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Materials for Functional Inkjet Printing: A Market Forecast, 2009-2016

Nano-062

Chapter One

Chapter One: Introduction

1.1 Background to this Report

Today, inkjet technology is the dominant printing technology used in most digital industrial applications. It has achieved this status as a result of simplicity, quality, and reliability at a relatively low cost. It can also produce very high quality with high resolution and the added feature of marking on many non-porous substrates. This is because fluid dynamics are easily controlled and because a wide variety of inkjet fluids can be ejected from the wide array of printhead hardware.

Inkjet is continuing to evolve well beyond traditional office environments. Inkjet is a proven technology that has already become well established in a wide array of functional printing and fabrication environments. This success is now spilling over into new and innovative manufacturing applications throughout the world and offers functional solutions to otherwise difficult and tedious production problems. What inkjet brings to the table in manufacturing environments is that it is not only simple, consistent, and efficient but cost-effective, as well. As a result, many traditional applications such as 3-D modeling and rapid prototyping, automotive component manufacturing, printed circuit board manufacturing, MEMs, biotechnology, textile manufacturing, photovoltaics, and packaging (to name just a few) are employing (or looking at employing) state-of-the-art industrial inkjet technologies. In theory at least, inkjet can provide a low-cost option to vacuum deposition, optical lithography, screen printing, soldering and some coating processes in specific applications. It is also ideally suited to creating functional devices on delicate substrates.

The *materials* processed through inkjet delivery systems for these functional applications are the primary focus of this report. In this report, NanoMarkets explores state-of-the-art inks and fluids and component materials as well as the related jetting systems currently enabling these markets. This analysis will be especially important to ink manufacturers and related component materials suppliers throughout the world. However, it will also address concerns of inkjet equipment/printhead companies, printing firms and investors looking for new opportunities and device/product manufacturers looking for more cost effective ways of creating what they have to sell.

Some of these opportunities for the functional materials are spread over a large number of applications and offer substantial revenue potential. Other applications may only offer a niche opportunity on their own, but will generate new revenues for established component materials. This raises the question of how ink makers and related materials suppliers can sufficiently capitalize on these emerging applications. This report identifies the optimal strategies for such suppliers to employ in this regard and forecasts these size and growth of the opportunities for jetted functional materials over the next eight years.

1.1.1 Evolution of Fluids for New Industrial Applications

The combination of new print hardware and inkjet fluid chemistries is enabling the evolution of highly novel industrial printing and fabrication applications. The interaction of state-of-the-art fluid materials with newly developed receiver substrates is also contributing to the overall success of inkjet in its myriad of new applications.

Conducting materials: Understandably, much of the focus on fluid development for inkjet has been on metals. Often this development has been done with electrical, electronic and thermal applications in mind. There is some history here. Screen printed silver has long been used to create PCBs, contacts for solar cells, and automotive heaters. However, the market orientation and constitution of metallic inks for inkjet are different than what went before. They are much more suited to small device sizes and thin layers. They are also likely to use nanoparticulate silver as a solid, which better enables them to be squeezed through an inkjet printhead. While the older thick film inks are likely to be used in the large format applications mentioned above, functional metallic inks for inkjet are more likely to find a home in electronic prototyping, repair of expensive systems such as displays, MEMS manufacture, interconnects of all kinds, and the construction of TFTs, RFIDs, sensors and other small devices.

A broad range of functional metallic inks are already available for inkjet. Silver predominates, partly because of history, but mostly because silver is the world's most conductive material with an oxide that is also conductive. But the number of conductive materials that are being turned into inks is growing. Gold inks are available and have found a niche for medical devices, since gold has long been established as a safe material to put inside the body. And there has also been a growing interest in copper inks for a variety of applications and some interest in nickel, too. Tin-lead solders have also been dispensed by inkjet and – perhaps most interestingly – inkjet has emerged as one of a number of competing ways for placing clumps of carbon nanotubes.

Organics and optical materials: While the printing of metals/conductors is surely the most visible part of functional inkjet, it is by no means the only one. Dielectrics have been jetted as part of novel electronics chip-scale packaging systems. Meanwhile, organic electronics is a newly commercialized discipline that relies very heavily on printing organic conductors and semiconductors, with inkjet being one of the favored modes of printing cited in the relevant literature. Many of the potential materials for organic electronics have yet to be available in quantities larger than those associated with R&D, but some, such as PEDOT, are commercialized. Others, such as the widely used organic semiconductor pentacene, have not yet been developed into an ink.

It is hard to ignore electronics when considering the functional materials that inkjet can deliver. But it is by no means the only area in which inkjet can serve. Optics is another direction. Inkjet is now routinely used in the fabrication of color filters for displays and it has been used to create microlenses that are used both for optical MEMS devices (now widely used in projection televisions) and for VCSEL laser devices (now widely used for data communications.) The jetted material used for such lenses is likely to be an epoxy material of some kind. Various materials have also been used to create integrated optical circuits, but the performance of such devices does not yet seem to be adequate for any serious commercialization effort.

Biological materials: Perhaps the most exciting potential for functional jetting involves biological materials. While the other areas that are discussed in this report exhibit the still-strong growth curves of the IT industries, "biojetting," has the potential for hypergrowth, given the current boom in biomedical technology that has come from the sequencing of the human (and other animal) genomes. When FujiFilm Dimatix developed its efficient R&D jet printer a few years back, it had electronic applications in mind. It was surprised to find that a lot of firms with biological applications bought its machine.

The initial application for jetting biological materials is in creating assays. This is now a fully commercialized application and typically consists of creating diagnostic test strips by jetting antibodies onto nitrocellulose membranes. The miniaturizing of assays has a number of advantages including increase sensitivity, reduced cost (less material) and the ability to conduct more tests in parallel. Gradually, this concept is also moving beyond antibody assays to DNA assays.

In addition to these potentially large-volume applications there are also smaller (but very high value added) applications for "biojetting" in the lab and hospital. In the lab, inkjet is a good tool for microchemistry; both synthesis and decomposition. Among the microchemical processes in which inkjet has become involved is the synthesis of both DNA and peptides. Somewhat more prosaically, inkjet seems to be a good microdispensing technology for reagents, enzymes and other fluids that are deposited on biological substrates. Finally, outside of the diagnostic or research lab, it seems that biojetting may have an important role to play in tissue engineering and the creation of implantable devices of various kinds.

1.2 Objective and Scope of this Report

The objective of this report is to assess the opportunities that are available to inkjet materials suppliers as the result of the important developments outlined above. We quantify the size and growth of these opportunities and also discuss the strategies being deployed in the relevant areas by leading fluids firms and also, where appropriate, leading suppliers of print heads and other jetting equipment. In addition to the opportunities, we also discuss the many challenges that arise in this field including the making of inks using unusual materials and the growing concerns with environmental friendliness.

As we have already noted, this report covers applications in the display, photovoltaics, RFID, packaging, smart textiles, MEMs, component fabrication, 3-D modeling and rapid prototyping, among other areas; and all the many materials associated with these applications.

1.3 Methodology

Our assessment of the various markets considered in this report is based on extensive interviews administered in the later-half of 2008 with ink manufacturers and their counterpart materials suppliers. We have also based our conclusions on Nanomarkets' ongoing research program in a variety of areas of inorganic and organic semiconductors, dielectrics, photoactive material, and thermally sensitive materials and biomaterials.

The secondary research for this report drew upon the World Wide Web, commercial databases, trade press releases and articles, technical papers, SEC filings, and other corporate literature to determine pertinent sector conditions and markets. Nanomarkets' researchers are also frequent attendees and speakers at important trade shows and conferences related to the matters discussed in this report. The forecasting approach and related assumptions is discussed in more detail in Chapter Four.

1.4 Plan of this Report

Chapter Two of this report is based on technology. We analyze the market for ink fluid materials as well as related state-of-the-art printhead technology developments. The relevant ink chemistries and related materials are discussed for both aqueous and non-aqueous systems. Important issues, for example, shelf-life, drying rates, substrate interaction, and relative cost structure are discussed. The key inkjet fluid manufacturers and printhead makers are also characterized.

In Chapter Three, we take an in-depth look at the evolving markets for inkjet fluids and the requirements of the leading industrial applications utilizing inkjet technology. The goal of this chapter is to identify niches and sectors where there are genuine opportunities for ink makers, materials vendors, and equipment manufacturers. We are less concerned with industrial corporations that exhibit "business as usual" and where we believe markets are mature or offer little growth opportunity. Where possible, we will discuss public intellectual property trends and how we think this technology will influence the future development of inkjet fluid systems.

Finally, in Chapter Four we provide our forecasts by ink type, region of the world, application, and also by delivery system. Our forecasts are based on an eight-year timeframe and assess both ink volume and corresponding revenue; component volume and corresponding revenue as well as the trends they represent.

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For additional information about the report, Materials for Functional Inkjet Printing: A Market Forecast, 2009-2016-Nano-062 please contact NanoMarkets at 804-360-2967 or sales@nanomarkets.net.