

33-455, 33-462, 33-470
Silver Conductor
SiN_x ARC Solar Cells

Description: For many years, Ferro has been the leading supplier of thick film silver inks designed for making contact to the n-doped silicon front face of photovoltaic devices. Achieving good adhesion with an excellent ohmic contact to this shallow junction is critical in the production of high efficiency cells. Ferro Electronic Materials has produced a number of different formulations for this application. It has been our experience that each cell type has variations in junction depth, dopant concentration and silicon orientation. For this reason, we suggest that a manufacturer new to our product test variations of these formulations, in order to capture the sometimes subtle advantages that one of them may offer for a particular cell type. For similar reasons, our recommended firing profile is meant to be taken as a starting point only and it is absolutely essential that a matrix of profiles be tested to achieve optimum output.

33-455, 33-462 and 33-470 are specially designed silver pastes for contacting p/n⁺ type silicon solar cells passivated with SiN_x coatings with thicknesses between 750 Å – 900 Å. When fired, these screen printable inks yield

very low bulk and contact resistivity which results in high a Fill Factor and energy conversion efficiency. During the firing process the glasses and additives contained in the inks react with silicon nitride to form a low resistance contact while providing good adhesion to the wafer and excellent solderability. While all the inks provide very good electrical contact to n+ surfaces passivated with SiN_x, Ferro recommends the three inks be tested to identify the optimal match to the manufacturer's emitter profile and SiN_x density. The following Table shows difference between various inks:

| Product | Sheet R (Ω/ρ) | Remark |
|---------|---------------|---|
| 33-455 | 45 – 80 | Reduces lead content by 50%. |
| 33-462 | 45 – 80 | Works on acid textured surface |
| 33-470 | 45 – 60 | Wider processing window; works on acid textured surface |

Typical Properties

| | 33-455, -462, -470 |
|--|---------------------------|
| Viscosity (poise) ¹ : | 1100 – 1400 |
| Solids Content: | 83.0 – 87.0% |
| Fineness of Grind: | < 14 / 11 μm |
| Dried Thickness: | 20 – 30 μm |
| Fired Thickness: | 12 – 18 μm |
| Resistivity ² (milliohms/square): | < 1.5 |
| Drying Profile: | 250 – 300°C, < 20 seconds |
| Peak Firing Temp: | 720 – 750°C |
| Time at Peak: | 1 second |
| Recommended Thinner | 0800 |

Notes:

¹Viscosity as measured on Brookfield model HBT cone/plate viscometer; 9.6 reciprocal seconds, 1.565"cone, 25°C.

²Milliohms/sq. at 25μm.

www.ferro.com

DISCLAIMER: Reasonable care has been taken in the preparation of this information, but **FERRO EXTENDS NO WARRANTIES, MAKES NO REPRESENTATIONS AND ASSUMES NO RESPONSIBILITY AS TO ACCURACY OR SUITABILITY OF THIS INFORMATION OF THIS PRODUCT FOR ANY PURCHASER'S OR USER'S USE OR FOR ANY CONSEQUENCE OF ITS USE. FERRO DISCLAIMS ANY WARRANTY OF MERCHANTABILITY OR WARRANTY OF FITNESS FOR ANY PARTICULAR USE.** All statements, technical information and recommendations contained herein are based on Seller's or Manufacturer's test and the test of others, and are believed to be accurate, but no guarantee of accuracy is made. Judgment as to the suitability of information herein or the user's purposes are necessarily the user's responsibility. Users shall determine the suitability of the products for their own intended application.

Users assume all risk of use or handling whether or not in accordance with any statements or recommendation of the seller or manufacturer. Liability, if any, is and shall be limited to the replacement of such quantity of material proved not to conform to specifications as set out in product specification. Statements concerning the possible use of these products are not intended as recommendation to use these products in infringement of any patent. No guarantee is made that any use of the products does not infringe third-party intellectual property or patent rights anywhere in the world.

Processing Recommendations

Printing: 250 – 325 mesh screen with a 20 μm – 25 μm emulsion thickness is recommended.

Drying: The ink can be dried in an Infrared or conventional dryer under wide range of conditions. Inks are typically dried in a IR dryer with set points of 250°C – 300°C in less than 20 seconds.

Firing: An Infrared furnace with belt speeds up to 120 IPM (inches per minute) is highly recommended. The front contact paste may be co-fired with the back contacts. The following furnace settings are suggested as a starting point:

| | |
|--------------|----------------|
| Furnace: | Infrared |
| Heated Zone: | 30 inches |
| Set Points: | Zone 1: 780 °C |
| | Zone 2: 830 ° |
| | Zone 3: 930 °C |
| Belt Speed | 120 IPM |

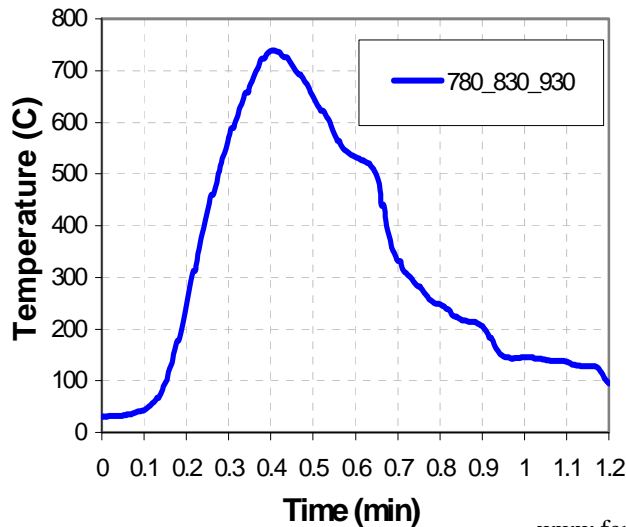
Since the furnace configurations, furnace loading and the lamp power vary; the above furnace settings may be used as a starting point. It is highly recommended that a matrix of profiles be tried to optimize cell output and efficiency

Thinning: Thinning is not recommended, since the paste is supplied at the correct viscosity for application. Contact your local Ferro Representative for appropriate solvent details, should thinning become necessary to replace solvent lost through evaporation.

Paste Storage & Shelf Life: The paste should be stored in tightly capped containers, in a cool, dry place away from direct sunlight. Properly stored material will have a shelf life in excess of 6 months.

Rev. 09/05

These parameters yield the following profile as measured using a thermocouple:



www.ferro.com

DISCLAIMER: Reasonable care has been taken in the preparation of this information, but FERRO EXTENDS NO WARRANTIES, MAKES NO REPRESENTATIONS AND ASSUMES NO RESPONSIBILITY AS TO ACCURACY OR SUITABILITY OF THIS INFORMATION OF THIS PRODUCT FOR ANY PURCHASER'S OR USER'S USE OR FOR ANY CONSEQUENCE OF ITS USE. FERRO DISCLAIMS ANY WARRANTY OF MERCHANTABILITY OR WARRANTY OF FITNESS FOR ANY PARTICULAR USE. All statements, technical information and recommendations contained herein are based on Seller's or Manufacturer's test and the test of others, and are believed to be accurate, but no guarantee of accuracy is made. Judgment as to the suitability of information herein or the user's purposes are necessarily the user's responsibility. Users shall determine the suitability of the products for their own intended application.

Users assume all risk of use or handling whether or not in accordance with any statements or recommendation of the seller or manufacturer. Liability, if any, is and shall be limited to the replacement of such quantity of material proved not to conform to specifications as set out in product specification. Statements concerning the possible use of these products are not intended as recommendation to use these products in infringement of any patent. No guarantee is made that any use of the products does not infringe third-party intellectual property or patent rights anywhere in the world.