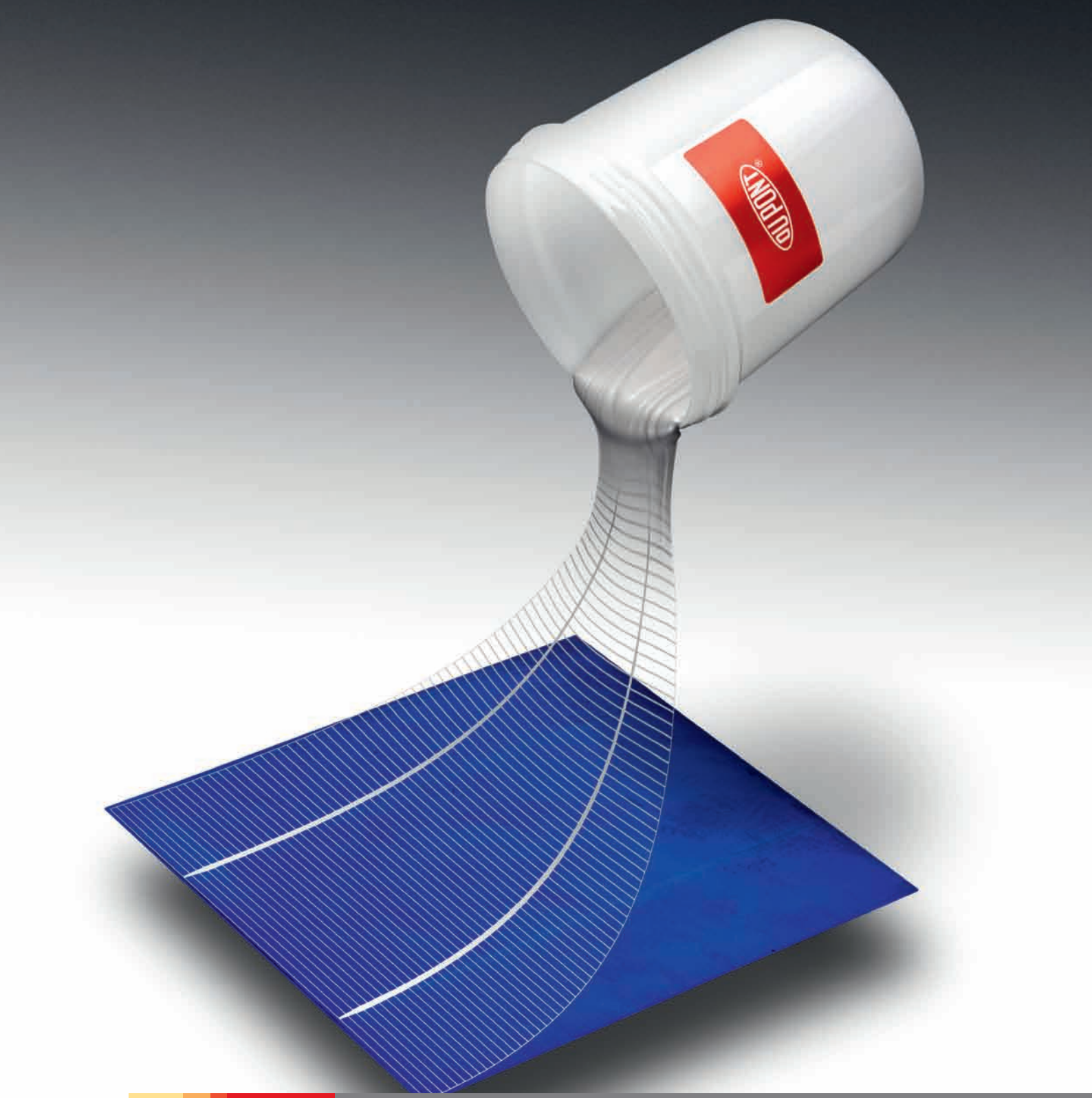


DuPont™ Solamet®
Photovoltaic Metallizations

DUPONT®

The miracles of science™

Introduction

DuPont's commitment as a major supplier to the electronic industry has been ongoing for more than 40 years. Since that time, DuPont has become a world leader in thick film pastes – a position it owes to its broad experience in materials science, chemistry, fine powder technology, organic materials and solvents. As one of the world's largest science based companies, its broad technology capability and global presence enable it to develop innovative products aimed specifically at meeting today's electronic requirements.

DuPont Photovoltaic Solutions is a leading material and technology supplier to the photovoltaic (PV) industry with more than 25 years of experience in PV materials development, applications know-how, manufacturing expertise and global market access. We offer a broad and growing portfolio of materials for crystalline silicon and thin film solar cells, including conductive pastes, films and resins. Through science and technology, these innovative materials from DuPont enable solar cells to run more efficiently, last longer and provide environmentally sustainable solutions, making the use of alternative energy easier for everyone.

Such developments need to be user friendly, with simple manufacturing steps and high yields, yet respectful of the environment. At DuPont, we are supported by a highly skilled R&D and technical service group as well as a specialized sales and marketing force. Both organizations are intent on pursuing new opportunities and providing novel solutions to the multitude of modern photovoltaic applications.

DuPont™ Solamet® Photovoltaic Metallizations

DuPont™ Solamet® offers a comprehensive system of thick film materials used in the construction of photovoltaic (solar) cells. The materials properties and functional requirements of the front and the back sides of PV wafers dictate significant differences in the functionality of thick film metallization pastes.

Printing

n-type Ag Metallization

The front side is responsible for absorbing light and generating most of the electrical carriers. The thick film conductor has the role of efficiently contacting the Si and transporting the photo-generated current without adversely affecting the semiconductor properties and without damaging the p-n junction. DuPont™ Solamet® front-side conductors offer the following important features:

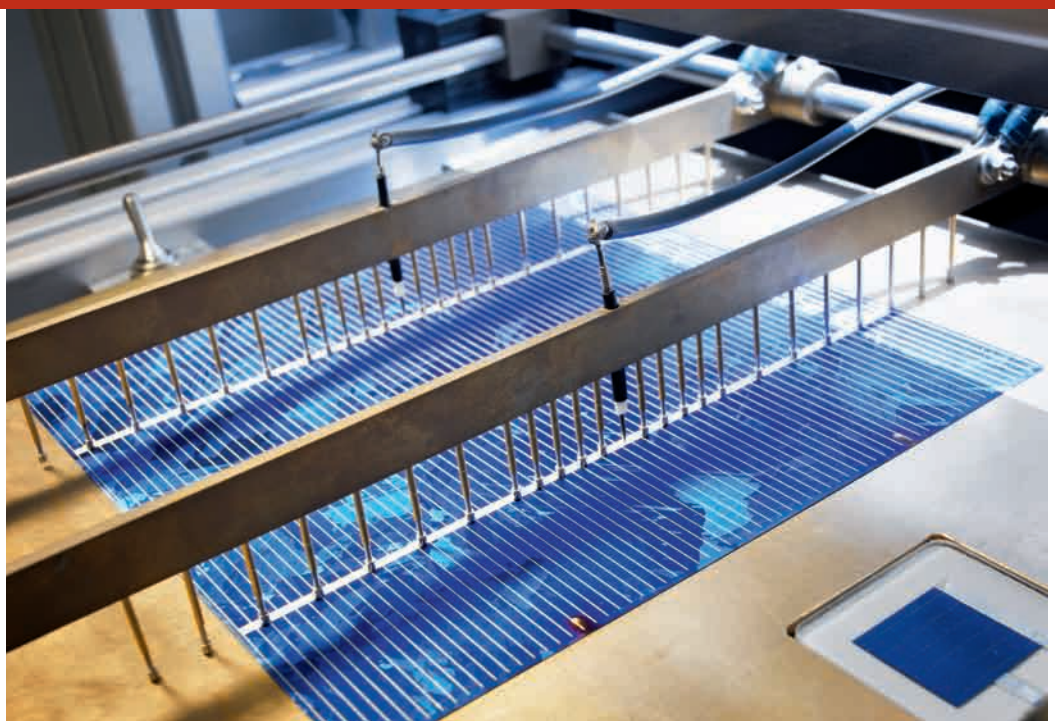
- **Low contact resistance** – Controlled penetration of barrier layers such as native SiO^2 and anti-reflective coatings (ARC). This is essential for making good electrical contact to the doped n-type layer, thus achieving a low contact resistance. Contact must be achieved without penetrating into the p-n junction region and shunting the cell.
- **High conductivity** – This is important for achieving a low resistance in the bus bar and grid lines of the front metallization and contributing to low series resistance. High conductivity is particulary important in todays' large scale cells with dimensions of 156 mm × 156 mm and more.
- **Good line resolution** – The front side conductor tracks must be as narrow as possible to maximize the area available for illumination (minimize shadowing).
- **Good solderability** – This is required for attachment of the ribbon contacts for connecting the cells together.

Firing

p-type Al Metallization

The function of the back-side conductor is to act as a second electrode in the cell. Al thick film technology is used to generate a p-type region with aluminum doped silicon sites that function as a back-surface field, enhancing the efficiency of the cell. As the back-side is not normally illuminated directly, there are no constraints on the electrode geometry. DuPont™ Solamet® p-type Al conductors offer the following features and benefits:

- **Utilization of the back-surface field effect** – During firing, aluminum will dissolve silicon that, during cool down, will dope aluminum at low levels on the silicon sites. The presence of the aluminum creates a back-surface field effect that directly contributes to the photo-current and cell voltage. Generally, the aluminum dopant level rises with increasing temperature correlating directly with improved performance.
- **Efficient use of aluminum** – Reduces material costs whilst maintaining the electrical properties.
- **Low stress** – Induces minimum bow.

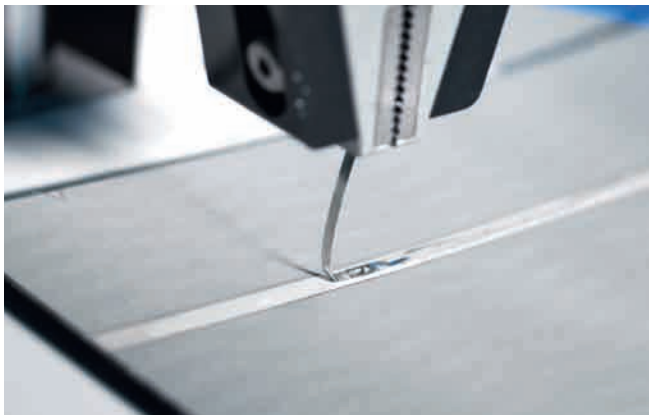


Testing

p-type Ag Metallization

The function of the back-side Ag or AgAl conductor is to act as the interconnect part of the second electrode in the cell. The following features are important for a back-side Ag or AgAl conductor:

- **Good ohmic contact** – This may be achieved by addition of aluminum to a thick-film silver paste. The aluminum is an effective reducing agent, helping to penetrate the native oxide layer on the wafer and generating better contact to the silicon. Equivalent properties can be achieved with the latest developments of pure Ag compositions.
- **Good solderability or weldability** – As with the front-side this is required for attachment of the ribbon contacts for connecting the cells together.
- **High paste coverage** – Reduces paste consumption and lowers cost.
- **High soldered aged adhesion** – Enables extended interconnect life time.



Materials for Thin Film Solar Cells

DuPont™ Solamet® now offers an expanded portfolio, with the introduction of a new range of low temperature screen printable pastes for all major thin film PV applications, enabling cost effective manufacturing of solar cells with improved efficiency and yield.

The main purpose of the low temperature curing Ag paste is for use as a front side current collector grid and bus bar to reduce the resistive losses due to the relatively low conductivity of the transparent conductive oxide (TCO) layer used in thin film PV devices.

To be effective in this role, the Ag paste must have excellent adhesion to the TCO, combined with low contact resistance and high sheet conductivity.

Other materials available include a silver coated Cu paste for solderable contacts and a low temperature carbon ink for CdTe cell back contact.

Customizable compositions for other thin film technologies such as DSSC and organic PV are also being considered.

DuPont™ Solamet® low temperature inks can be used on both rigid (glass, silicon) and flexible (polyimide, polyester, stainless steel) substrates.

Applications

- a-Si/µc-Si – Ag grid and bus bar
- CIGS – Ag grid and bus bar
- Heterojunction – Ag grid and bus bar
- CdTe – Carbon ink (back contact)

Key Front Side Ag Paste Properties

- High conductivity and low contact resistance to minimize series losses
- Good line resolution to reduce shadowing loss
- Good flex properties for durable flexible thin film cells
- Excellent adhesion to a variety of TCOs
- Dry at low temperature, typically 130 °C to 200 °C
- Designed for screen printing on reel-to-reel/mass production
- Customizable technology platform for other thin film cell structures.

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Innovating for the Future

Building on 40 years of thick film experience, DuPont continues to lead the exploration in the field of PV solar cell metallizations and processing. Our R&D labs are agressively working on next generation solutions to further improve cell efficiency, process productivity, cell production yield and long term reliability.

The Science of Listening

Our research and development activities are geared towards finding sustainable solutions that meet the needs of our customers and end-users. This means the most important skill for both our scientists and our marketing teams is listening; listening to the challenges of our customers and to the trends which are shaping consumer demands.

So whatever challenge you face in PV metallizations – please talk to us first. You can find your local contact on the back cover.

We offer expertise in the following areas:

- Alternative deposition technologies
- Paste delivery systems
- Customized products
- Metallizations for n-type Si wafers
- Metallizations for selective emitters
- "Fire through" aluminum
- Through hole metallizations for MWT cell designs
- Through hole plugs
- Al pastes for local BSF and controlled alloying
- Contactless bus bar pastes
- SixSigma Methodology Support
- Training and Seminars

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