White Paper:

Polysilicon Shortages Magnify the Need for Purity

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Fossil fuel depletion, and concerns with global warming have ignited the demand for alternative energy sources. Solar power and photovoltaic producers must step up their manufacturing capabilities to meet future demand and insure inventory stockpiles. Current needs for silicon wafers are forecasted to outstrip existing supplies, putting pressure on manufacturers to reduce waste and maximize saleable output. Neutron Activation Analysis (NAA) may improve outputs by detecting contaminants early – reducing wasted time and materials.

This paper will address:

- The impact of ratcheting demand for polysilicon materials, driven by smaller, higher-quality, refined semi-conductor production - including nano-technology in the telecommunications sector -, photovoltaic fuel cells and resource intensive computing.
- A summary of science including the damage of impurities and the role of high-purity analysis.
- Conclusion - The key takeaway of how high-quality, stringent testing might drive the industry. The importance of early production purity levels in a high-demand low-supply market, and in a market of demand/supply correction.

Ratcheting Demand Outstrips Current Supplies

Demand for high purity polysilicon materials continues to outstrip supply capacity across multiple industries. Primary causes for this shortage are twofold:

1. ramping down of production facilities as fallout from the Internet bust of 2001
2. high growth from new application sectors, most notably nano-technology requirements from new telecommunications devices and from photovoltaic fuel cell manufacturers as fuel prices soar and demand for alternatives intensifies.

Much of the shortage stems from the hesitancy of industry to break ground on capital intensive plants in the wake of the 2001 market crash in the technology sector. At that time, semi-conductor production slipped to a commoditized market, driving prices down. The commoditization trend, combined with market volatility, slowed the drive for increased production capacity.

However, three key areas of new growth kicked in to drive demand to new levels:

1. The solar industry grew at an impressive 30% in 2005 over 2004, but may cap out at the 6% level in 2006-2007, according to a report by Jesse W. Pichel and Ming Yang, Piper Jaffray & Co., Research Analysts.[1]
2. Ramp-up of computing demand from emerging economies like Asia and India has increased demand for semi-conductors.
3. New nano-chips like the 65 nano-chips now being produced, and consumer demand for smaller, multi-use electronic devices.

Until 2006, most of the industry was working off of inventory stockpiles from 2001-2002. However, as these supplies have dwindled, shortages have occurred. Although most major polysilicon producers are significantly increasing production facilities, most will not be fully productive until 2008. This leads to two core issues:

1. Waste factors have critical importance during the raw materials shortage.
2. Pent-up demand for solar will heighten production requirements, with an extended emphasis on production efficiency and reduced margins of error.

Gartner predicts the market will remain tight for the supply of Polysilicon materials through 2008, a result of strong semiconductor wafer production and rapid consumption gains in the photovoltaic cell industry.[2] This demand/supply imbalance will most likely begin to correct as new production facilities come on board beginning in 2008.

Purity Testing: Catching Contamination Early

Purity is critical for performance. Focus on the ability to produce high-purity products is critical to manufacturers. Trace impurities as low as ppt (parts per trillion) can drastically reduce the effectiveness of semiconductors, and can reduce the lifetime of charge carriers.[3] Therefore, monitoring potential contamination levels is critical to the manufacturer.

Neutron Activation Analysis (NAA) can be conducted throughout the entire poly silicon production process and detect minute contaminant levels to the ppq (parts per quadrillion) detection for nearly 40 trace elements, without dissolving or digesting the sample.

NAA is one of the most sensitive analytical techniques used for multi-element analysis available today. The NAA procedure is capable of providing both quantitative and qualitative results for individual elements, with sensitivities that can be superior to those possible by any other analytical technique. Elemental Analysis Incorporated (EAI), as an innovator in the development and application of radio-nuclear chemistry analytical techniques, now offers its clients the ability to analyze some 75 individual elements (including certain organic elements) by NAA at trace and ultra-trace concentrations.

Figure 1: Scope of NAA testing

Research conducted over the past three decades has indicated that purity levels have increased over time. This most likely stems from the use of robotics, which decreases potential contamination from handling the wafers in production by humans- which could introduce contaminants.[3] At the same time, industry requirements for purity are increasing as market driven demands for multi-use requirements for wafers grow.

The Science Behind NAA

NAA is a physical technique that is based on nuclear reactions whereby the elemental content is determined by irradiating the subject sample with neutrons, creating radioactive forms of the desired element in the sample. As the sample becomes radioactive from the interaction of the neutron particle source and the nuclei of the element's atoms, radioisotopes are formed that subsequently decay, emitting gamma rays unique in half-life and energy. These distinct energy-signatures provide positive identification of the targeted element(s) present in the sample, while quantification is achieved by measuring the intensity of the emitted gamma rays that are directly proportionate to the concentration of the respective element(s) in the sample. When neutrons activate the nucleus of the atom, it allows the total elemental content to be observed regardless of the oxidation state, physical location, or chemical form of the desired element. Since neutrons possess the ability to pass through most materials with little difficulty, this allows the center of the sample to become as radioactive as the surface, thereby reducing or even eliminating the potential for matrix effects. Because neutron activation can be applied to any element with an appropriate isotope, nearly 70% of elements in the Periodic Table can be analyzed by NAA.

Why make the investment in NAA testing for your silicon wafer production?

NAA provides two key benefits for the poly silicon producer:

1. Level of accuracy to ppq (parts per quadrillion) answer the need for increased purity levels
2. Speed to market results: testing can be turned around within 1 to 3 weeks, versus previous waits of up to 3 months for this procedure. However, for optimum precision and low detection levels, some analyses may take from 3 to 5 weeks to complete.

Neutron Activation Analysis (NAA) may improve outputs by detecting contaminants early – reducing wasted time and materials. Proven approaches to stringent quality assurance, including increased analytical sensitivity will insure consistent levels of product purity.

Elemental Analysis, Inc. and their testing partners strive to deliver high-purity testing and remove contamination entry points, allowing silicon wafer producers to tap world-class testing expertise and facilities.

References

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2. “Dataquest Insight: Polysilicon Market Outlook, 1Q07 Update”, February 28, 2007
3. “Can instrumental neutron activation analysis keep pace with the needs of the high purity materials industry?”, Akademiai Kiado, Budapest, 2001.