	High-quality, accurate, and creative presentation of nominees' successes
8 <b>Reconnect with panel of industry experts</b>	Finalize the selection of the best-practice Award recipient	<ul style="list-style-type: none"> <li>Review analysis with panel</li> <li>Build consensus</li> <li>Select recipient</li> </ul>	Decision on which company performs best against all best-practice criteria
9 <b>Communicate recognition</b>	Inform Award recipient of Award recognition	<ul style="list-style-type: none"> <li>Present Award to the CEO</li> <li>Inspire the organization for continued success</li> <li>Celebrate the recipient's performance</li> </ul>	Announcement of Award and plan for how recipient can use the Award to enhance the brand
10 <b>Take strategic action</b>	Upon licensing, company is able to share Award news with stakeholders and customers	<ul style="list-style-type: none"> <li>Coordinate media outreach</li> <li>Design a marketing plan</li> <li>Assess Award's role in future strategic planning</li> </ul>	Widespread awareness of recipient's Award status among investors, media personnel, and employees

## The Intersection between 360-Degree Research and Best Practices Awards

### *Research Methodology*

Frost & Sullivan's 360-degree research methodology represents the analytical rigor of our research process. It offers a 360-degree-view of industry challenges, trends, and issues by integrating all 7 of Frost & Sullivan's research methodologies. Too often companies make important growth decisions based on a narrow understanding of their environment, leading to errors of both omission and commission. Successful growth strategies are founded on a thorough understanding of market, technical, economic, financial, customer, best practices, and demographic analyses. The integration of these research disciplines into the 360-degree research methodology provides an evaluation platform for benchmarking industry participants and for identifying those performing at best-in-class levels.

### 360-DEGREE RESEARCH: SEEING ORDER IN THE CHAOS



## About Frost & Sullivan

Frost & Sullivan, the Growth Partnership Company, enables clients to accelerate growth and achieve best-in-class positions in growth, innovation and leadership. The company's Growth Partnership Service provides the CEO and the CEO's Growth Team with disciplined research and best practice models to drive the generation, evaluation, and implementation of powerful growth strategies. Frost & Sullivan leverages more than 50 years of experience in partnering with Global 1000 companies, emerging businesses, and the investment community from 45 offices on six continents. To join our Growth Partnership, please visit <http://www.frost.com>.