Markets for ESD and Antistatic Protection Materials in Electronics

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Chapter One: Introduction and Background

1.1 Introduction to the Electrostatic Dissipation and Antistatic Materials Markets

The control of electrostatic charge buildup—and its discharge or dissipation—has been a thriving industry for many years. In the electronics industry, the major goal is to prevent sparks from uncontrolled electrostatic discharge that can damage sensitive electronic equipment. Also important is preventing the attraction of particles to statically charged surfaces—the reason why antistatic coatings are applied to digital camera sensors, for example.

The ESD protection sector is expected to see quite strong growth during the eight years for which we forecast revenues, with steady gains over the forecast period. This growth is largely being driven by ongoing, long-term trends in electronics:

- First, the proliferation of pervasive computing and electronics in everyday life has led to more and more production of electronic devices of many kinds and across many sectors, and they all need antistatic protection during production, assembly, shipping, transport, and use.
- In addition, the miniaturization of electronics in accordance with the onward march of Moore's Law means that a higher level of ESD protection is required to protect the increasing circuit density and sensitivity to ESD.

In this context, an exciting development is the introduction of new, high-tech materials into the ESD marketplace. The "old guard" of commodity antistatic materials—metals, ITO and other metal oxides, carbon black- and carbon fiber-filled composites, and organic materials such as amines, amides, and esters—is now supplemented with more advanced materials like nanomaterials based on metals, metal oxides, carbon, and graphene, as well as inherently conductive polymers like PEDOT:PSS and polyaniline (PANI). These newer materials are expensive today, but they carry the promise of introducing new capabilities for improved performance, reduced material usage, and greater ESD protection that will bring new life into a mature industry.

1.1.1 ESD Applications and Products

ESD products are diverse, but many of them can be categorized by their function. These include the following:

- Packaging products, including bags, totes, and shipping containers that protect sensitive devices contained within them;

- Products designed to create a static-free local environment, such as flooring, mats, furniture, and clothing;
- Products designed to provide permanent protection of an enclosed or covered device, often made using bulk-loaded plastics but also by coatings, and
- Transparent ESD coatings and materials for both rigid and flexible substrates, especially those used in the display industry and in antistatic protection of windows in sensitive equipment or environments. Note that "transparent ESD coatings" is an overlapping category in which the products could also fall into one or more of the aforementioned general groups of ESD products.[1]

Within these functions, ESD protection can be divided into two different—but often complementary—goals. One goal is to eliminate static charges as they occur, a task that can be accomplished simply by providing a rapidly conducting path to ground or often more effectively, by controlled dissipation, sometimes with conversion of much of the electrical energy into heat.

The second goal of ESD protection is to prevent the triboelectric generation of static charge buildup in the first place. Triboelectric generation is common with typical plastics, glass, and other insulating materials used in electronics products for substrates, housings, packaging, etc. The use of inherently antistatic materials—metals, certain polymers, etc.—designed to be less prone to triboelectric charge buildup is one way around the problem; more commonly, typical insulative materials either are coated with ESD materials or are loaded with ESD additives.

Generally, the most sensitive ESD applications are those involving direct contact with sensitive electronic components, and are typically required in electronics manufacturing and assembly operations. ESD protection is thus an integral part of the design of every piece of equipment and other parts of a wafer fab, for instance, and is of paramount importance in circuit board and device assembly and in the handling of electronic components.

The ESD products used in these environments add up quickly. At the wafer fab level, millions of square feet of fab flooring are used in addition to the containers for the wafers, the tools handling them, and the garments for the workers. And at the assembly level, the ESD products add up similarly, but now include ESD bags and other packaging materials for components and

[1] Also note that there are various additives for fuels and other fluids, ionizing devices designed to neutralize static charges on demand, devices for monitoring ESD protection, and more mundane devices like grounding cables. These products are outside of the scope of this report.

boards. Even the smallest PC upgrade outlets must use an ESD system—including an ESD-protected work area, ESD bags, and grounding of the workers—to minimize component and device damage due to ESD.

As the most sensitive devices shrink to smaller circuit dimensions and lower operating voltages, they also become increasingly sensitive to ESD. Combined with the growth in the number of devices—especially handheld devices like mobile phones and music players—ESD requirements will grow along with the volume of these products, yet face increasingly more demanding performance requirements and rising cost sensitivity.

1.1.2 ESD Materials

The old guard: There is something of a "changing of the guard" beginning in the field of ESD materials. Conventionally, the materials used for ESD applications have been metals—a metallic strip or wire included within a non-conductive bulk material, forming a network—or carbon-filled materials such as plastics containing carbon black or carbon fibers. There have also been metal oxides—ITO and other tin oxides, mostly—used where transparency is important, and somewhat conductive organic compounds including quaternary ammonium salts, amines, amides, and esters. But the newer conductive materials—nanomaterials and some conductive polymers—that are finding their way into many sophisticated applications are also finding niches in the less glamorous applications including ESD materials.

Nanometals: Metal nanoparticles can be applied as the main ingredient in a coating or as a conductive filler in a bulk material like a plastic that is otherwise insulating. The small size of nanoparticles combined with the low conductivity requirements of ESD materials offers the potential to use such small amounts of metals that even an expensive metal like silver is not cost prohibitive.

Carbon nanomaterials: Also promising is carbon in the form of carbon nanotubes (CNTs) or other carbon nanostructures, which can be used in even smaller quantities and which are not inherently expensive. Today, their cost, although still quite high, is falling, as these products are being increasingly used in various non-ESD applications—mainly structural composites—that are allowing the CNT industry to realize economies of scale.

With respect to ESD, it is also important to note that only modest conductivity levels are required, so painstaking separation of the different CNT nanostructures—multi-walled *vs.* single-walled, and the like—is not necessary. CNTs are also very compatible with the fabrication of diffuse conductive networks; CNT coatings or filled polymers offer a modern take on the old-fashioned wire networks that have been used for so long—but with "wire" diameters 1000

times thinner, and with the wires randomly distributed rather than forming a grid. And graphene, as it becomes easier to produce, will also find its way into applications that take advantage of its electrical conductivity.

Inherently conductive polymers (ICPs): ICPs like PEDOT:PSS, polypyrrole, and polyaniline are also widely used in ESD protection products. In general, the ICPs have mid-range levels of conductivities, from around 1000 Ohms/square and up. While this moderate conductivity has limited their utility in the highest value applications, such as for ITO substitutes, they are extremely well-suited to less conductive applications in the ESD sector.

In addition, while not immune, they are subject to far less influence from percolation effects in coatings, making them more adaptable and adjustable to particular surface resistivity (SR) requirements than many competing materials. The major drawback to conductive polymers today remains their relatively high cost, at least when compared to the cheapest antistats on the market. These materials are not inherently expensive but have not come down in price as rapidly as hoped. Still, they are flexible and often transparent—especially in very thin layers as required for the high resistivity of ESD applications—and offer the likelihood of much lower cost if suppliers can reach economies of scale over the next decade.

1.2 Objectives and Scope of this Report

In this report, NanoMarkets examines the markets for ESD materials and products—coatings and bulk materials, garments and fabrics, furniture, flooring, bags and other packaging, laminates, and films—and translates the analysis into opportunities for ESD materials and products, and the firms that produce them. The analysis includes technical issues such as the relative performance and features of different solutions, and how these characteristics relate to applications, as well as business issues such as how growth in the applications for these products and materials will affect volumes and costs.

Thus, the principal objective of this report is to provide detailed, eight-year forecasts of the markets analyzed, both in volume terms and in monetary terms—broken out by material type and product type, within the framework of the applications for which they are used and the types of end users. As part of the analysis, we consider the factors that affect the overall electronics markets, such as the influence of global economic growth rates, lingering fiscal uncertainty in important global markets, and/or inflation rates that influence the costs of ESD products. We also consider how trends within the electronics markets will increase or decrease the need for certain ESD materials or products in specific application areas.

NanoMarkets identifies the opportunities that are available for ESD products and materials and covers several industries, including electronics manufacturing and assembly, sensitive electronic device protection, and transparent ESD protection in displays and related industries. The report includes coverage of established antistatic materials like metals, metal oxides, carbon, and organic additives as well as newer materials based on conductive polymers and nanomaterials. It also examines alternative scenarios for ESD products.

The classes of basic ESD materials discussed are as follows:

- Metals and metal oxides,
- Carbon materials, including carbon nanomaterials, and
- Organic materials, including conductive polymers.

Applications covered include:

- Electronics manufacturing and assembly,
- Packaging, shipping, transport, and storage,
- Textiles, personal grounding, and furniture,
- ESD floor coverings, and
- Transparent ESD coatings in displays and electronics.

Through a review of each of the various market segments, we show where new business revenues will be created in the next eight years, and we provide detailed eight-year market forecasts for the use of ESD products in electronics applications broken out by material type, product type, and end-use application. The forecasts are provided in value terms and, where relevant and possible, in volume terms. In addition, the report discusses the strategies of key firms to watch in this important sector.

This report is international in scope. The forecasts herein are worldwide forecasts and we have not been geographically selective in the firms that we have covered in this report or interviewed in order to collect information.

1.3 Methodology of this Report

To assess the markets for ESD materials and products, we used a two-pronged analysis. The materials and products themselves were first evaluated for suitability, performance, likely

improvements, and likely cost developments, while the applications and markets were analyzed for their needs, volume growth, and what they can gain from new material and product developments. Since ESD protection—and especially ESD materials—is a dynamic field, a "supply side" analysis must consider how the materials will change and how those changes will influence the development of products and applications over the next several years. From the "demand side," shifting needs and devices—especially with regard to the level of ESD sensitivity of future devices—must be considered in terms of how they will affect the development of ESD products and materials.

In the course of our analysis, we assess the traditional ESD materials and the current state of the ESD products market as well as the state of development of the more advanced ESD materials and trends in the types of ESD products in production and use. We also assess the anticipated growth and trends in the applications for which the ESD products are used, and how the materials, products, and applications relate to and influence one another.

The information for this report is derived from a variety of sources, but principally comes from primary sources, including NanoMarkets' ongoing interview program of entrepreneurs, business development and marketing managers, and technologists involved with electronics applications of all kinds. We also use information from secondary sources, such as relevant company and industry organization websites, commercial databases, trade press articles, technical literature, SEC filings and other corporate literature.

Some background information for this report has been taken from the previous version of this report, "*ESD Products and Materials: Markets and Opportunities*" from March 2010. In addition, some of the more recent market information in this report comes from our most recent reports on conductive coatings and the electronics markets, especially from *"Conductive Coatings in Electronics and Energy Markets"* from January 2012. Where information has been used in an earlier report, it has been reconsidered in light of current developments and updated accordingly.

The basic forecasting approach is to identify and quantify the underlying addressable electronics markets, the ESD materials needs, and the technological and market pressures that are expected to influence the suitability and likely mix of ESD materials used in these markets. We also consider broader economic developments that impact electronics markets, materials development and commercialization.

This report on ESD materials and products forms part of a series of reports published by NanoMarkets covering the commercialization of advanced materials used in electronics

applications. Other related areas covered by NanoMarkets' reports include analyses of the markets for electromagnetic compatibility (EMC) materials and components, conductive coatings in energy and electronics applications, and other materials markets for use in electronics.

1.4 Plan of this Report

In Chapter Two, we examine the different materials technologies for ESD protection as well as the products made using those materials. We consider conductive, antistatic, and dissipative materials commonly used in bulk, in coatings, or as additives, and we consider various products that are made with ESD materials.

We also discuss in Chapter Two the important applications and markets for ESD products and materials, including the protection of sensitive electronic devices and prevention of electrostatic attraction in electronic manufacturing and assembly. The goal is to identify key opportunities for materials suppliers in the ESD protection markets, so we pay particular attention to any emerging trends or changes in the market that will affect business opportunities. As part of this analysis, and to illustrate important trends and developments, we briefly examine the focus and strategies of some of the key suppliers and end users of ESD materials in electronics applications.

Chapter Three contains our eight-year forecasts of the markets for ESD materials and products broken out by material type, by product type, and by end-user type.