Combating the impact of contamination in solar cell production

by Sheila Hamilton, Teknek, Renfrew, Renfrewshire, UK

Photo voltaic cell manufacturers today are under increasing pressure to increase yields and improve the efficiency of their products. This has become more imperative as the cost of raw materials has risen dramatically in recent years. One of the main barriers to achieving this is the incidence of contamination in the production environment. If contamination is present before coating, metallization, printing or lamination yields may be affected.

This article will look at the impact of contamination, the key sources of contamination and the problems which can arise, and suggests possible solutions to negate the effects of contamination.

Keywords: Contact Cleaning, Printing, Contamination, Debris, Yield

How contamination affects PV module production depends on which of the three types of solar cell being produced.

In first generation solar cells—silicon wafers—the presence of dirt and debris can affect the screen printing process, leading to problems such as tombstoning, pin holes, open and short circuits. Contamination of solder joints can lead to miniature 'blow outs' as organic materials vaporize and expand, rapidly causing voids and dry joints.

The solar cell modules are then encapsulated in an EVA film. If dust or particles become trapped between the film and solar cells, it can affect the efficiency of the cells by blocking sunlight. Given that efficiencies are already generally low, this is something manufacturers will wish to avoid. Even particles too small to be seen, due to a tenting effect, can produce visible defects in the laminated surface (fish eyes).

The second generation of PV cells—vacuum metalised—are more efficient; however the substrate needs to be cleaned before and during the deposition chamber process. In addition, the connector circuits face similar problems to first generation PV cells in terms of tombstoning, blow-outs and short circuits, if contamination is present. Likewise, at the encapsulation stage, the glass or film must be cleaned if maximum efficiency is to be achieved.

> "Conductive materials (debris) can result in corrosion of the finished product and may only show up in the field later in the product's life."

Third generation solar cells use screen printing techniques similar to those employed in the microelectronics sector. This type of cell generally has a lower efficiency than generations one and two, so it is important that contamination does not lower the efficiency even more. The substrate and stencil must therefore be thoroughly cleaned before each printing stage. As the collector patterns become ever finer to produce greater efficiencies, the impact of particles becomes greater. The substrate used for printing is generally polyester film or thin sheet steel. These substrates arrive for coating or deposition direct from the supplier and are frequently contaminated with debris from the manufacturing process. For example, rolls of polyester are usually slit to a specific width and slitter dust can

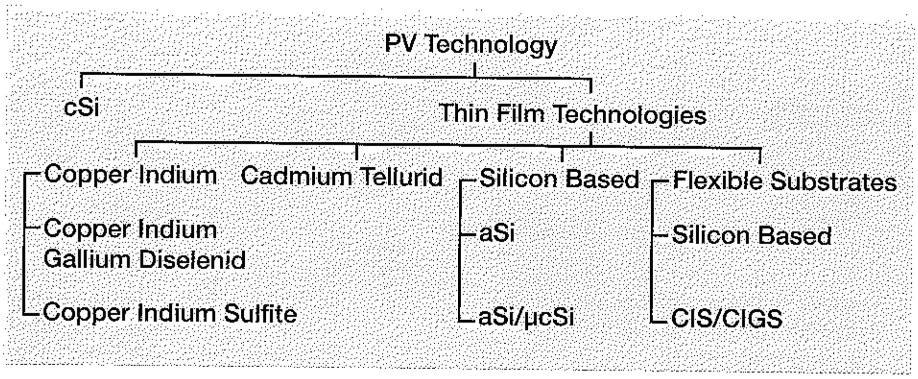

Figure 1. PV technologies.

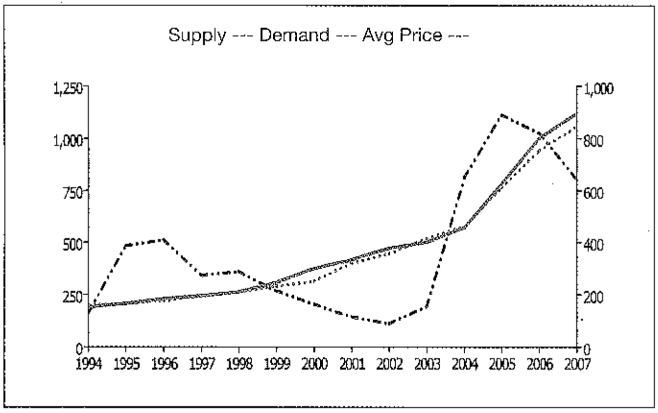

Figure 4. Price history–indium.

the indium used today, on an annual basis, is reclaimed and placed back into the supply chain. Virgin indium is extracted from zinc as direct result of demand. For CIGS, demand is based upon MW output. For every 1 MW of CIGS based solar cell production, 60 kgs of indium is consumed. By 2010, this equates to approximately 60 mts, <5% of the total indium demand for the same time period. Therefore, the FPD market is expected to remain as the dominant application using indium for years to come. As this market is considered more predictable (allowing supply to meet demand) versus five years ago when demand spiked as a result of LCD and plasma displays, meeting demand for all applications, including CIGS solar, is of less concern. Additionally, the continuous improvement in reclaim efficiencies and cycle times will further ease the necessity for virgin indium extraction.

To avoid any temporary material supply shortages it is essential that good communication exists relative to forward demand between the users and indium suppliers. The issue is less about the availability of indium and more centered on the availability of information (of future demand). Although there may be periods of intermittent volatility, long term there are no supply concerns.

Gallium

Gallium is extracted from bauxite, which has no supply concern. It is used in applications including GaAs devices, LEDs and solar cells. The availability and hence supply of gallium is only limited by the capacity of existing facilities to increase output. The primary driver for investment in increasing output is based upon the economies associated with its price level. At the time of this writing, gallium is considered to have stable supply in relation to demand. It is plentiful with possible periods of intermittent volatility.

> "Short term bottlenecks exist in the supply of key components. Alignment of technology, product development and capacity roadmaps between manufacturers and suppliers is critical for success."

Silicon

Silicon-based technology remains the dominant technology for PV supply, roughly 90%. Although Si is currently experiencing a supply imbalance, which has resulted in an escalation of price, this is expected to be overcome as additional capacity comes online in 2008 and 2009.

Tabbing ribbon

Typically a Cu cored and solder tinned (pb free or standard Sn/Pb alloys) tabbing ribbon is used to interconnect solar cells while creating the least amount of resistance between them. The key concerns revolving around tabbing ribbon are availability and quality. Typical lead times range from two months to as long as four months. Additionally, from a material quality perspective, achieving a low camber value is problematic.

Custom sputtering targets for CIGS As CIGS is an emerging technology, it is common that each company has a unique approach to developing the absorber layer. As such, each user has a unique alloy combination and composition that may result in forcing the supplier into a 'trial and error' mode of fabrication.

Metallization pastes/inks for CIGS

Very few metallization pastes/inks for CIGS exist on the market today, in combination with very few companies operating in a production mode. This of course will change over time. Additionally, each company has a proprietary process that inhibits the flow of information relative to specific process parameters in which the material must perform. The challenge becomes hinged with suppliers' ability to quickly develop new materials designed for the unique process environment.

Conclusion

The growth of PV technology and hence production and capacity is forecasted at

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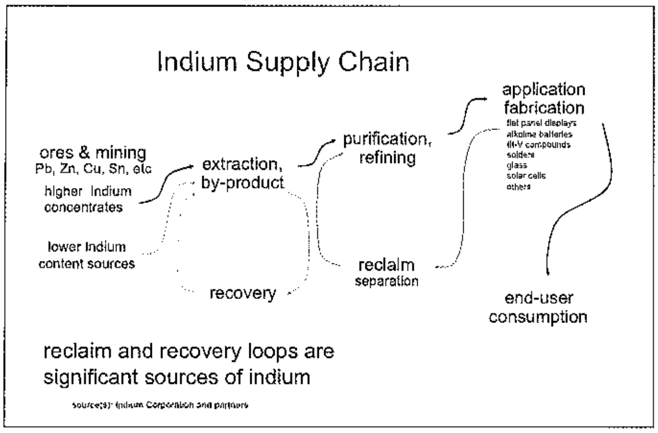

Figure 5. Indium supply chain.

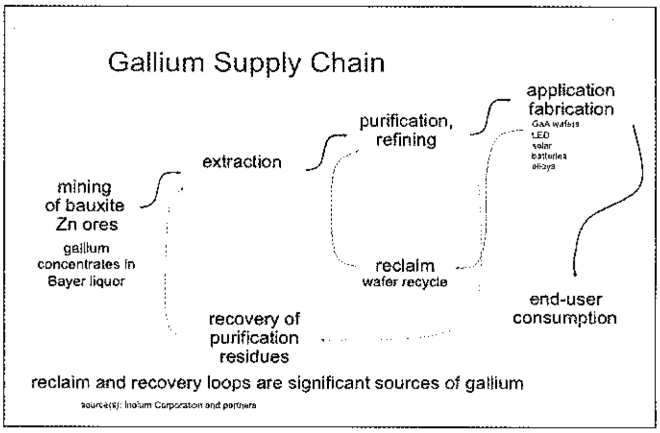

Figure 6. Gallium supply chain.

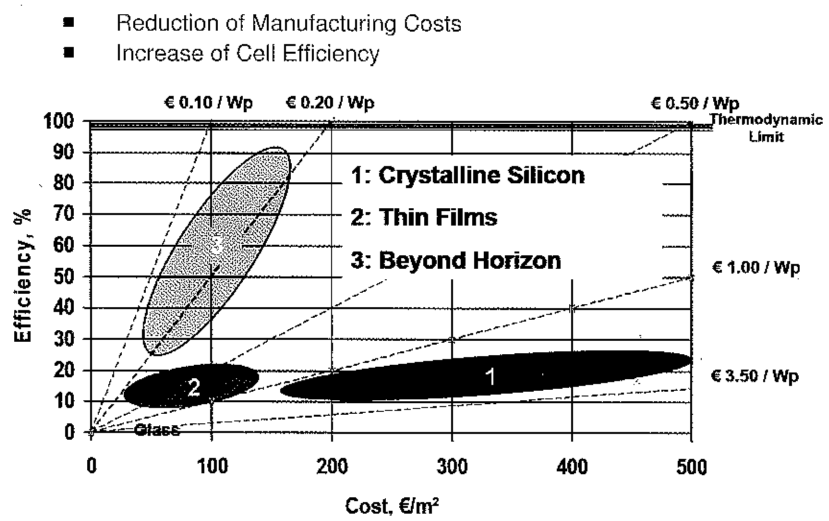

Figure 2. PV technology roadmap. Courtesy Shiller Automation.

be present on the surface of the material. Statically attracted particles are also an issue for dielectric base materials.

It is not only during the manufacturing process that contamination can cause problems. Conductive materials (debris) can result in corrosion of the finished product and may only show up in the field later in the product's life.

So what can be done to minimise the impact of contamination in a PV cell production environment? Many manufacturers are turning to a proven technology from the semi-conductor sector—contact cleaning.

Using contact cleaning equipment, it is possible to remove loose particles down to one micron in size from a silicon wafer or substrate, such as glass or EVA film, without damaging the surface. The equipment, pioneered by Teknek, uses a special elastomer roller to lift the contamination from the surface and transfer it to a roll of adhesive film for examination and disposal of the debris. When used at each stage of the production process where contamination could be present, contact cleaning equipment can lead to dramatic increases in yields and the efficiency of the PV cell. Contact cleaning methods have proven to be the most effective means of removing contamination as the roller makes contact with the surface. Other methods, such as blowers and vacuum systems, cannot cut through the boundary layer of air which sits just above the surface of the substrate.

Contact cleaning equipment—both standard and bespoke—is available to suit most PV production environments for both in line (continuous/reel to reel) processing and discreet items, such as wafers.

Conclusions

With the costs of raw materials rising, it is more important than ever for PV manufacturers to find ways of increasing yield and reducing waste. Contamination has a major impact on both production efficiency and efficiency of the solar cells themselves. By removing contamination using methods such as contact cleaning it is possible to increase yields and improve the efficiency of solar cells.

Sheila Hamilton is technical director and a board director with Teknek, responsible for keeping the company at the forefront of its field in terms of innovation and product design. Sheila joined the company in 1987 as technical director after working as a product designer and power station engineer. She has also run her own consultancy in the field of electronics component packaging. Sheila has a BSc in mechanical engineering from Glasgow University and is currently studying for an MBA at Strathclyde University. She is a recipient of two Smart Awards in the field of Electromagnetic Interference.