Silver Inks and Pastes Markets—2012

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About the Report:

This new report on opportunities in the silver inks and pastes market provides an up-to-date survey of the market conditions today and a forecast of the next eight years. NanoMarkets has been covering this sector now for more than five years and this is latest in our ongoing series of industry analysis on silver conductors of various kinds.

In the report, we consider how the persistent environment of relentlessly high silver prices – with no relief in sight – is affecting the markets for these materials. Will this mean a sustained opportunity for alternatives to silver? We also identify the niche opportunities that continue to emerge from the traditional thick-film industry and conversely whether the profound changes going on in the display and solar panel industry will reduce the demand for silver. For example, will the reduction of subsidies for crystalline silicon solar panels (a large consumer of silver pastes) ultimately hurt the silver pastes business and similarly will the steady decline of the plasma display industry have a similar effect? Also examined in this report is the future of nanosilver inks, a product that has been full of unfulfilled promise for several years now. Is it time to give up on the commercialization of these materials?

This rather gloomy set of questions is balanced in the report by an examination of emerging opportunities. For example, large OLED lighting and television panels are just a few years out. Will they prove a vibrant market for printed silver bus lines and interconnects? In addition, in the new policy environment for solar panels, entirely new kinds of photovoltaics are likely to emerge quite quickly. Will they make use of silver in the electrodes the same way that older types of PV did? And all those sensors that will deployed as part of the "Internet of Things," will they also make significant use of printed silver?

This report explores the emerging opportunities in silver inks and pastes in the light of all these trends and provides an up-to-date guide for finding the growth opportunities and navigating the market challenges. As part of this analysis, we examine the strategies of the key players in the silver inks/pastes markets, and identify what we believe to be the trends indicating likely success (or not) at different firms. Finally, as always we include eight-year market forecasts for silver inks and pastes by application and by material.

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Related Reports:

Nanosilver Markets 2011

Markets for Silver-Based Transparent Conductors – 2011

Silver Powders and Flakes - 2011

Silver Inks and Pastes Markets – 2011

Silver in Photovoltaics: 2010

For additional information about the reports, please follow the hyperlinks from the listed titles.

Chapter One: An Introduction to the Report

1.1 Ongoing Importance of Silver Inks and Pastes to Industrial Electronics Markets

1.1.1 The Effect of the High Price on Silver on the Industrial Inks and Pastes Market

Silver has always been an expensive metal and probably always will be. But the most obvious change in the silver inks/pastes market since our last report is the seemingly *persistent* high price of silver, with no relief in sight. Silver commodity prices have been pushed upward because of the uncertain global economic environment in which investors have shifted increasingly toward "hard" assets. Silver ETFs have accumulated large stores of silver in order to handle the increased demand for precious metal investments.

At the time of writing, silver prices have somewhat stabilized, but they have done so at a level nearly twice that of just two years ago (in inflation-adjusted dollars). And there are no good reasons that the situation will change very much over the next five years or so.

None of this is especially good news for the silver inks and pastes business, since the price of these materials is largely determined by the price of silver and these materials are often sold into moderately price sensitive environments. Despite these negatives, however, there are some reasons for executives in the silver inks and pastes business not to feel too depressed:

- The high price of silver is now a fact of life for the electronics industry. On the one hand, its unique conductivity characteristics ensure that silver is hard to dispense with in many applications.

- Where silver inks and pastes can be dispensed with their high price will enable supplier firms to develop silver inks and pastes substitutes with an assurance that the market for them will persist. In the past, silver ink/paste substitutes have appeared and then disappeared when the price of silver fell again. Given the current economic climate, it seems that the manufacturers of silver ink/paste substitutes are in for the long haul this time around.

- Counteracting ongoing worldwide economic sluggishness will be increased industrialization and urbanization of the developing world; which is likely to increase the per capita expenditures on the kinds of products in which silver inks and pastes are used. And, of course, silver inks and pastes are now used in so many consumer products that the increase in the world population is itself a spur to demand for silver inks and pastes.

- There are a number of interesting applications for silver inks and pastes that are just emerging. They include, for example, OLED lighting, and sensors. NanoMarkets believes that there are real opportunities here, but we also caution that some traditional applications that use quite a lot of silver paste at the present time are likely to experience at best modest growth, and this could hurt the silver inks and pastes business in the next few years. Examples here are plasma TVs (in long-term decline) and crystalline silicon solar panels (a market likely to see a decline in government support).

1.1.2 Where is the Growth for Silver Inks?

Despite high silver prices (indeed, partially *because* of them), NanoMarkets expects that revenues from silver inks and pastes will remain substantial in a number of applications.

Traditional thick-film electronics: Thick-film electronics, which comprises a vast number of printed circuit board applications as well as printed membrane switches and the like, has traditionally been the largest user of conventional silver inks and pastes (mostly pastes), and we expect it—absent a serious worldwide financial crisis—to remain a relatively stable high-volume market with even a few genuine opportunities appearing from time to time:

- *We think that with so many mature processes in place and so much accumulated manufacturing experience in the thick-film sector, it is going to be very hard for firms to get rid of silver pastes and inks in a wholesale manner, unless very close substitutes can be found.* As to replacing printed silver with some entirely different process, this would also be hard to achieve. "Printed silver" provides not only higher resolution and fewer process steps than subtractive processes such as etched copper, but also the option of applying conductive traces at different times.

- *Substitution of traditional thick film pastes with silver inks, including potentially nanosilver inks, in this segment will be driven by the trend toward miniaturization of consumer electronics and the need for finer lines and higher resolution of conductive traces.* Here, again, is an opportunity of sorts for the silver inks and pastes business.

- Even without high volume growth—and with some negative growth in certain sub-sectors like membrane switches—increases in silver prices will drive substantial revenue growth. *An open question for suppliers of inks and pastes is how they are going to capture some of the new value encapsulated in silver metal.*

Suppliers of silver inks and pastes (except *maybe,* boutique suppliers of nanosilver products) cannot afford to ignore the thick-film sector, simply because it is so large; traditional thick-film paste sales will still make up nearly half of the total silver inks and pastes market for the

foreseeable and thus present significant opportunities. Still, we think that silver paste suppliers should not expect too much from this sector. It is, after all, highly mature. In this market, customers for inks and pastes will continue to balance the risks of switching to a new material against attempting to ride out the high silver commodity prices while sticking with conventional silver pastes. *For materials suppliers of all kinds in this sector, the business development struggle for the next few years is going to center around these switching economics issues and arguments that either turn customers to a new material or calm their concerns about the high price of silver.*

Displays, OLEDs, and solid-state lighting (SSL): Silver inks and pastes are used to create electrodes and interconnects in a broad array of displays and lighting products:

- Here the good news for the silver inks and pastes business is that new types of technologies are apparently coming to market quite quickly in this sector and could emerge as sizeable markets for silver inks and pastes over the next five years.

- The bad news is that one sector—plasma displays (PDPs)—that has been a large user of silver in the past seems to be in slow and steady decline. *We think it will be hard for the newer applications that fall into this segment to offset the declining demand from PDPs for quite a few years; these newer applications aren't mature enough yet.*

It is too early to say with much certainty what opportunities will appear in this segment. But there are a couple of such opportunities that seem to be looming:

- Flexible displays have been talked about for many years, but now seem to be at the cusp of commercialization (thanks largely to Samsung). This implies the arrival of flexible backplanes; a huge challenge. Such backplanes would seem to require flexible interconnects that could be provided with silver traces of some kind. Flexible displays are unlikely to appear on the market until 2012 and nobody can be really sure if consumers will like them. But if (say) they were to attract an iPad-like following they might represent a significant opportunity for silver inks going forward.

- The OLED lighting market seems poised for very rapid growth, especially after 2015 when it is anticipated that the technical performance of this kind of lighting will be sufficient to meet market needs. In addition, the demise of the historically dominant incandescent bulb is creating a market opening in the general lighting market, which may partially filled by OLED lighting panels. OLED lighting may employ printed silver, mainly in the form of (1) bus bars, to prevent visible brightness gradients due to the significant voltage drops and resistive heat losses across long spans of (less) conductive

transparent electrodes and (2) interconnects for concatenated OLED lighting panels. If OLED lighting ultimately attracts consumer attention this could be another mass market silver ink user. A good sign is that OLED lighting is attracting the attention of an impressive list of electronics and lighting companies, some of whom are constructing pilot plants to build OLED lighting panels.

Silver inks: The long-term trajectory of such products and markets is still very uncertain, but it is quite possible, as we have already noted, that they will end up using plenty of silver. In particular, we see the thin silver traces that OLED lighting and flexible displays might need as an opportunity for nanosilver inks. One reason for this is that historically nanosilver inks were developed specifically with these applications in mind. (This was the area that Cabot actively pursued when this company heavily marketed its silver inks for printed electronics a few years back.) It seems to be the applications not the inks that failed to emerge.

If some of the applications listed and hinted at above, take off, then a variety of opportunities open up for ink makers, including inks that are designed to work specifically with inkjet, gravure, flexographic, etc. Unfortunately, this is not exactly news. There are quite a few firms that have emerged in the past five to seven years with ambitions to supply novel silver inks fine-tuned to emerging applications. For the most part they have not found the market very encouraging. Some of these firms have already gone out of business and OLED lighting, flexible displays and the like might turn out to be their last best opportunity.

1.1.3 Prospects for Silver Inks and Pastes in Photovoltaic Panels

The solar panel industry was, for several years, one of the fastest growing sectors for printed silver; primarily because crystalline silicon solar panels use silver paste to create the front electrode. However, in the past few years a lot has happened to discourage manufacturers of silver inks and pastes in this sector:

- The newer thin-film PV technologies that are taking an ever greater share of the solar panel industry are less likely to use silver for electrodes;

- The badly depressed construction industry in much of the world has reduced many major addressable markets for solar panels generally;

- Governmental support in the form of consumer subsidies and loan guarantees is under considerable challenge around the world as governments look for areas to cut back on. This could have very serious consequences for firms selling materials into the PV sector. When Spain ended PV subsidies, the market in Spain lost 90 percent of its value.

All of this suggests that the opportunities available for suppliers of silver and silver products into the PV space are highly dependent on policy consideration, which should be judged a significant risk factor in view of the current worldwide financial problems. It also suggests that silver inks and pastes firms are not going to have it especially easy in the near future. There are some signs of hope though:

- The end of subsidies could be good news in the long run since it encourages market oriented PV technologies (although the near-term effects are certainly chilling).
- Silver inks and pastes used in crystalline silicon (c-Si) PV electrode fabrication make up the largest share of the PV market. We expect this sector to retain a strong position in the solar panel market, but expect growth *rates* in this sector to cool significantly.
- Silver ink manufacturers have developed silver ink products specifically for TFPV that help to address TFPV-specific challenges. It is also possible that next-generation PV technologies, not out the lab, may use silver.

PV of all kinds is very sensitive to materials costs, especially in the current era of collapsing solar panel prices. Therefore innovations to reduce the cost of the printed silver electrodes are going to be welcomed by the marketplace in the next few years. These innovations might include not only ways of making silver more effective as a conductor—such as through the use of nanosilver inks—but also through ways of using less silver in conventional inks and pastes.

1.1.4 Up-and-Coming Materials–Hybrids, Nanosilver and Silver Substitutes

Inexpensive alternatives: Hybrid inks and pastes—combining silver and carbon or silver and copper, for instance—can offer modest savings when a high level of performance is not critical. In the paste sector materials of this kind have been available for decades.

This kind of material generally disappears from the market as soon as silver prices start to come down. But, as we explained earlier, this is precisely what seems unlikely to happen in the near term. As a result, as we also mentioned earlier, it seems likely that there may be more of an opportunity for these inexpensive alternatives than in the past.

Printed nanosilver: A more strategic alternative to conventional silver inks and pastes is nanosilver. As we have mentioned, this may have a future in printed electronics, but this has yet to be proven and nanosilver ink makers have had a hard time of it as they have chased after new markets that don't really exist yet.

Printed nanosilver makers claim other advantages over more conventional materials, too. These include lower temperature processing and less usage/wastage of precious silver. These

advantages would seem highly compelling. But nanosilver-based inks and pastes have been around for nearly a decade now, and they have yet to take off in the market. What is behind the lack of progress?

- *That nanosilver can accomplish what conventional silver can but at much lower loading, thereby reducing costs substantially—has come into serious question.* Savings from using less silver are still largely eaten up by the higher cost of the nanosilver itself, let alone the changes in design and equipment that are needed to use it. This remains at least partially true despite the recent spike in silver prices that should have led to a bigger narrowing of the cost-in-use gap between conventional silver and nanosilver.

- Economic uncertainty leads to risk aversion and causes device manufacturers to stick with the conventional silver materials with which they are already comfortable.

- The outlook for printed nanosilver is complicated by a murky regulatory environment for silver specifically and nanomaterials.

There is *some* good news:

- *High silver commodity prices over $30 per troy ounce are a relatively recent phenomenon that will—at the margin—encourage more customers to switch to higher-performance nanosilver.* High silver commodity prices *have* narrowed the cost-in-use gap between nanosilver and silver in a meaningful way, even though more can be done.

- Today, a large fraction of nanosilver ink costs is still tied up in processing, scale-up, and production costs, and these costs should decline further as the material matures.

- There is growth in high-resolution printing inks, especially in emerging printed electronics, where traditional silver pastes are generally not suitable. High resolution printing is tailor-made for nanosilver, and these new applications may be able to support nanosilver's higher price, at least for a few more years.

In this new market, nanosilver inks (and nanosilver pastes) may finally have a chance to grow beyond niche status, although this is a long way from saying they are going to be big business. After years of watching not much happen in the nanosilver inks business NanoMarkets now believes that only modest growth will come from this segment until some clear advantage of application emerges in the marketplace. For the time being, nanosilver firms have done just about all they can do in terms of market development; they are going to have to wait until the silver ink users catch up!

1.2 Objectives and Scope of This Report

The primary objective of this report is to identify and quantify the opportunities for silver inks and pastes. NanoMarkets has been covering the electronics markets for silver for over five years, and is widely regarded as the premier supplier of industry information in this segment. With this in mind, the goal of this report is to adjust and expand our previous forecasts and strategic analysis with the constantly changing markets for these materials in mind.

In addition, as part of this analysis, we critically examine the strategies of the key players in the silver inks/pastes markets, and identify what we believe to be the trends indicating likely success (or not) at different firms. Finally, as always in NanoMarkets reports, we include eight-year market forecasts for silver inks and pastes by application and by material.

The scope of the materials covered in this report is silver and nanosilver inks and pastes. We have excluded from coverage here transparent nanosilver inks (covered in other NanoMarkets reports and involving different players and markets than the materials covered here); printed antimicrobial silver (better covered as part of a broader consideration of antimicrobial silver), and silver-based conductive adhesives. The applications covered are the ones in which printed silver of various kinds is a major factor including the traditional thick-film electronics applications, solar panels, and next-generation printed electronics (especially displays).

This report is international in scope. The forecasts are worldwide forecasts and we have not been geographically selective in the firms that we have covered in the report or interviewed in order to collect information. Where there are geographical factors at work—as is the case in the display sector—we discuss this more fully in the report.

1.3 Methodology

The methodology for this report is explained in more detail in Chapter Five of this report which deals with forecasts. Here we note that in general the approach we take, broadly speaking, is to apply economic analysis to the information that NanoMarkets continues to collect on the silver inks and pastes market and other related sectors.

The information for this work 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 silver materials and emerging electronics of all kinds. We also drew on the technical literature, relevant company Web sites, trade journals, government resources, and various collateral items from trade shows and conferences.

Some of the applications-related market information in this report comes from our most recent reports on the covered applications areas. Reports from which some data have been shared include: *"Nanosilver Markets – 2011," "Silver Powders and Flakes – 2011"* and "*Silver in Photovoltaics – 2010."* In addition, some of the historical information on silver and silver inks/pastes has been carried over from the last version of this report, "*Silver Inks and Pastes 2011*," from December 2010. Where information has been used in an earlier report, it has been reconsidered in light of current developments and updated accordingly.

The forecasting approach used in this report is to identify and quantify the underlying applications markets, the materials needs that are or can be served by silver inks/pastes, and the technological and market pressures that affect ink/paste usage in those markets. The stated plans of the key firms are, of course, of special interest, although NanoMarkets critically considers these claims in light of all available data.

1.4 Plan of This Report

In Chapter Two, we examine the silver inks and pastes that are used in the electronics industry; the strategies to reduce cost, increase performance, and customize materials to specific uses; and the materials that are used or likely to emerge as partial substitutes for silver in inks and pastes.

In Chapter Three, we discuss the applications and markets for silver inks and pastes. We discuss printed silver in the traditional thick-film applications and identify opportunities that may still exist for suppliers to make money is this mature market. We also examine the other applications for silver inks and pastes in displays, solid-state lighting, photovoltaics, RFIDs and security printing, and sensors. We identify trends in these sub-sectors that will affect silver ink and paste suppliers' abilities to sell into them, and we identify key areas that show promise for making money.

In Chapter Four we discuss the profiles and strategies of the major suppliers of silver inks and pastes of various types, and Chapter Five contains our eight-year forecasts of silver inks and pastes used in the electronics industry. These forecasts are presented by market segment and by type of silver ink/paste wherever possible.